Communications Department
External Information Services

[redacted]

29 January 2018
Reference: F0003547

Dear [redacted]

I am writing in respect of your recent request of 4 January 2018, for the release of information held by the Civil Aviation Authority (CAA).

Your request:

'I need BCAR (British Civil AW requirements), section G (rotorcraft) document.'

Our response:

Having considered your request in line with the provisions of the Freedom of Information Act 2000 (FOIA), the information you have requested can be found attached.

If you are not satisfied with how we have dealt with your request in the first instance you should approach the CAA in writing at:-

Caroline Chalk
Head of External Information Services
Civil Aviation Authority
Aviation House
Gatwick Airport South
Gatwick
RH6 0YR

caroline.chalk@caa.co.uk

The CAA has a formal internal review process for dealing with appeals or complaints in connection with Freedom of Information requests. The key steps in this process are set in the attachment.

Should you remain dissatisfied with the outcome you have a right under Section 50 of the FOIA to appeal against the decision by contacting the Information Commissioner at:-

Information Commissioner's Office
FOI/EIR Complaints Resolution
Wycliffe House
Water Lane
Wilmslow
SK9 5AF
https://ico.org.uk/concerns/

If you wish to request further information from the CAA, please use the form on the CAA website at http://publicapps.caa.co.uk/modalapplication.aspx?appid=24.

Yours sincerely



Rihanne Stephen
Information Rights Officer

CAA INTERNAL REVIEW & COMPLAINTS PROCEDURE

- The original case to which the appeal or complaint relates is identified and the case file is made available;
- The appeal or complaint is allocated to an Appeal Manager, the appeal is acknowledged and the details of the Appeal Manager are provided to the applicant;
- The Appeal Manager reviews the case to understand the nature of the appeal or complaint, reviews the actions and decisions taken in connection with the original case and takes account of any new information that may have been received. This will typically require contact with those persons involved in the original case and consultation with the CAA Legal Department;
- The Appeal Manager concludes the review and, after consultation with those involved with the case, and with the CAA Legal Department, agrees on the course of action to be taken;
- The Appeal Manager prepares the necessary response and collates any information to be provided to the applicant;
- The response and any necessary information is sent to the applicant, together with information about further rights of appeal to the Information Commissioners Office, including full contact details.

MISCELLANEOUS AMENDMENTS DERIVED FROM SECTION D, "AEROPLANES"

INTRODUCTION

Although certain new technical amendments were included in Issue 1 of Section G, the issue was in the main a reprint of the Provisional Issue. As this reprint was produced fairly quickly to replenish stock, it was not possible to review the amendments made to Section D, during the period of currency of the Provisional Issue of Section G, in order to decide if any such amendments were applicable to rotorcraft. The amendments to Section D were numerous because the period of currency of the Provisional Issue of Section G was long (1949 to 1953). The review has now been made and the more minor amendments for inclusion in Issue 2 of Section G are listed in this Paper.

Material differences between the requirements of the current Section G and those of this Paper are indicated with a marginal line.

CHAPTER G2-6, paragraph 3.3 - Control Forces, Handling

DISCUSSION Section D "Aeroplanes" has a definition of "Excessive Control Forces" in Chapter D2-6, Handling. Since there are references to excessive control forces in the Rotorcraft Handling Requirements (in Chapter G2-7, paragraph 2.1 and Chapter G2-8, paragraph 3) the relevant part of the aeroplane definition is to be adopted for rotorcraft.

TEXT OF AMENDMENT

"3.3 Excessive Control Forces. The assessment of whether a control force is excessive, apart from a maximum figure which may be prescribed, may be influenced by the ease of applying it and the general level of control forces for the rotorcraft."

CHAPTER G3-8, paragraph 3 - Equipment and Seat Attachment

DISCUSSION It was argued in the case of aeroplanes that the ability of seats and aircraft structure to yield considerably before total failure may permit them to survive the period of peak acceleration; whereas the design local to the attachments was such that it failed rapidly. It was felt that this suggested additional

/local strength

local strength might be of material advantage without an appreciable cost in weight and a recommendation on the subject was agreed for inclusion in Section D. The existing paragraph 3 is, therefore, to be enlarged in the same way with the following recommendation.

TEXT OF AMENDMENT

"3 Equipment and Seat Attachment. It is recommended that inertia forces corresponding to higher accelerations than those prescribed should be used for the design of seat and equipment attachments, etc., since, in the event of a crash involving such higher accelerations, it is desirable to protect occupants from injury by detached equipment and seats."

CHAPTER G4-1, paragraph 3 - Fabrication Methods, Flaw Detection and Forgings

DISCUSSION No requirements have been included in Section G dealing with the control of forging methods other than the general statement in paragraph 3 of Chapter G4-1. More detailed requirements are, therefore, to be included in this paragraph relating to grain flow tests, strength tests and magnetic flaw detection tests for certain classes of forgings.

No specific mention has been made previously in Section G of the magnetic flaw detection test which is now to be considered for each steel Class 1 or Class 2 part.

TEXT OF AMENDMENT

"3 Fabrication Methods
(Existing paragraph now becomes 3.1, General.)

3.2 Magnetic Flaw Detection. The designer shall consider the need for a magnetic flaw detection test on each steel Class 1 or Class 2 part, and shall endorse the drawings accordingly, giving details of the technique to be employed.

3.3 Forgings. Where forgings are Class 1 parts, this shall be indicated on the drawing, together with the direction of grain required. A Class 1 forging of each new pattern is to be selected at random for sectioning and etching to confirm that the grain flow is correct.

3.3.1 Where a light alloy Class 1 forging is made of material whose specification requires an ultimate tensile strength of 25 tons per sq.in. or more in test pieces representing the forging, at least one specimen from each source of supply shall be strength tested to the ultimate load in

/in the critical

in the critical design case. (A note to this effect shall be included in the drawings of the forging.) However, where a forging is sufficiently similar to already tested forgings from the same source of supply that its strength may be estimated reliably from existing test results, the test may be waived."

CHAPTER G4-2, paragraph 1.6 - Controls Used for Take-off and Landings, etc.

DISCUSSION. It was agreed at the Airworthiness Requirements Co-ordinating Committee in 1948 to accept a requirement for aeroplanes stating that the pilot's controls shall be arranged so that he does not have to change hands on the controls during critical manoeuvres.

TEXT OF AMENDMENT

"1.6 Controls intended for operation by the pilot during take-off, approach, landing and/or overshoot shall be arranged so that their operation during these manoeuvres does not necessitate the pilot having to change hands on the cyclic pitch control."

CHAPTER G4-2, paragraph 1.7 - Control System, Reversal of Direction of Movement

DISCUSSION When a power-operated essential service has been put in motion the consequences might be serious if in circumstances such as those quoted below, it is not possible to change the selected direction of movement before the initially selected movement has been completed, or if attempting to change the selected direction of movement results in jamming or damage to the system:-

(i) A change in flight conditions.

(ii) A control having been operated inadvertently in the wrong direction and this having been discovered promptly after its initiation.

(iii) An emergency having suddenly developed which caused the crew member to change his orginal plan of action.

On an essential service it should, therefore, be possible, irrespective of whatever selection has been previously made, to select any desired new position without using a special control sequence and without the necessity for the service to complete the initial movement. For certain of the services, particularly those having a direct and immediate effect on the performance of the rotorcraft, it will also be essential that the service immediately starts to move to the finally selected position.

/TEXT OF AMENDMENT

TEXT OF AMENDMENT The following paragraph is to be included in Chapters G4-2 and G5-7:-

"Change of Direction of Movement. Essential services and their control systems shall be so designed that when a movement to one position has been selected, a different position can be selected without having to wait for completion of the initially selected movement. It shall not be necessary for the pilot to follow other than a normal control sequence in selecting the new position. Following selection the service being operated shall start to move to the finally selected position in a normal manner. Any time lag before commencement of movement to the finally selected position shall not be such as to effect adversely the airworthiness of the rotorcraft."

CHAPTER G4-2, paragraph 5 - Controls, Incorrect Assembly

DISCUSSION It was found desirable in Section D to give detailed amplification of the requirements for incorrect assembly of controls. This information is also to be made available in the rotorcraft requirements.

TEXT OF AMENDMENT

"5 Incorrect Assembly. Control systems shall be designed so as to minimize the risk of incorrect assembly. (See Recommendations appended to this Chapter.)

RECOMMENDATIONS APPENDIX TO CHAPTER G4-2

1 Incorrect Assembly

1.1 In meeting the requirement of G4-2, 5, the requirement of 1.2 shall be applied to all control systems, irrespective of the type of system (mechanical electrical, fluid, etc.) except those which,

(a) if assembled incorrectly are unlikely to prejudice the immediate safe operation of the rotorcraft,

(b) are operated before take-off can be commenced, so that incorrect assembly would be obvious.

NOTE: Such operation before take-off does not include special "drills" but only those operations which must of necessity be made before a take-off

/ 1.2

1.2 Each such control should be so designed and constructed that, at all reasonably possible break-down points in the system, it is mechanically impossible to,

(a) assemble the controls to be disastrously out of phase, or,

(b) assemble the controls so that they operate in the reverse sense, or,

(c) interconnect the controls of two systems where this is not intended.

1.3 All other controls, the faulty operation of which might affect the continued safe operation of the rotorcraft, should be so designed and constructed as to be mechanically difficult to misconnect or so that misconnection is obvious from the appearance of the system."

CHAPTER G4-3, paragraph 8.4 - Compartment Fire Precautions

DISCUSSION The Board found it necessary to amplify the compartment fire precautions for aeroplanes in 1950. Although the text of the aeroplane requirements hardly applies to rotorcraft, the following minor amendment to paragraph 8.4 is to be included in Chapter G4-3.

TEXT OF AMENDMENT

"8.4 Compartments which are unoccupied, or may be unoccupied in flight in which a fire hazard may exist shall either -

be constructed of and contain only such materials and equipment as will not propagate combustion when subject to a minor fire, or

be equipped with suitable fire detecting, indicating and extinguishing apparatus.

NOTE: If it can be demonstrated that the presence of fire makes itself known immediately then fire detecting and indicating devices may be omitted.

8.4.1 When extinguishing apparatus is fitted, suitable instructions for its use shall be placarded at the appropriate crew member's station."

CHAPTER G4-3, paragraph 10 - Signal Pistol and Discharger

DISCUSSION The risk of fire following improper use of a signal pistol has long been recognized and other national authorities have had occasion to introduce safeguards into their legislation for aeroplanes. Although, fortunately, no evidence of this need on British civil aircraft has been experienced, a suitable protective clause is to be introduced into Chapter G4-3.

/ TEXT OF AMENDMENT

TEXT OF AMENDMENT

"10 Signal Pistol and Discharger. When a signal pistol is carried a mounting shall be provided such that the pistol can be loaded, fired and unloaded in the firing position."

CHAPTER G6-1, paragraph 3 - Pitot-Static Systems

DISCUSSION It was found desirable to extend the requirements for static systems to cover pitot systems in Section D. Those parts of that amendment which are applicable to rotorcraft are to be included in G6-1, as paragraph 3.9, the current 3.9 and subsequent paragraphs being renumbered accordingly.

TEXT OF AMENDMENT

"3.9 Pitot-static Systems

3.9.1 The lag and the possibility of moisture blockage in pitot-static lines shall be kept to an acceptable minimum.

NOTE: In this connection tubing having an inside diameter less than a quarter of an inch will not normally be acceptable.

3.9.2 Sufficient moisture traps shall be installed to ensure positive drainage throughout the whole of the system.

CHAPTER G6-1, paragraph 4.3.2 - Fire Extinguishers

DISCUSSION Now that rotorcraft are being manufactured that have more than one compartment, it is considered necessary to replace the existing paragraph 4.3.2 with the following, which was derived from Section D, "Aeroplanes".

TEXT OF AMENDMENT

"4.3.2 One portable fire extinguisher for each enclosed passenger and crew compartment, one of which shall be convenient to a number of the flight crew."

CHAPTER G6-1, paragraph 4.3 - Spare Electrical Fuses

DISCUSSION The Air Navigation Regulations call for spare fuses to be carried as detailed below. Since 1951 it has been the practice of the Board to include such items in British Civil Airworthiness Requirements.

TEXT OF AMENDMENT

"4.3.3 Spare electrical fuses for all electrical circuits, the fuses of which can be replaced in flight, consisting of 10% of the number of each rating, or 3 of each rating, whichever is the greater."

CIVIL AVIATION AUTHORITY

BRITISH CIVIL AIRWORTHINESS REQUIREMENTS

PAPER NO. G707

20th November 1985

SECTION G
ROTORCRAFT

ELECTRICAL SUPPLY, SYSTEMS AND EQUIPMENT

INTRODUCTION

The requirements and recommendations of this Paper have been agreed by the Co-ordinating Committee for Electrical Requirements and the Rotorcraft Requirements Co-ordinating Committee, and are made effective upon acceptance of the advice of the Airworthiness Requirements Board.

TEXT OF AMENDMENTS

As all the material contained in this Paper is new to Section G and as it is the result of a major technical and presentation review of material from Section J "Electrical", the whole of the text is shown with a marginal line.

The following two new Chapters G6-13 and G6-14 are inserted:-

CHAPTER G6-13 - ELECTRICAL GENERATION, SUPPLY AND DISTRIBUTION

1 INTRODUCTION

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1.1 This Chapter states the requirements governing:-

(a) The reliability and the capability of the electrical supply system under normal and emergency conditions.

NOTE: The failures required to be taken into account in this Chapter are those in the electrical generation, supply and distribution systems. However, where relevant, requirements relating to failures elsewhere in the rotorcraft will also need to be taken into account in the electrical system (e.g. debris from high energy rotating parts, bird strikes).

(b) The provision and installation of generators and batteries, together with their control and indicating equipment.

(c) Electricity distribution systems.

1.2 Where the rotorcraft uses a number of separate or interrelated electrical systems, the provisions of this Chapter shall apply to each system and to the systems as a whole.

2 SYSTEMS RELIABILITY (See G6-13 App. No.1)

2.1 The review required will normally show that compliance with the reliability requirements is achieved by meeting the specific requirements of this Chapter G6-13. However, for the electrical supply and distribution system, additional analysis or assessment may be required where:-

(a) there is a major interrelationship with other critical systems in the rotorcraft, or

(b) there could be an effect upon critical characteristics of the rotorcraft.

Where such analysis or assessment shows that specific requirements of this Chapter G6-13 are inapplicable, this needs to be clearly stated in the review documentation.

A 2.2 The electrical and mechanical arrangements of the electrical supply and distribution system(s) shall be such that in the event of failures, including single and multiple failures within the electrical system itself and also including those of the Power-unit(s) or other means of driving the generators, the requirements of the safety review are met. (See G4-1, 1). An assessment shall be made of the dependence of the rotorcraft type on continuity of electrical supply to determine the possible need for additional independent supply system(s). (See G6-13, App. No. 1).

3 SYSTEM CHARACTERISTICS

3.1 The electrical equipment in the rotorcraft shall be afforded an electrical supply having the characteristics required for the normal functioning of the equipment and to suit its role and performance.

3.2 The voltage and frequency of each system shall be so regulated as to ensure the reliable and continued safe operation of all necessary equipment while operating under the normal and emergency conditions detailed in 4.

3.3 The system characteristics in regard to voltage and frequency under steady state and transient conditions shall be defined for each electrical supply system on the rotorcraft. This definition shall be used as a basis for the specification of generating and consuming systems and equipment.

NOTE: Wherever practical, the characteristics of the system should provide a power supply to utilisation equipment which conforms to the latest issue of British Standard 3G.100:Part 3.

4 SYSTEM CAPABILITY (See G6-13 App.No.1)

4.1 General

4.1.1 The primary electrical power supply or systems shall consist of a sufficient number of generator channels and primary busbars and have characteristics of nominal voltage and, where appropriate, frequency, suitable for the type and role of the rotorcraft having regard to the extent of dependence on electrical power, the nature of the loads, appropriate failure cases of Power-units or other mechanical drives, failures in other systems and failures within the electrical power supply defined in 4.3.

A | 4.1.2 Secondary electrical power supply systems shall consist of a sufficient number of conversion units, or independent power sources, and have electrical characteristics and system arrangement to achieve the objectives of 4.1.1 or the objectives appropriate to the sub-system(s) supplied.

4.1.3 The performance predicted for mechanically driven electrical generation equipment shall be compatible with the capability and reliability of the mechanical drive system comprising Power-units, auxiliary power units, conversion units from other rotorcraft power systems and where appropriate constant-speed drive units.

4.2 The continuous and overload capacity of each generator channel, each conversion unit, and each section of each electrical supply system, as well as of the system as a whole, shall be adequate to ensure the satisfactory functioning of all normal likely combinations of equipment powered from the system, having due regard to failure cases and to any unserviceability likely to be authorised in the minimum equipment list for operation of the rotorcraft.

4.3 Under each of the following failure or emergency conditions, and having regard to their possible duration and to the most onerous combinations of equipment likely to be used in the particular condition, such an electrical supply shall be afforded to equipment required to operate under each condition as will enable that equipment to function satisfactorily for the duration required (see 4.4, 4.5 and 4.6).

(a) During and after all possible combinations of failure of Power-units, from single Power-unit failure up to and including all Power-units having failed.

NOTE: The reference to failure of Power-units in 4.3(a) is primarily a reference to failure of Power-units from which generators are driven. It is not intended that the coincident failure of mechanical drive systems of fundamentally different design should be considered in association with Power-unit failure(s), unless the nature of that drive is such that its failure would be a logical consequence of Power-unit failure or would be likely to occur in circumstances of multiple Power-unit failure.

(b) Failure of any single source of electrical power (or conversion unit in the case of secondary systems).

(c) Failure of any two sources of electrical power (or conversion units) on rotorcraft having two or more Power-units.

A (d) The failure of any group of electrical power sources (or conversion units) connected to the same busbar.

(e) The total failure or temporary interruption of power from a group of sources constituting one supply system, but not necessarily connected to the same busbar, for reasons of single or multiple failures within the electrical supply system itself, including the possibility of incorrect diagnosis and mismanagement of the system by the flight crew.

(f) The inadvertent parallelling of generation sources, (or conversion units) not intended by design to be paralleled, as a result of switchgear or other faults.

(g) The loss of any one busbar.

(h) Under conditions applicable during, or after, drills for the dispersal of smoke.

(j) Under any of the above conditions, taking into account any unserviceability likely to be authorised in the minimum equipment list for operation of the rotorcraft.

4.4 In considering the failure and emergency conditions of 4.3 due regard shall be given to the following:-

(a) The provision of an adequate electrical supply to equipment required for the restarting of Power-units.

(b) The provision of an adequate electrical supply to the equipment and services which are required to make a controlled descent and landing in the event of the failure and inability to restart all Power-units. The minimum endurance for this power supply shall be 15 minutes.

(c) Delays in flight crew recognition of failures and completion of drills may be assumed to be:-

(i) Normally 10 minutes, for multiple and single source failures, where such a delay is acceptable and in order to allow the crews' primary attention to be given to other vital actions.

(ii) 5 minutes, for multiple and single source failures, provided that the failure warning system has clear and unambiguous attention-getting characteristics and where such a delay is acceptable and compatible with the crews' primary attention being given to other vital actions.

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(iii) Shorter times may only be assumed where a high priority warning is provided for a system which requires immediate restoration of electrical power for the continued safe flight of the rotorcraft and where the necessary drills can be completed rapidly.

(d) The role of the rotorcraft and the possible duration of time of flight to make a safe landing. The emergency power supply shall:-

(i) Be of sufficient endurance, and of such capacity and independence from the main electrical system, as to allow the flight to be completed and a safe landing made. (see also G6-13 App. No.1 and G4-1, 2.2*)

(ii) For time-limited supplies, have an endurance which is not less than half the rotorcraft endurance at the representative true air speed of G2-2 para. 4.1, having due regard to the delay times defined in para. 4.4(c).

NOTES: (1) This minimum endurance time is defined particularly in relation to those rotorcraft which are utilised for extended operation over water or unfriendly terrain and which may be dependent on battery power to complete a flight and make a landing in the event of interruption of all normal generated electrical power.

(2) A lower endurance time may be acceptable depending on the intended role of the rotorcraft and subject to a suitable Flight Manual Limitation.

(3) The minimum endurance time, determined by calculation or actual measurement, should be stated in the appropriate section of the Flight Manual (see also G6-13 App. No's 1, 2 and 3).

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* As contained in Paper G780.

A 4.5 It shall be shown by analysis, test, or both, that the rotorcraft is capable of operating safely under VFR conditions, initially at its maximum altitude, and with the critical type of fuel (from the standpoint of engine flame-out and restart capability) for 5 minutes with the normal electrical power system inoperative (i.e. electrical power sources excluding the main battery) prior to any flight crew action which may be required to provide the emergency supplies required to complete the flight in safety. If the main battery is used as the source of emergency power during the failure of the normal electrical power, then it shall be shown that no single malfunction, electrical or mechanical, will simultaneously affect the normal electrical power and power from the battery. (See G6-13 App. No.1, 2.6).

4.6 Where applicable an emergency electrical power supply shall be provided to meet the attitude display system requirements of G6-10, 2.4 and 2.5.

4.7 Ground Operation. The characteristics and the capacity of the electrical supply system during ground operation of the rotorcraft shall be such as to ensure the satisfactory functioning for an adequate period of the most onerous combination of apparatus likely to be supplied under this condition. Where a battery supplies some part of the power required, the characteristics of the system shall be such as to ensure that the battery is maintained in a state of charge that will ensure satisfactory operation of all equipment and also provide adequate power to enable the rotorcraft to reland in the event of a failure of generated electrical power shortly after take-off.

4.8 The electrical power supply system shall be capable of affording an adequate supply to those items of equipment required to operate during or following an emergency alighting on land or water including any required Emergency Lighting. The circuits to these services shall be so designed and protected that the risk of their causing a fire, under these conditions, is minimised.

5 LOAD ANALYSES (See G6-13 App. No.3)

5.1 Load analyses shall be prepared giving details of the maximum continuous electrical power and the maximum demand needed to ensure compliance with 4. Account shall be taken in the analyses, of the equipment required to operate under normal and emergency conditions.

5.2 When any additions, either temporary or permanent, are made, reference shall be made to these load analyses to ensure that, under the new loading conditions, the requirements of 4 are still met.

A 6 EARTHING OF SUPPLY SYSTEM

6.1 Earthing arrangements shall comply with the requirements of G6-14,6.3.

6.2 The failure of a single earth connection shall not cause the loss or malfunctioning of more than one source of electrical supply or more than one busbar.

6.3 Electrical supplies of different characteristics (e.g. voltage and frequency) shall be connected to separate earth points unless it can be established that the joining of the circuits with the earth disconnected will not produce more than a Minor Effect.

7 GENERATORS

7.1 Rating. Generators shall be so designed and installed as to meet the requirements of 4 at all the appropriate generator speeds corresponding to rotorcraft operating conditions.

7.2 Excitation. Generators shall, when used in conjunction with their appropriate control equipment, be capable of building up their output voltage and connection to their busbar, without the need of a supply separate from the machine.

7.3 Cooling

7.3.1 The cooling installation for the generator system shall be effective for all conditions for which the rotorcraft is certificated including overload operation under emergency conditions and any ground manoeuvres. (See also G5-4).

7.3.2 Effluent air shall be so discharged that it does not constitute a fire risk even under generator fault conditions (e.g. bearing failure).

7.3.3 The cooling installation shall not be liable to inadvertent damage and the intake shall be so situated that it does not, even under fault conditions, collect such Flammable fluids as will endanger the rotorcraft. Precautions shall be taken to prevent the accumulation of water, snow and ice in the cooling system.

NOTE: G5-5,* gives requirements for de-icing and anti-icing precautions for air intake systems.

*As in Working Draft Paper G610

A 7.3.4 Where fluid cooling media or heat exchangers are used, the risk of Catastrophe resulting from ignition of the cooling agent shall be Extremely Improbable. Unless the adverse effects of the loss of such cooling media from any generator cooling system are confined to that particular generator channel the effects and probability of occurrence shall be declared. There shall be no hazardous physical or chemical deterioration of the cooling media.

8 SUPPLY AND DISTRIBUTION SYSTEMS - EQUIPMENT AND CIRCUITS (See G6-13 App. Nos. 1, 3 & 4)

8.1 The electrical supply system shall be so designed that each of the sources of electrical supply functions properly, both when connected in combination and independently.

8.2 To ensure compliance with the system characteristics of 3, means shall be provided to maintain the voltage and frequency within the required limits.

8.3 The electrical and mechanical arrangements for each source of electrical supply, its associated wiring and control equipment and circuits, and the arrangement and sub-division of busbars shall be such that no failure which is more probable than Extremely Remote, will:-

(a) cause any hazardous malfunction or the loss of more than the particular source of electrical supply or major busbar which the failure affects, and/or

(b) cause any dangerous effects in circuits other than that in which the failure occurs.

8.4 The protective and controlling devices shall be such as to de-energise and disconnect faulty sources of electrical supply from their associated system with sufficient rapidity to prevent dangerous malfunctioning of the system, but shall not cause nuisance disconnects due to transients caused by normal system operation. (See also 8.5 and Section C Chapter C3-2, 3.1.3 and G4-9).

8.5 Isolation. Means shall be provided for such individual isolation of sources of electrical supply from the main busbar(s) as are necessary for the tracing and isolation of major faults. These means and all other protective and controlling devices which are under the control of the flight crew shall be available to the appropriate flight crew members in their normal seated positions, and so located that they can be operated with sufficient rapidity in the case of an emergency.

A (a) A switch, directly or remotely operated, shall be provided to isolate the battery from the electrical system irrespective of whether the system is wholly or partly dependent on the battery. This switch shall be so located, or guarded, as to render its inadvertent operation unlikely. Any load circuits which are required to remain connected to the battery after its isolation from the main electrical system (e.g. those required by G6-14,6.9.2) shall be limited in number and protected by suitable circuit protective devices located adjacent to the battery.

(b) Means shall be provided to ensure that the battery cannot be connected inadvertently to an external source of supply.

8.6 Resetting

(a) It shall be possible in flight to make at least one restoration or resetting of any protective device in the electrical supply system, unless the probability of its inadvertent operation is Remote, and/or its operation would lead only to a Minor Effect.

(b) It shall not be possible to override the operation of the protective device when an overload or circuit fault exists.

8.7 Warning Devices. For each source of electrical power, clear and unmistakable warning of failure shall be given to the flight crew to enable them to take the appropriate action within a suitable period, (see also 4.4).

8.8 Indicating Equipment. Such instruments shall be provided as are necessary to enable the appropriate flight crew members to determine those generating system quantities which are essential for the safe operation of the system, to assist the flight crew in the correct operation of the facilities provided for 8.5 and to take such action as is required to meet 4.4.

9 BATTERIES (See G6-13 App.No.4,4)

9.1 Batteries shall have such characteristics and be so installed that for all the operating conditions and manoeuvres for which the rotorcraft is certificated:-

(a) they are capable of supplying the electrical power required for the normal and emergency conditions described in 4,

A (b) they do not constitute a danger to the rotorcraft or to the occupants,

(c) they, and their compartments are adequately ventilated, and sealed to prevent escape of electrolyte and gases to the interior of the rotorcraft and

(d) unless it can be shown not to be necessary, the battery case or the battery compartment(s) is located, and constructed of suitable materials, such as to contain safely any fire or explosion which may occur within it.

9.2 Account shall be taken of any normal deterioration of the battery which may take place during service or operational life, and of the physical environment in which the batteries are located.

9.3 Means shall be provided to minimise the risk of overcharging or overheating of batteries.

9.4 For nickel-cadmium batteries used for engine or APU starting, and/or as part of the main power supply system, an overheat warning at the flight crew compartment shall be provided unless an automatic charge control system provided to meet 9.3 affords an equivalent level of safety.

9.5 Metal-cased batteries shall be electrically insulated from the airframe structure. Where bonding to earth of the case is necessary for other reasons, the connection shall be made through a fusible element.

10 DISTRIBUTION

10.1 The arrangment, protection and control of the feeders from the busbar(s) to the distribution points, and the division of loads among the feeders, shall be such that no single failure or combination of failures which is more probable than Extremely Remote, occurring in any feeder, group of feeders, or associated control circuit can cause Hazardous Effects.

10.2 Where electrical services are multiplicated in order to comply with the requirements, their loads shall be distributed between different busbars and/or different feeders and shall be routed separately to the maximum extent practical. (See also G6-14, 6.2.1).

A 10.3 Where duplicate electrical power supplies for particular items of equipment are prescribed in the Requirements, these shall be derived from different busbars. If, in addition to duplicated electrical power, duplicated feeders are necessary to limit the possibility of physical damage due to, for example, fire or mechanical damage from non-containment of debris from high energy rotating parts, then such feeders shall be routed separately. Where multiple power supply systems are provided to meet 2.2 and 4.3 or 4.4, due account shall be taken of the need for the duplicate power supplies to be derived from different systems.

11 MECHANICAL PROTECTION OF LIVE PARTS OF THE SUPPLY AND DISTRIBUTION SYSTEM (See also G6-14, 7.1) Live parts shall be so mechanically protected that the probability of short circuits and earth faults is Extremely Remote.

12 FLUID AND VAPOUR CONTAMINATION (See G6-14, 6.5)

13 ELECTRICAL AND MAGNETIC INTERFERENCE (See also G6-14, 6.8). Any conducted or radiated interference present in the rotorcraft due to the operation of generation or utilisation equipment shall not result in a Catastrophe or Major Effects upon the system required by this or other Chapters. All practical steps shall be taken to minimise the hazardous effects of a lightning discharge through, or static discharges from, the rotorcraft (see G4-6).

14 GENERAL INSTALLATIONAL REQUIREMENTS The requirements of G6-14, 6.5 Precautions against Deterioration, 6.6 Precautions against Fire and Explosion, 6.7 Precautions against Injury and 6.9 Crash Fire Precautions shall apply in so far as they are appropriate to the electrical supply and distribution system.

15 TESTS (See G6-13 App. No.2 and G6-14, 6.10)

15.1 Ground Tests. Tests shall be made to establish, as far as is practicable the satisfactory collective performance of equipment comprising a functional system, in order to confirm that the individual components of the system are correctly related to each other and to the duty which the system is required to perform. Such tests shall be made with an equivalent standard of equipment as used in the rotorcraft under conditions which simulate the various flight and ground conditions of the rotorcraft.

15.2 Flight Tests. To confirm the system performance in flight and to test those parts of the system where the conditions of flight have not been adequately simulated during the ground tests of 15.1, tests under prescribed conditions of flight shall be made using a suitably instrumented test rotorcraft.

APPENDIX NO.1 TO CHAPTER G6-13

SYSTEMS RELIABILITY

1 INTRODUCTION (See G6-13, 2 and 4)

1.1 This Appendix describes acceptable methods of compliance with G6-13,2 and 4, and the general system requirements with particular reference to electrical supply and distribution systems. Other methods are acceptable, as long as an equivalent level of safety is achieved, see G1-1, 4.1. In addition, examples are given of faults which have led to electrical system failures.

1.2 For the purpose of this Appendix only, rotorcraft are classified as in (a) to (c):-

(a) Class P rotorcraft in which loss of electrical supply will result in a Catastrophe (e.g. those rotorcraft which are vitally dependent on electrically-powered flight control and stabilisation systems).

(b) Class Q rotorcraft in which a continued loss of electrical supply may result in Hazardous or Major Effects (e.g. where substantially uninterrupted power supplies are required for flight instruments, such as attitude and altitude indicators, for Power-plant control systems and communication and navigation systems).

(c) Class S rotorcraft in which the loss of the electrical supply results only in Minor Effects.

2 ALL ROTORCRAFT

2.1 The duration of power available from emergency sources should, in addition to meeting the requirements of G6-13, 4.3 to 4.7, take into account the operational requirements for the particular rotorcraft (e.g. single engine endurance on a twin-engined rotorcraft and any time required for necessary flight crew action to be taken).

2.2 Due account should be taken, when considering the requirements for the provision of emergency electrical supplies, of any unserviceability in the normal electrical supply system which may be authorised in the minimum equipment list for the operation of the rotorcraft.

2.3 Means independent of the main generating system should be provided for the restarting in sequence of all main Power-units and of any driven sources of emergency power.

2.4 Arrangements should be made so that in the event of failure of all rotorcraft Power-units, sufficient electrical supply is available to those services required to maintain control of the rotorcraft during its descent and landing (e.g. from the transmission or separately driven auxiliary generators or from batteries).

2.5 In considering those loads which, under emergency conditions, require electrical power to enable the flight to be completed and a safe landing made, the following should be included:-

(a) Attitude information.

(b) Essential radio communication.

(c) Essential navigation or direction finding equipment.

(d) Essential cockpit lighting.

(e) Pitot head heating, where air speed or altitude information are essential.

(f) Any other services essential for continued safe flight or landing of the particular rotorcraft, such as emergency flotation equipment.

2.6 In meeting the requirements of G6-13, 4.5 it is recognised that, under certain critical conditions, an engine or engines may flame out. This is acceptable if:-

(a) The relight capability of the engines is guaranteed.

(b) No hazard will ensue during the period prior to relight, and

(c) All services necessary for such a relight are available under the specified conditions.

3 CLASS P ROTORCRAFT

3.1 Provision should be made such that in the event of the loss of all main generated power, adequate electrical power is available from a source, electrically and mechanically independent of and separated from, the main generation system, to enable the flight to be continued safely to its destination or an alternative landing ground. Such auxiliary power sources (e.g. transmission or A.P.U. driven generators) should provide adequate power and endurance to supply the required loads under likely combinations of environmental and rotorcraft range conditions.

3.2 The rotorcraft loads should be divided between two or more electrical systems which can be separated from each other in such a way that the failure of any one electrical system can be sustained for the duration of the flight without endangering the rotorcraft. These electrical systems should be so electrically and mechanically separated from one another that no single event, including the cutting of a cable bundle or the loss of a junction box, which the rotorcraft would otherwise survive, is likely to cause a loss of electrical supply which may lead to a Catastrophe.

4 CLASS Q ROTORCRAFT

4.1 Arrangements should be made so that in the event of a major fault in the main electrical system sufficient services can still be supplied to enable the flight to be completed in safety. For example, where a service is duplicated for reasons of safety then no fault in the system should cause the permanent loss of both the means of operation of the service. Similarly, where an emergency means of operating a service is provided, no fault should cause the permanent loss of both the main and emergency means of operation.

4.2 Three examples of methods by which 4.1 may be achieved are given in (a), (b) and (c). The method used will depend on the size of the electrical loads and their probable duration.

(a) Division of System. In the event of a major fault the electrical system may be divided into at least two parts. The sustained loss of any part should not endanger the rotorcraft for the duration of the flight.

(i) The separate systems should be so electrically and mechanically separated from one another that no single event, other than an Extremely Remote one, will lose all the systems.

(ii) It is important that the system be so designed that the separation of the two parts does not depend upon the use of equipment which could be concerned in the initial failure, and such that a failure cannot affect more than one part.

(iii) The equipment used for dividing the system should be of simple and robust construction and it should be possible to select the division manually even if automatic features are embodied.

(iv) In such systems, indication should be given of the correct functioning of each part.

(b) Regaining of Main Generators. In the event of a major loss of electrical power, provision may be made to regain the output from one or more main generators using separate control and switching arrangements on the generator side of the main busbars. It should be shown that no failure, other than an Extremely Remote one, will lose both the main system and the alternative means of control and distribution.

(c) Provision of Emergency Systems. In the event of a major loss of electrical power, an emergency electrical system may be used to supply those services necessary to complete the flight in safety.

(i) The emergency system should not be dependent on equipment or circuits which may have been damaged or made inoperative by the failure of the main system.

(ii) The source of supply for the emergency system will depend on the size and duration of the loads. A storage battery may be used when the total energy required is relatively small; in such cases the battery should be connected so that it will not be discharged to any serious extent except by deliberate selection of the emergency system.

5 CLASS S ROTORCRAFT No separate emergency supply would normally be required, unless the particular conditions under which the rotorcraft is to be flown (e.g. IMC conditions) alters the requirements for instruments or other equipment.

6 MALFUNCTIONS AND FAILURES

6.1 Definition. For the purpose of this Chapter a Probable Malfunction is defined as any single electrical or mechanical malfunction or failure within a rotorcraft electrical system which is considered probable on the basis of past service experience with similar components in rotorcraft applications. The definition should be extended to multiple malfunctions when:-

(a) the first malfunction would not be detected during normal operation, including periodic checks which are carried out, the intervals between which are consistent with the degree of hazard involved, or

(b) the first malfunction would inevitably lead to other malfunctioning.

6.2 The following are examples of failures and malfunctions (some of which have occurred a number of times) which have led to a complete loss of electrical supply on rotorcraft. These at least, should be included in investigations into Probable Malfunctions:-

(a) Consecutive failures of generators, on two-generator rotorcraft including cases of reversed polarity and of consecutive failures of shear or quill shafts.

(b) Sticking of unprotected starter relays.

(c) Over-voltage causing damage to the whole of the system.

(d) Busbar faults (short circuit, open circuit and the effects of loose connections of heavy duty cables and switchgear on the busbar).

(e) Consecutive operation of forward protection devices (e.g. fuses and thermal circuit breakers).

(f) Instability of system with battery disconnected.

(g) Single fault affecting the control system of more than one generator (e.g. fault between adjacent terminals, fault to equalising system).

(h) Faulty protective gear.

(j) Flight crew error in switching off the wrong generator, or the battery.

(k) Fault in the secondary system in rotorcraft in which primary and secondary systems are interdependent.

(l) The use of unsuitable insulation materials not capable of withstanding the temperature of fault as well as normal operating conditions. In a number of cases, the use of insulating materials capable of ignition and subsequently supporting combustion under electrical fault conditions.

(m) The presence of foreign objects in vital parts of the electrical system.

(n) The impingement of quantities of hot air or gases on vital parts of the electrical system resulting from failures in Power-units or ducts.

(o) Common maintenance errors which result in the loss of more than one power supply.

APPENDIX NO.2 TO CHAPTER G6-13

GROUND AND FLIGHT TESTS

1 INTRODUCTION This Appendix gives guidance on the tests which should be carried out to meet the requirements of G6-13, 15.

2 GENERAL Sufficient tests should be made, on the ground or in flight as appropriate, to determine that the performance of the electrical supply system meets the declared characteristics of G6-13, 3.3, under all the appropriate normal and emergency conditions required by G6-13,4. Due account should be taken in these tests of load switching and flight crew operation of the system.

3 GROUND TESTS

3.1 All tests should be carried out with equipment as representative as possible of the actual rotorcraft. In particular, the simulation should include the correct representation of rotorcraft cables in size, length and impedance, the correct ground (airframe) impedance and their correct relative location and location to other cables or systems that could influence performance. Consumer loads and the generator drive system should also be correctly simulated.

3.2 The tests may be carried out on representative laboratory rigs or in an actual rotorcraft as appropriate.

3.3 Schedules should be prepared to cover the conditions of the tests.

4 FLIGHT TESTS

4.1 If not fully covered by ground testing, such flight tests should be carried out as are necessary to meet 2.

4.2 Temperature tests should be carried out on equipment where the operation of the cooling media is dependent upon the motion of the rotorcraft.

4.3 Measurements should be made to ensure that all equipment, particularly the rotorcraft battery, is operating within its specified environmental conditions.

4.4 Schedules should be prepared to cover the conditions of the tests.

APPENDIX NO.3 TO CHAPTER G6-13

ELECTRICAL LOAD ANALYSES

1 INTRODUCTION

1.1 This Appendix describes acceptable methods of preparing the electrical load analyses and summaries prescribed in G6-13, 5. Other methods are acceptable as long as the equivalent information is provided, see G1-1, 4.1.

1.2 The purpose of the load analysis is to demonstrate the system capacity needed to supply the most onerous combinations of electrical loads and it achieves this by evaluating the average and maximum demands under various conditions of flight. The purpose of the summary is to relate the load analyses to the system capacity and probable duration of the various normal and emergency conditions, and to draw attention to any limitations, with particular reference to future in-service use and possible modifications to, and additions of, equipment.

1.3 Guidance is given below upon the factors which should be taken into account when preparing the load analyses for both AC and DC systems under normal and emergency conditions. This list of factors involved should not be considered exhaustive and it is the responsibility of the designers concerned to ensure that the analyses take into account all the variables covering the type of system used and the particular rotorcraft roles.

1.4 If, in the estimation of maximum demand, the assumption is made that all the loads for each operating condition are switched on at the same time, each load remaining on for its appropriate operating period, then a value, probably well in excess of the actual maximum demand ever achieved on the rotorcraft, will be used. This assumption does however avoid the difficulty of determining which loads will not be operated simultaneously. In cases where suitable provision has been made to ensure that certain loads cannot simultaneously operate or where there is adequate reason for assuming that certain combinations of load are not likely to occur, appropriate allowances may be made; in such cases adequate explanation should be given in the summary. When considering intermittent loads, average currents may, in general, be used. Checks should however be made, using RMS values, to ensure that these average currents are sufficiently accurate.

1.5 The analyses should indicate the conditions and periods of flight for which the equipment is required.

2 NORMAL CONDITIONS

2.1 The analyses should cover the electrical loading conditions appropriate to the various conditions of flight, e.g. take-off, cruise and landing for both day and night conditions, taking into account any additional loads, such as de-icing, when required.

2.2 The analyses should also identify permissible unserviceability recognised and likely to be authorised in the minimum equipment list during the certification of the rotorcraft and should include calculations appropriate to these cases.

2.3 For 3-phase AC systems the phase loads should be considered individually and in total.

2.4 The effect of parallelled and/or non-parallelled operation should be covered for generation systems as applicable.

2.5 The individual currents for each equipment or system, with phase values and power factors if appropriate, should be stated in the analyses with the number of such equipments and the time of operation to enable total loading to be assessed.

2.6 When considering short term loads, RMS currents may be used to determine the heating effects upon generators which are capable of carrying overload currents for limited periods. However for generators which have no overload capacity and which may suffer a voltage collapse if overloaded, due account should be taken of the total current possible at any time. (See also 1.4).

2.7 The analyses may be used to calculate and record the voltage drop to consumer equipment.

3 EMERGENCY CONDITIONS

3.1 The analyses should cover all possible combinations of power source failure, including complete loss of power from the normal generation sources and take into account any unserviceability likely to be authorised in the minimum equipment lists.

3.2 The analyses should take into account both automatic and manual load shedding and in the latter case due account should be made for the time taken to initiate such load shedding (see G6-13, 4.4).

3.3 For rotorcraft using a battery to meet the requirements of G6-13,4, an analysis should be provided of the load required from the battery in order to determine the time available for supply of these required loads. This analysis should take into account the minimum voltage acceptable for the required loads, the battery state of charge, the minimum capacity permitted during service life and the battery efficiency at the discharge rates and temperatures likely to be experienced.

NOTE: For the purposes of calculation, a battery capacity, at normal ambient conditions, of 80% of the nameplate rated capacity at the 1 hour rate and a 90% state of charge may be assumed (i.e. 72% of nominal capacity).

3.4 For any other emergency sources of electrical power, analyses are required which should define and take into account any limitation, such as endurance, rotorcraft altitude and speed, which may affect the capabilities of the power source.

4 LOAD SUMMARIES

4.1 Load summaries should be prepared, based upon the detailed load analyses, giving total loads upon the rotorcraft power sources and major sub systems under both normal and emergency conditions. For AC systems these summaries should include power factor and phase loadings.

4.2 These theoretical analyses may be verified by ground and/or flight tests.

APPENDIX NO.4 TO CHAPTER G6-13

GENERATOR SWITCHGEAR AND BATTERY INSTALLATION

1 INTRODUCTION This Appendix describes acceptable methods of complying with the requirements of G6-13,9 and 10. Other methods are acceptable as long as an equivalent level of safety is achieved, see G1-1, 4.1.

2 SUPPLY SYSTEM CONTROL - EQUIPMENT AND CIRCUITS (See G6-13,8)

2.1 Isolation. For each generator, means should be provided for its independent and rapid electrical disconnection from the system. When disconnected its voltage should be controlled to a safe value. The controls provided for disconnection should be grouped together for each section of the busbar system so that any busbar section can be rapidly selected for disconnection from power sources without confusion. The resetting requirements of G6-13, 8.6 should also be met by this generator control system.

2.2 Load Sharing. Means should be provided to ensure the sharing of load between generators in parallel. The tolerances on load sharing will have to be taken into account in meeting the requirements of G6-13, 4. Where generators are not normally connected in parallel, transfer arrangements may be made to ensure satisfactory operation following a failure.

2.3 Provision of Protective Devices

2.3.1 Short-circuit Protection - Generators

(a) Means should be provided to protect the generators and associated feeders.

(b) Individual protection should be provided for each generator circuit so that any dangerous short circuit which occurs on that circuit will result in its disconnection and de-energisation without adverse effect upon the operation of other generator circuits.

(c) The protective devices should be so designed and installed that they will not operate under any acceptable overload conditions which are applied at the main busbar.

2.3.2 Protection of Busbars

(a) The main and distribution busbars should be arranged, located and/or protected so that no failure (other than an Extremely Remote one), which can arise within the busbar system or an Event affecting the rotorcraft can cause a loss of electricity supply or of services which may lead to a Hazardous Effect.

NOTE: See also G6-13 App. No. 1 and 3

(b) Busbars should be limited in extent and only those devices essential for the protection of feeders and electrical supply system circuits should be connected to them. These protective devices should be free from any danger of short circuits in themselves. The busbar system should have no externally exposed conducting surfaces.

2.3.3 Protection Against Excess Voltage

(a) Where failure of voltage regulating equipment, or a fault in an associated circuit, may produce an over-voltage condition such as to disturb significantly the operation of the electrical supply system, provision should be made to limit this voltage to a safe value or to disconnect the generator circuit concerned. Where necessary the correct regulation of a generator voltage should be assessed prior to its connection to a busbar. Particular care should be taken to limit other than transient effects of such faults to the affected channel and thus other generating channels which may be operating in parallel with it should remain unaffected after fault clearance.

(b) Transient voltages which may have an adverse effect on the operation of equipment which is necessary for rotorcraft safety should be kept to an acceptable minimum and equipment should be so designed as to be capable of withstanding any such transient voltages which may be applied to them. (see G6-13, 3.3).

2.3.4 Protection against Reverse Current. Where a generator is so connnected that reverse power conditions can occur, automatic means should be provided for opening the generator circuit under such conditions before a hazard can occur.

2.3.5 Protection against Incorrect Phase Sequence. Provision should be made to prevent a supply of incorrect phase sequence being connected to a busbar.

2.3.6 Connection of rotorcraft to Ground Power Supplies. Where means are provided to enable a ground power source to be connected to the rotorcraft system, it is desirable that protection be provided, in the rotorcraft to prevent damage to the rotorcraft or its systems, from incorrect polarity, incorrect phase sequence, open circuit line, incorrect frequency or over-voltage and under-voltage of the ground power source.

3 WARNING AND INDICATING APPARATUS (See G6-13, 8)

3.1 Supply Failure. The supply failure warning may consist of a single warning for the whole system coupled with a series of devices which will indicate the state of each source of electrical power, and each secondary system conversion unit. For multiphase systems the warning should also sense or detect the loss of any phase. The warning should be automatically cancelled when corrective action is taken. The single warning may be cancelled by the flight crew.

3.2 D C Systems. It should be possible to measure, with the instruments normally provided in the rotorcraft the voltage and current supplied by each generator and the voltage at the busbar.

3.3 A C Systems

3.3.1 Parallelled Systems. It should be possible to measure, with the instruments normally provided in the rotorcraft, the RMS voltage and the real and reactive power supplied by each source of electrical power in addition to the RMS voltage at the busbar.

3.3.2 Non-parallelled Systems. It should be possible to measure with the instruments normally provided in the rotorcraft the RMS voltage and RMS line current supplied by each source of electrical power.

3.3.3 Frequency. Where the control of frequency is important, means should be provided for measuring the frequency of the output of each generator.

3.4 Self-regulated Systems. In the case of self-regulated generators, an ammeter should be connected permanently in the battery circuit.

4 BATTERIES (see G6-13, 9)

4.1 General

4.1.1 Battery terminal arrangements should be such as to obviate the possibility of incorrect connection.

4.1.2 Battery containers should be constructed of impervious and non-flammable material. Where metal containers are employed these should be coated with an anti-corrosive, non-conducting material to minimise the risk of internal short circuits.

4.2 Charging. Precautions should be taken, in the arrangements for charging batteries in the rotorcraft to prevent abnormal conditions of charging.

NOTE: Such conditions can cause loss of electrolyte, accumulation of gas and excessive temperature of plates or electrolyte, and thermal instability of the battery, with possible fire and smoke hazards.

4.3 Installation

4.3.1 Location. Batteries and their containers should be securely fixed in positions such that they are easily accessible for inspection, replacement and necessary tests.

4.3.2 Temperature of Electrolyte. The installation and method of cooling should ensure that, under operating conditions, the temperature of the electrolyte is maintained within the limits necessary for satisfactory operation.

4.3.3 Ventilation. Ventilation adequate for the prevention of dangerous concentrations of ignitable or toxic gases should be provided for the battery and the compartment in which batteries are installed. These arrangements should take account of the quantities of gas likely to be released under conditions of thermal instability of the battery, and of ground charging (where applicable).

4.3.4 Corrosion. Precautions should be taken to prevent corrosion of the rotorcraft structure or other equipment by battery fluids and vapours. (see also G4-1, 8)

CHAPTER G6-14 UTILISATION AND INSTALLATION OF ELECTRICALLY OPERATED SYSTEMS AND EQUIPMENT

A 1 INTRODUCTION This Chapter states the requirements governing the the following:-

(a) Circuit controls and devices for circuit protection.

(b) General design, installation and testing standards required for electrical circuits, systems and equipment.

(c) Installations where particular requirements are necessary (e.g. cables, domestic equipment).

2 ELECTRICAL SYSTEMS - RELIABILITY AND MALFUNCTIONING

2.1 Each electrical system and the equipment associated with it shall be so designed and installed that it will not jeopardise the safety of the rotorcraft or its occupants, under any operating conditions for which the rotorcraft is certificated,

(a) when subject to a single failure or combination of failures which is not Extremely Remote,

(b) when subject to the conditions which could be imposed on it as a result of a Failure Condition in another system in the rotorcraft,

(c) when operating normally.

NOTES: (1) The failures required to be taken into account in this Chapter are those in electrically operated systems and equipment and in other associated systems and equipment. However, where relevant, requirements relating to failures elsewhere in the rotorcraft will also need to be taken into account (e.g. debris from high energy rotating parts, bird strikes).

(2) This requirement may entail the provision of duplicate or emergency systems depending on the type of hazard likely to result from malfunction or failure.

A 2.2 A fault analysis shall be prepared for each electrical system and the equipment associated with it for which it is not clear from examination or by simple test that the requirements of 2.1 have been met.

3 CIRCUIT FAULT CONTROL

3.1 Control and circuit arrangements shall be such that faults result in the condition of least danger to the rotorcraft and its occupants.

3.2 Manual or automatic means shall be provided for opening non-essential and other circuits where their continued operation in the event of fault conditions would be detrimental to the operation of circuits essential to airworthiness. Where manual means are employed suitable instructions shall be given to the flight crew.

3.3 It shall not be possible in flight to override the functioning of installed circuit breakers in cases where such overriding would enable an overload or circuit fault to persist (e.g. the circuit breakers should be of the 'trip-free' type).

4 CIRCUIT INTERLOCKING

4.1 The electrical position of switches in circuits shall be chosen in relation to the load and the supply so as to provide the maximum degree of safety.

4.2 For all electrical circuits, means shall be provided to minimise the possibility of inadvertent operation, if such operation would cause more than a Minor Effect.

4.3 If a circuit or group of circuits is switched off and then re-established the re-establishment shall not result in more than a Minor Effect.

NOTE: The means of switching should include those switches available. to the crew and any automatic switches in the circuits including interlocks.

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5 PROTECTION OF CIRCUITS AND EQUIPMENT

5.1 Circuit Protection

5.1.1 All electrical circuits shall be protected against excessive overloads and short circuits by means of suitable current-sensitive devices. Overcurrent protective devices shall be so arranged that when the current in any circuit exceeds the rated current to a dangerous extent, the current will be cut off automatically from that circuit.

5.1.2 For circuits where protection by a current-sensitive device is impracticable (e.g. engine or APU starter circuits) and where failure to open of the circuit control switch or contactor could result in overheating of electrical cables or components (e.g. starter motor) means shall be provided to enable the circuit involved, following such a failure, to be identified and isolated.

5.1.3 Every circuit or group of circuits shall be protected in such a way that a fault in the circuit(s) will not create a fire or smoke hazard. Where a single device protects more than one circuit the rating of the device and the circuit cables shall be such as to ensure freedom from fire or smoke hazard on all connected circuits (see also 6.6).

5.1.4

(a) The protective devices associated with circuits and equipment which may affect airworthiness and those associated with emergency systems, shall be so designed, located and identified that they are capable of being reset rapidly at least once, after automatic operation, when the rotorcraft is in flight.

(b) It shall not be possible to override the operation of the protective device when an overload or circuit fault exists.

5.2 Fault Protection Discrimination

5.2.1 Unless it occurs as a result of a multiple failure, the operation of any single protective device shall not produce more than a Minor Effect.

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5.2.2 Circuit protective devices shall be so arranged that the probability of circuits which affect airworthiness being disconnected automatically in consequence of a fault in any other circuit is Extremely Remote. Additionally, they shall be so arranged that the probability of circuits or group of circuits not directly affecting airworthiness being disconnected automatically in such a way as to produce more than a Minor Effect in consequence of a fault in any other circuit is Improbable.

5.2.3 Graded Protection. The performance of protective devices (including tolerances) shall be graded throughout the system so that under overload or fault conditions the protective device nearest to the fault and on the supply side of it, will operate first.

5.2.4 Separately Protected Parallel Feeders. Where, to improve integrity, separately protected parallel feeders are employed, the discrimination of the protective devices shall where possible, be such as to cause automatic isolation of only that feeder with which the fault is associated.

5.3 Protection of Equipment. Where overloading of equipment can present a danger because of overheating, the operating characteristics of the protective device shall be correctly related to the characteristics of the equipment it is protecting.

6 GENERAL REQUIREMENTS FOR THE INSTALLATION OF SYSTEMS AND EQUIPMENT

6.1 Design of Equipment

6.1.1 Parts and equipment essential to airworthiness shall conform to an approved specification and shall be subject to the procedures of Section A Chapter A3-3. British Standard Specifications of the 'E' and 'G' (Aeroplane) series are approved as being appropriate to rotorcraft electrical parts and equipment.

6.1.2 Parts and Equipment not essential to airworthiness shall be suitable for their intended use in the rotorcraft environment and those features of such parts and equipment which may affect airworthiness (e.g. risk of fire, smoke, electrical or magnetic interference) shall be controlled by the Applicant to a standard which ensures compliance with the relevant requirements of this Section.

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6.2 Segregation of Services (See G6-14, App. No.1)

6.2.1 Wherever the equipment which is necessary for the fulfilment of an essential function is multiplicated in order to achieve the necessary standard of airworthiness, such multiplication shall be so electrically and mechanically discrete that the probability of any failure or Event which can cause failure of the function is Remote.

6.2.2 Cables for different types of duty (e.g. general services DC, general services AC, radio navigation) shall be so installed as to meet the electrical and magnetic interference requirements of G6-13,13 and this Chapter. Such cables shall also be so installed as to avoid the risk of:-

confusion during maintenance or repair,

electrical contact, or

dangerous electro-magnetic coupling.

6.2.3 Electrical connections shall be so arranged as to limit the possibility of cross connections during servicing and maintenance. Where such cross connections could result in Major Effects, means shall be provided to minimise such an occurrence.

6.2.4 Cables shall be so routed as to minimise the risk in the event of an over-current fault or local heating or arcing, combined with the failure to operate of the protecting device.

6.3 Earthing Arrangements (see also G6-13,6)

6.3.1 The earthing arrangements shall comply with the requirements of G4-6, Electrical Bonding and Lightning Discharge Protection.

6.3.2 When an earthed system is used the earth path shall be electrically continuous and the resistance between any two points in the earth path shall remain substantially constant. The earth path shall be adequate for the conduction of any current, including possible fault currents, which it may be necessary to transmit.

6.3.3 The failure of any single earth connection shall not result in more than a Minor Effect.

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6.3.4 The requirements of G6-13, 6.3 shall apply insofar as they are appropriate to systems and equipment.

6.3.5 The probability of hazardous damage to Primary Structure by the failure or corrosion of any earth connection shall be Extremely Remote.

6.3.6 Where a system using voltages of greater than 50 volts RMS is employed, all domestic equipment (e.g. cooking appliances, refrigerators) shall be provided with suitable earth terminals to which non-current-carrying metal parts of the appliances shall be effectively bonded and which shall themselves be effectively connected to the rotorcraft structure or bonding system.

6.4 Precautions against Mechanical Damage (See also 7.1)

6.4.1 Systems and equipment shall be installed so that, under normal conditions, they will not be exposed to the risk of mechanical damage.

6.4.2 Exposed live parts of systems and equipment shall be so mechanically protected that the probability of short circuits and earth faults is Remote.

6.5 Precautions against Deterioration

6.5.1 Precautions shall be taken to minimise deterioration and the possibility of failure of equipment as a result of conditions encountered in service. Equipment shall be suitable for the environmental conditions applied to them (which shall be specified by the rotorcraft constructor) and shall, so far as practicable, be installed in positions protected from the weather. Precautions shall be taken to ensure that any fluid in vapour, mist or liquid form likely to be encountered in the position in which the equipment is installed, has no dangerously adverse effect.

6.5.2 Particular attention shall be paid to the installation of electrical equipment relative to the position of the rotorcraft water system, galleys, toilets, doors and openable windows and protection shall be applied against water ingress, leakage and spillage where necessary.

6.5.3 Equipment shall be so installed and located that it is not subject to dangerous deterioration due to heat effects including hot air, under both normal and fault conditions.

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6.5.4 The specification referred to in 6.1 shall include requirements for all the environmental and installational conditions likely to be met on the rotorcraft.

6.5.5 Precautions taken against deterioration shall be consistent with G4-1, 8.

6.5.6 All electrical connections liable to vibration or contamination by fluids shall be of such a nature that the vibration or contamination does not cause dangerous deterioration of the installation, assuming that regular inspections are made to an agreed maintenance schedule.

6.6 Precautions against Fire and Explosion

6.6.1 Electrical equipment shall be so designed and installed that, under the normal or emergency operating conditions for which the rotorcraft and its systems are certificated, it will not create a fire hazard.

6.6.2 Electrical equipment in regions immediately adjacent to fire-walls shall be of such materials and at such a distance from the firewall, that they will not suffer damage that could hazard the rotorcraft if the surface of the firewall adjacent to the fire is heated to 1100°C for 15 minutes.

NOTE: The requirements of G5-8 may make it necessary for electrical equipment to be made Fire-resistant or Fireproof as appropriate and tests made to demonstrate these qualities.

6.6.3 All electrical equipment including cables and their accessories shall, as far as is practicable, be constructed of materials which do not support combustion and which meet the relevant requirements of CAA Airworthiness Division Specification No.8 "Flame Resistance Testing for Aircraft Interior Materials". Other materials shall be so applied and/or protected that the risk of fire is not increased by their use. (See also G4-3, 9).

NOTE: In cases where air is blown through equipment the danger of fire may be increased because of the increased rate of combustion and the length of the flame. Particular care should be taken in the choice of materials for such applications.

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6.6.4 Electrical equipment shall be so constructed and/or installed that in the event of failure, no hazardous quantities of toxic or noxious products (e.g. smoke) will be distributed in the crew or passenger compartments.

6.6.5 Precautions shall be taken to prevent any Flammable material from coming into contact with any portion of electrical equipment which may attain a temperature exceeding 200°C under either normal or fault conditions.

6.6.6 Electrical equipment, which may come in contact with Flammable vapours shall be so designed and installed as to minimise the risk of the vapours igniting and exploding under both normal and fault conditions.

NOTE: An acceptable method of meeting this requirement is to comply with the appropriate explosion proof categories given in British Standard 3G100, Part 2, Section 3, Sub-section 3.5, as applicable to the various environments defined.

6.6.7 Electrical equipment and cables shall be installed so that the probability of fire, due to the presence of oxygen, under both normal and fault conditions in either the oxygen or the electrical equipment is Extremely Improbable.

6.7 Precautions against Injury

6.7.1 Electric Shock. The electrical system shall be so designed as to minimise the risk of electric shock to crew, passengers and servicing personnel, and also to maintenance personnel using normal precautions. In particular, the requirements of (a), (b) and (c) shall be met.

(a) All equipment likely to need attention during its operation shall be designed and installed so that attention can be given without risk of electric shock (e.g. the replacement of lighting equipment; the plugging in of galley and other equipment).

(b) At junction and distribution points adequate separation shall be made between connections of different (nominal) system voltages. In areas where there may be a hazard during maintenance, panels, etc., carrying voltages of above 100v DC or 50v AC RMS shall be marked with the voltage.

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(c) Where socket outlets are provided for passenger use (eg for electric razors), these shall be labelled as to use and with the output voltage or voltages and where the output voltage exceeds 100 volts DC or 50 volts AC RMS, then the output shall be electrically isolated from the rotorcraft structure.

6.7.2 Burns

(a) The temperature rise of any item which has to be handled during normal operation by the Flight crew shall not be such as to cause injury to the crew member or dangerous inadvertent movement.

NOTE: A temperature rise in the order of 40C^{O} for items made from a poor thermal conductor, or 30C^{O} for items made of metal, should be the objective.

(b) For other equipment (excluding the heating surfaces of properly installed cooking apparatus) mounted in parts of the rotorcraft normally accessible to passengers or crew, or which may come into contact with objects such as clothing or paper, the surface temperature shall not exceed 100^{O}C, at the maximum ambient temperature.

NOTE: The provision of guards around hot surfaces is an acceptable method of complying with this requirement.

6.8 Electrical and Magnetic Interference (See also G6-13, 13)

6.8.1 General. All electrical systems and equipment shall be so designed and installed as to avoid hazardous conducted or radiated interference with the operation of other systems and equipment, and so that they will not be susceptible to such electrical and magnetic interference as may exist in the rotorcraft.

6.8.2 Avoidance of Interference with the Compass (See G6-14, App.No.2)

(a) Electrical cables and equipment shall be so installed as to comply with the requirements of G6-8.

(b) To assist the rotorcraft designer in complying with 6.8.2(a), the designer of electrical equipment shall determine and declare the Compass Safe-Distance for each item of equipment when required by the rotorcraft constructor. The method of measurement of Compass Safe-Distance shall be defined in the specification required in 6.1.

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6.8.3 Avoidance of Interference with Radio Communication and Navigation Systems

(a) Disturbances affecting radio communication and navigation, whether by radiation or conduction, shall be reduced to a safe level of interference.

(b) The rotorcraft constructor shall include in the specification required in 6.1, a definition of acceptable tolerances of radio interference including audio-interference, and where appropriate, electrical equipment shall be tested for compliance with this.

(c) The rotorcraft constructor shall make tests in the rotorcraft to determine whether radio interference is reduced to a level compatible with safety and ease of communication.

NOTE: Where the interference occurs in bursts, it may, under certain circumstances be acceptable. The acceptability of such bursts of interference will depend upon the equipment affected and the level, length and frequency of the interference.

6.8.4 Avoidance of Interference with other Systems

(a) Electrical or magnetic interference present in the rotorcraft shall not produce Hazardous Effects except under conditions, the probability of which is Extremely Remote.

(b) The types of interference to be considered shall include the following:-

(i) Conducted and radiated interference caused by noise generation by equipment connected to the busbars.

(ii) Coupling between electrical cables or between cables and aerials or aerial feeders.

(iii) The malfunctioning of electrical and radio equipment.

(iv) Parasitic currents and voltages in the electrical distribution and earth and systems including the effects of lightning currents or static discharges.

(v) Difference frequencies between generating or other systems.

(vi) Transient spikes on electrical power supplies.

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(c) The rotorcraft constructor shall ensure that the specification required in 6.1 contains a definition of interfering voltage characteristics and frequencies which equipment and systems shall be able to withstand without hazard. Where appropriate, equipment and systems shall be tested to ensure compliance with this specification.

(d) Tests shall be made to assess the interference likely to be present in the rotorcraft (See 6.10).

6.8.5 Lightning and Static Electricity. All practical steps shall be taken to minimise the hazardous effects of a lightning discharge through, or static discharges from, the rotorcraft (see G4-6).

NOTE: Magnetic effects should be considered as well as electrical ones.

6.9 Crash Fire Precautions

6.9.1 Arrangements shall be made so that in the event of a crash, such electrical circuits as are likely to cause ignition of fuel, including that spilt because of the crash, can be isolated quickly. The arrangements shall be such as to preclude inadvertent operation.

6.9.2 Such circuits as are required during or after the crash shall be left connected and shall be so protected that the risk of their causing a fire under these conditions is minimised.

6.9.3 Main power cables (including generator cables) in the fuselage shall be designed to allow a reasonable degree of deformation and stretching without failure and shall either be isolated from Flammable fluids or be shrouded by electrically insulated flexible conduit or equivalent, which is in addition to the normal cable insulation.

6.10 Tests on Electrical Systems and Equipment (See also G6-13,15) Tests shall be carried out as appropriate, on systems and equipment to determine compliance with this Chapter. These tests shall include the following:-

6.10.1 Bench tests on systems shall be carried out, as appropriate:-

(a) to establish compliance with the specification for the system and to confirm that the characteristics of the individual items forming the systems are correctly related to each other and the duty which the system has to perform,

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(b) to provide information for the Safety Assessment,

(c) to complete sufficient endurance testing to establish confidence in the airworthiness of the system,

(d) to provide proof of the effectiveness of fault protection systems.

6.10.2 Group tests on the rotorcraft or a representative ground rig shall be carried out, as appropriate:-

(a) to establish as far as is practicable the satisfactory performance of all electrical systems and circuits having airworthiness significance when operating together as they would in flight, and to confirm that the characteristics of the individual systems are correctly related to other systems interconnected with them,

(b) to assess the likelihood and extent of electrical and magnetic interference between systems,

(c) to provide information for the Safety Assessment,

(d) to assess crew drills including emergency procedures,

(e) to investigate difficulties revealed by flight testing.

6.10.3 The test rig shall be representative as far as is practicable of the electrical system in the rotorcraft. The earth system shall be representative of that of the rotorcraft in respect of impedance and coupling. The control panels shall be arranged as near as possible to the arrangement in the rotorcraft so that flight crew procedures will be representative.

NOTE: The wiring should be made to rotorcraft drawings and the equipment used should be to the same specification as that fitted to the rotorcraft. The cable, looms and ducting should be representative of those in the rotorcraft.

6.10.4 Where the conditions of flight have not been adequately simulated in the preceding tests, tests under prescribed conditions of flight shall be made on test rotorcraft to confirm the suitability of systems.

A 6.10.5 Such tests shall be carried out on series rotorcraft as are necessary to confirm the correct functioning of electrical systems and equipment.

(a) These tests shall be in accordance with schedules prepared by the rotorcraft constructor.

(b) Suitable instrumentation shall be provided to record the parameters required by the test schedule.

(c) The test schedule shall include the checking of emergency procedures.

7 PARTICULAR REQUIREMENTS FOR THE INSTALLATION OF SYSTEMS AND EQUIPMENT

7.1 Cables and Associated Fittings and Equipment (See also G6-14, App.No.3)

7.1.1 Types of Cable. The conductor(s), insulation and protective coverings, if any, of electrical cables shall be so designed and constructed that the cables can perform their respective functions satisfactorily under the conditions to which they will be subjected in service. These shall include the following:-

(a) Cables shall be suitable for the voltages which will be applied to them under all the conditions of operation in flight and on the ground.

(b) The current rating of the cables shall be such that when the cables are installed and carrying the most onerous loads in the most adverse ambient temperatures probable, the temperatures attained by the conductors will not cause damage to, or deterioration of, the cables or the rotorcraft or injury to the occupants of the rotorcraft. Due account shall be taken of the maximum current ratings for the cables under the appropriate installational conditions.

NOTE: Information on the ratings of standard cables for general services wiring is given in the appropriate cable specification.

(c) Cables shall be sufficiently robust to withstand, without risk of failure, all movement, flexing, vibration, abrasion and other mechanical hazards to which they may be reasonably subjected when installed in the rotorcraft and shall be so supported as to prevent mechanical damage.

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(d) The circuit protection system and the cables used shall be such that the cables meet G6-14, 5.1.3 under both continuous and temporary over-load conditions.

(e) Cables shall be so designed or installed as to be Fire-resistant or Fireproof where compliance with the requirements of G5-8 makes this necessary.

NOTE: The requirements of (c), (d) and (e) may be met by providing suitable mechanical protection for the cables. For example, cables not in themselves completely Fire-resistant may be enclosed in conduits or installed in protected places provided such procedure can be shown to be adequate.

7.1.2 Identification. In order to facilitate the checking of cable runs and the testing of equipment and circuits, adequate means of identification shall be provided for cable runs, connectors and terminals. The means employed shall be such as to ensure that the identification is preserved in service.

7.1.3 Accessibility of Cables and Connections. The disposition of cables and connections shall be such, so far as is practicable, as to enable scheduled inspections and/or tests to be made without undue disturbance to the installation.

7.1.4 Damage to Cables. The risk of mechanical damage, and of damage by fluids and vapours to cables, shall be minimised. Where practicable, cables shall be so routed as to avoid such risks; otherwise adequate protection shall be provided for the cables.

7.1.5 Cable Temperatures. Cables shall be so installed or protected as to be unaffected by sources of heat which, together with heat generated within the cables, could produce temperatures in excess of the maximum permissible temperature for which the cable is suitable.

7.2 Switch Indication and Warning Lights

7.2.1 Manually-operated switches shall be so installed and labelled that no dangerous ambiguity can arise regarding the state of a circuit.

A 7.2.2 The use of red warning lights in the flight crew compartment shall be confined to the indication of conditions damanding immediate attention unless otherwise required elsewhere in this Section e.g. G4-5, App.2 for landing gear warning lights. The dimming of red warning lights shall not be provided for unless specific approval has been obtained, and in any such cases all practical precautions shall be taken to ensure that these are not left in the dimmed condition.

7.2.3 Where light signals are used as continuous indicators they shall not interfere with the external vision capabilities of the flight crew.

7.3 Galleys and Domestic Equipment (See also G6-14, App.No.4)

7.3.1 Domestic appliances shall be so designed and installed that, in the event of failures of the electrical supply or control system or faults in the equipment itself, no hazard shall occur to either the rotorcraft or to passengers or cabin personnel.

NOTE: When considering failure cases, the effect of the loss of the water supply to a water heater with the electrical supply maintained should be taken into account.

7.3.2 The installation of galleys and cooking appliances shall be such as to minimise the risk of a fire.

NOTE: The design of the installation should be such as to facilitate cleaning and to limit the accumulation of extraneous substances which may constitute a fire risk.

7.3.3 Domestic applicances and equipment, particularly in galley or toilet areas, shall be so installed or protected as to prevent damage or contamination of other equipment or systems from fluids or vapours which may be present during normal use, or as a result of spillage, where such damage or contamination may hazard the rotorcraft. (See also G4-1, App.No.2).

7.3.4 Live heating elements shall be protected against contact with cooking utensils or equipment, except where it can be demonstrated that such contact will not constitute a danger.

7.3.5 Adequately insulated means of operating switches and switch-gear shall be provided, particularly where such switches may be operated by crew or passengers with wet hands.

7.3.6 The main galley structure shall be bonded to the rotorcraft structure.

APPENDIX NO.1 TO CHAPTER G6-14

INSTALLATION

1 INTRODUCTION This appendix amplifies the requirements of G6-14, 6.2 which deals with the segregation of services and the prevention of inadvertent operation.

2 SEGREGATION OF SERVICES AND PREVENTION OF INADVERTENT OPERATION (See G6-14, 6.2)

2.1 Power-unit Controls. The implications of G6-14, 6.2, together with G5-1 entail careful attention to detail in the installation of electrical wiring and equipment.

2.1.1 Cases to be Considered. The following cases which have occurred in the past are typical of the possible faults to be borne in mind in new designs both from the point of view of double failures and of inadvertent operation.

(a) Cables rubbing together in loose looms.

(b) Broken connections falling on other terminal blocks, and faults between adjacent connections on terminal blocks, or in plugs and sockets.

(c) A fire in one Power-unit affecting the controls to another.

(d) Feedback from a faulty earth connection affecting more than one Power-unit.

(e) Damage to components, systems and cables caused by uncontained debris following a Power-unit failure.

2.1.2 Loss or Malfunctioning of More than One Power-unit

(a) It is not acceptable that the failure of one item of equipment should cause the loss of more than one Power-unit (e.g. an electrically operated tank cock which could fail to open during flight would constitute such a hazard), nor that loss or malfunctioning of more than one Power-unit should result from a single failure. (See G5-1). The most likely causes of the latter occurrences would be:-

(i) Cross connections where equipment and connections for more than one Power-unit are housed in a common compartment or taken through the same plugs and sockets and cable looms, or

(ii) where it is possible to make cross connections during servicing (e.g. by inter-changing plugs and sockets),

or

(iii) where common earth connections are used (See G6-14,6.3).

(b) In general, therefore, equipment controlling separate Power-units should be housed in separate compartments and any cross connections between compartments should be kept to a minimum and arranged so that no possible single failure to any of them can dangerously affect more than one Power-unit.

NOTE: In the case of controls for a rotorcraft having two Power-units a control box for each Power-unit or a single control box divided mechanically by a barrier of earthed metal or insulating material would be acceptable.

(c) The arrangement of external connections to the control boxes be such that there is no danger of confusion between services to different Power-units.

(d) Major controls to more than one Power-unit should not be taken through the same plug and socket.

(e) Cables to individual Power-units should be so grouped and routed that failures or accidental damage producing inter-connection between circuits or Power-units, or failures producing loss of vital controls to more than one Power-unit are not possible.

2.1.3 Catastrophe. It is not acceptable that a Catastrophe should result from a single failure on one or more Power-units (e.g. failure of an automatic control system). Likely causes of such an occurrence would be:-

(a) The failure of switches or relays, or

(b) inter-cable or connector faults, or

(c) feedback from earth connections.

2.2 Other Controls and Systems Affecting Airworthiness. In general, the same principles can be applied as for Power-unit controls, that is:-

(a) Precautions should be taken to prevent confusion during repair or maintenance between circuits for different controls or systems.

(b) Where a control or system is duplicated for airworthiness reasons the two circuits should be so mechanically and electrically separated that the probability of a single failure causing both controls or systems to fail is minimised.

(c) No single failure should cause operation of any control or system in such a manner as to endanger the rotorcraft.

APPENDIX NO.2 TO CHAPTER G6-14

INTERFERENCE

1 INTRODUCTION This Appendix amplifies the requirements of G6-14, 6.8.2, which refer to magnetic interference with compasses which are actuated by the horizontal component of the earth's magnetic field.

2 AVOIDANCE OF MAGNETIC INTERFERENCE WITH THE COMPASS

2.1 It is possible for interfering magnetic fields to be set up in rotorcraft by electrical apparatus, by electric currents in the wiring or rotorcraft structure, and by magnetic material.

2.2 In the case of electric currents, it is the steady or continuous component which produces the field interfering most with compasses. Interrupted D C should be regarded as continuous current in this respect. Magnetic fields due to alternating currents do not generally interfere with compasses unless of a frequency below 10 c/s or of a magnitude sufficient to modify the magnetic characteristics of adjacent material.

2.3 Magnetic interference with the compass may be avoided by reducing the magnitude of the interfering fields at the compass. This may be done by:-

(a) the removal of each source of magnetic interference to or beyond the safe-distance from the compass;

(b) the reduction, at source, of the interfering field.

2.4 Cases to be Considered. The following cases (some of which have occurred a number of times)are typical examples of possible interference sources:-

(a) Local earthing of navigation lights with a single feeder cable being run in close proximity to a remote compass detector unit.

(b) Installation of batteries of D C rotating machines in the nose of a rotorcraft with local earthing of the negative.

(c) Single pole wiring for instrument lights.

(d) Segregation of supply and return wiring to equipment in the cockpit area.

(e) Installation of busbars and routing of heavy duty feeders adjacent to the cockpit in such a manner as to form an electrical loop.

(f) Electrically heated windscreens, and associated power supplies.

APPENDIX NO.3 TO CHAPTER G6-14

CABLES AND CABLE INSTALLATIONS

1 INTRODUCTION This Appendix provides guidance material on the installation and termination of cables to meet the requirements of Chapter G6-14, 7.1.

2 INSTALLATION

2.1 Cables should not be so sharply bent as to cause risk of damage or deterioration.

2.2 Preparation of Conduits, etc. The ends of all conduits, tubes and ducts which carry electrical cables should be so prepared or bushed with insulating materials at the points of entry or possible contact, as to reduce to a minimum the risk of damage in service and when drawing in the cable.

2.3 Wherever possible and to assist drainage, cables connected to equipment should be arranged to run downward from the equipment.

NOTE: This may necessitate the incorporation of a loop immediately before entering the equipment.

2.4 Where conduits, tubes or ducts are used, they should be so installed that any moisture accumulating in them will drain safely away; in addition, the cables used in them should be capable of withstanding such moisture as may nevertheless be encountered.

2.5 The methods used for the connection of cables to equipment or to each other should ensure that the mechanical strength, electrical insulation and protection from damage are adequate. The methods should be of a type established to be reliable under the appropriate conditions,by test and/or experience.

2.6 The installation should be such that it is not necessary to make soldered joints within the rotorcraft except where a control specification is agreed which adequately controls both the effectiveness and safety of the operation.

3 TERMINATIONS Where aluminium conductors are used, particular care should be taken in the choice and quality control of the cable terminations. Rigorous attention to these aspects should be made to limit the possibilities of in-service deterioration.

APPENDIX NO.4 TO CHAPTER G6-14

DESIGN AND INSTALLATION OF GALLEYS AND DOMESTIC EQUIPMENT

1 INTRODUCTION This Appendix provides guidance material on the installation of galleys and other domestic equipment, to meet the requirements of G6-14, 7.3.

2 OVENS AND HEATING DEVICES

2.1 The design and installation of heated domestic appliances should be such that no single failure (e.g. welded thermostat or contactor) can result in dangerous uncontrolled heating and consequent risk of fire or smoke or injury to cabin staff or passengers.

2.1.1 An acceptable method of achieving this is by the provision of a means, independent of the normal temperature control system, which will automatically interrupt the electrical power supply to the unit in the event of an overheat condition occurring. The means adopted should be such that it cannot be reset in flight.

2.2 The design and installation of micro-wave ovens should be such that no hazard could be caused to the occupants or the equipment or the rotorcraft under either normal operation or single failure conditions. (See British Standard 5175 para. 32 for guidance on microwave leakage).

3 HEATED LIQUID CONTAINERS

3.1 Heated liquid containers, e.g. water boilers, coffee makers, should in addition to overheat protection, be provided with an effective means to relieve overpressure.

3.2 Where pressure vessels are utilised in such equipment the design of the unit and its installation should be such that there is no possibility of any fault or combination of faults which will result in explosion.

NOTE: Due account should be taken of the possible effects of lime scale deposit both in the design and maintenance procedures of water heating equipment.

4 CONTAMINATION FIRE AND SMOKE In addition to the requirements of G6-14, 6.6.5 and 7.3.2, the following precautions should be taken:-

(a) Electrical/electronic components should be so located as to minimise their exposure to cooking steam or vapour, cooking or waste residues and water system leakage.

(b) Measures should be taken to limit the possibility of use of heated areas for storage of, or contact with, potentially Flammable or smoke producing articles.

CIVIL AVIATION AUTHORITY BRITISH CIVIL AIRWORTHINESS REQUIREMENTS

PAPER NO. G749

SECTION G
ROTORCRAFT

5TH SEPTEMBER 1986

CHAPTER G4-8 CONTROL SYSTEM DESIGN

INTRODUCTION

The requirements of this Paper have been agreed by the Rotorcraft Requirements Co-ordinating Committee, and are made effective upon acceptance of the advice of the Airworthiness Requirements Board.

TEXT OF AMENDMENTS

Material differences between the current requirements of Section G and those of this Paper are indicated with a marginal line.

The existing G4-8, 2.1 is replaced by the following:-

AB

2 FLIGHT CONTROL SYSTEM (See G4-8, App., 3)

2.1 General

2.1.1 The flight control system shall, for the purposes of this Chapter, include the Primary Flight Control System, (see 2.3.1 for definition) and trim and feel systems, together with any flight control lock systems and any parts of ancillary systems which cannot be disconnected from the flight control system by the pilot from his seat, (eg. auto-pilot, artificial stabilisation - see G6-4).

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2.1.2 In assessing the compliance of the flight control system with the systems requirements of the safety objectives, it shall be shown that the rotorcraft will be capable of continued safe flight and landing within the manoeuvring load envelope of G3-2, without experiencing Effects worse than those permitted by the safety objectives, after the occurrence of any of the failures of (a) and (b). In addition where a failure causes a disturbance of the flight path, recovery to straight and level flight shall be possible without producing Effects (in the form of dangerous attitudes or conditions) more severe than those permitted by the safety objectives, allowance being made for delays before initiating recovery action. (See also G2-8, 8 and G4-8, App., 3.)

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(a) Any single failure of any element which is not Extremely Improbable, but excluding jamming (see 2.1.2(b)). Compliance with this requirement shall be established by the provision of either an alternative means of controlling the rotorcraft or an alternative load path except where it can be shown for particular elements that this cannot be achieved within the limits of either good engineering practice or the geometry of the application, allowing for inspection needs.

NOTE: If a single load path has to be employed, then a Safe Fatigue Life shall be established in accordance with the requirements of G3-1, 5.

(b) Any jam occurring in a control position encountered during normal operation unless any such jam is shown to be Extremely Improbable. (See G4-8 Appendix 4.6)*. Where alternative means are provided for controlling the rotorcraft after such a jam has occurred, their use shall be unambiguous and compatible with the general philosophy of flight control operation.

B

2.1.3 The Primary Flight Control System (see 2.3.1), together with the trimming control system shall be such that the likelihood of Failure (including disconnection) of any element which could result in a hazardous measure of control being applied or lost at any speed up to V_{NO} (see G8-2 para. 2.3 for definition) is Extremely Remote.

NOTE: The failure or disconnection of certain parts need not be assumed if their integrity, taking into account their properties and working conditions, is such as to provide an equivalent level of safety to that implied in the requirement.

The following new paragraph 4.6 is added to the Appendix to G4-8:-

4.6 (See G4-8, 2.1.2(b)). The assessment of a jam as being Extremely Improbable on a rotorcraft having simple control systems should be based upon a review of all the aspects of the particular installation including a visual survey of the jamming hazards based upon previous experience from similar systems. If the runaway of a flight control to an adverse position could at the same time produce jamming, this case should be included in the assessment.

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* As contained in this Paper.

PAPER NO. G774

5th April 1982

SECTION G
ROTORCRAFT

INSTALLATIONAL ASSUMPTIONS INVOLVED IN ENGINE CERTIFICATION

INTRODUCTION

The requirements of this Paper have been agreed by the Rotorcraft Requirements Co-ordinating Committee and are made effective upon acceptance of the advice of the Airworthiness Requirements Board.

TEXT OF AMENDMENTS

Material differences between the current requirements of Section G and those of this Paper are indicated with a marginal line.

The following new paragraph is added as G5-1, 2.1 and subsequent paragraphs are re numbered accordingly:-

AB | 2.1 Engine Installation. The statement of assumptions provided under C4-1,3 together with any special qualifications of the engine approval shall be taken into account when establishing the acceptability of the installation.

CIVIL AVIATION AUTHORITY

BRITISH CIVIL AIRWORTHINESS REQUIREMENTS

PAPER NO. G778

7th October 1985

SECTION G
ROTORCRAFT

SUB-SECTION G4 - DESIGN AND CONSTRUCTION

CHAPTER G4-9 - ROTOR AND TRANSMISSION SYSTEMS

INTRODUCTION

The requirements of this Paper have been agreed by the Rotorcraft Requirements Coordinating Committee, and are made effective upon acceptance of the advice of the Airworthiness Requirements Board.

TEXT OF AMENDMENTS

Material differences between the current requirements of Section G and those of this Paper are indicated with a marginal line.

Existing Chapter G4-9 is deleted and replaced by the following:-

SUB-SECTION G4 - DESIGN AND CONSTRUCTION

CHAPTER G4-9 - ROTOR AND TRANSMISSION SYSTEMS

1 GENERAL

AB

1.1 Applicability. This Chapter applies to the Rotor System and Transmission System as defined in G1-2, 1.18 and 2.3.

1.2 Definition. For the purposes of this Chapter the following definition applies.

1.2.1 Critical Part. Where the Safety Assessment shows that a part must achieve and maintain a particularly high level of integrity if the design criteria of 2.3 are to be met, then the part is a Critical Part. (An alternative name may be agreed with the Authority.)

AB

2 DESIGN CRITERIA

2.1 The design of the Rotor and Transmission System shall be such as to enable satisfactory functioning over the full range of conditions for which certification is sought, and to enable compliance to be shown with the requirements of this Chapter applicable to either Group A or Group B Rotorcraft* as appropriate.

2.2 The design of each part of the Rotor and Transmission System shall be such as to enable the tests of Sub-section G7, Rotor and Transmission System Tests, to be complied with.

2.3 (a) Group A and B. The probability of failure of the Rotor and Transmission System, from all causes, that would prevent a controlled 'power-off' descent and landing shall be Very Remote*.

A (b) Group A

(i) The probability of failure of the Rotor and Transmission System, from all causes, that would prevent the flight to the intended destination, (or for a declared time interval) and a controlled power-on landing shall be Very Remote.

(ii) Where a time interval is declared, this shall be promulgated in the Flight Manual.

In order to allow reasonable time for decision making and effecting a controlled power-on landing, any declared time interval shall not be less than 10 minutes.

NOTES: (1) The declared time interval commences when the failure symptoms are presented to the flight crew.

(2) After the declared interval the rotorcraft may have to land immediately.

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*As defined in Blue Paper G780

B (c) Group B. The probability of failure of the Rotor and Transmission System, from all causes, that would prevent a controlled power-on landing shall be Remote.

NOTE: Following failure the rotorcraft may have to land immediately.

AB 2.4 The Rotor and Transmission System shall be designed to minimise the probability and consequences of failure. (See G4-9 App. para. 1.)

2.5 Any parts of the Transmission System which are within a Designated Fire Zone shall comply with G5-8.

2.6 On rotorcraft in which it is necessary to maintain two or more Rotors in phase with one another, means shall be provided to maintain such relationship under all operating conditions. If there are any points in the Transmission System at which it is intended the correct relationship settings may be frequently disturbed (e.g. for stowage or transportation purposes) then the design of such points shall be such that it is mechanically impossible to reassemble the Transmission System so that the Rotors are incorrectly phased. At all other points, the design and procedures shall be such as to minimise the possibility of reassembling the Transmission System so that the Rotors are incorrectly phased.

2.7 The Rotor and Transmission System shall be protected from failure caused by the application of high torques transmitted by the Power Unit(s) or resulting from control movements.

NOTE: The Authority will be prepared to consider the display of suitable markings or placards as the means of complying with this requirement if the inherent characteristics of the rotorcraft and instrumentation are such that the pilot can safely be left to provide the protection.

2.7.1 Catastrophic failure of the Rotor and Transmission System shall not be caused by an over-torque which can be attained under flight conditions that the rotorcraft would otherwise survive.

2.7.2 A torque limiting device may be incorporated. Such a device shall have a torque limiter setting at least 10% above the declared Rotor Maximum Over-Torque value.

2.7.3 If any possible torque loading condition necessitates additional inspections or removal of any part from service, a device shall be fitted to automatically record the excursions.

AB

2.8 The Rotor and Transmission System shall be shown to have static and fatigue strengths meeting the relevant requirements of Section G. Where the Safety Assessment objectives are met by the substantiation of a safe fatigue life, the probability of fatigue failure for the component shall be Extremely Remote.

NOTE: See G3-1 for general requirements and G3-4 Appendix 1 for torque loads and fatigue testing of gearboxes.

3 SAFETY ASSESSMENT The results of the Failure Analysis of para. 4, together with any other appropriate considerations, shall be used to show with reasonable confidence that the basic airworthiness objectives of para. 2.3 will be met, as far as the Rotor and Transmission System is concerned.

3.1 Using the results from the Failure Analysis a summary shall be made of those failures (including combination of failures), which could affect the ability of the rotorcraft to continue flight or make a controlled landing, or could hazard the occupants, together with estimates of their probability of occurrence.

3.2 (i) For compliance with para. 2.3(a) and (b) either each failure condition shall be assessed to be less probable than 10^{-8} per hour of flight, or all failure conditions taken together shall be assessed to be Very Remote.

(ii) For compliance with para. 2.3(c) either each failure condition shall be assessed to be Extremely Remote, or all failure conditions taken together shall be assessed to be Remote.

3.3 It is recognised that the probability of prime failures of certain single elements (e.g. shafts, spindles) cannot be sensibly estimated in numerical terms. Where the failure of such elements is likely to result in Hazardous Effects, reliance must be placed on their meeting requirements, aimed at providing high integrity, such as ground endurance tests, over-torque and overspeed tests, fatigue life substantiations etc., and where this is so it shall be stated in the Safety Assessment.

3.4 Where the Safety Assessment shows that the acceptability of the design is dependent on one or more of the following, these shall be identified in the analysis and appropriately substantiated.

(a) A safe life being determined.

(b) Critical Parts - all such parts shall be listed and appropriate manufacturing procedures established with the Authority. (See para. 3.3 and 5.)

AB

(c) Maintenance actions, including the verification of serviceability of items the failure of which could be dormant, being carried out at stated periods. These periods shall be identified accordingly and published in the appropriate Manual.

(d) The avoidance of single errors of assembly which could be hazardous. The appropriate vital points shall be identified for inclusion in the Maintenance Manual.

(e) Verification of satisfactory functioning of safety or other devices at pre-flight or other stated periods; the details shall be published in the appropriate Manuals.

(f) The provision of specific instrumentation not otherwise required.

4 FAILURE ANALYSIS (See G4-9 App. Para. 2)

4.1 A failure analysis of the complete Rotor and Transmission System shall be carried out, in order to assess the likely consequences of all conceivable failures.

4.2 Where significant doubt exists on the effects of failures or likely combinations of failures, the Authority may require any assumptions to be verified by test.

4.3 Where reliance is placed on safety devices, instrumentation, early warning devices, maintenance checks etc., to limit the effects of a failure, the analysis shall cover the safety system failure in combination with the basic Rotor and Transmission System failure.*

5 MANUFACTURE OF CRITICAL PARTS (See G4-9 App. Para. 3)

5.1 Critical Parts shall be subjected to a manufacturing control procedure agreed by the Authority. The procedure shall identify:-

(a) The design features influencing the integrity of the Critical Part.

(b) The detailed manufacturing process including material manufacture, forging procedures, tooling standard and acceptance standards.

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*See also Paper No. G811 for requirements relating to health monitoring.

AB (c) The source of supply.

(d) The procedure which must be followed before a change can be made to any of the factors in (a), (b) or (c).

5.2 Critical Parts and other such parts as may be required by the Authority shall be marked, and the constructor shall maintain records related to the marking, such that it is possible to establish the relevant manufacturing history of the parts.

5.3 In cases where the integrity of the part is dependent on a safe fatigue life, or damage tolerant characteristics, any change in the manufacturing process or design shall be evaluated and subjected to re-testing to establish the effect of the change unless justified as not requiring re-testing. The use of larger reduction factors may be accepted as an alternative to testing representative specimens.

6 ROTOR DESIGN

6.1 Rotor Blade Clearance. Adequate clearance shall be provided between any Rotor and all other parts of the rotorcraft to prevent the blades striking any part of the rotorcraft during any permitted ground or flight manoeuvre (see Chapter G2-8). The clearance shall also be such that the probability of the blades striking any part of the rotorcraft during any foreseeable manoeuvre that might inadvertently occur shall be Extremely Remote.

NOTE: The combined effect of the manoeuvring loads and gust loads of the magnitudes prescribed in G3-2, 2 should be considered.

6.2 Rotor Balancing

6.2.1 Means shall be provided to enable the balance of the Rotor(s) and rotor blades to be adjusted to within the limits specified by the constructor.

6.2.2 The blades shall be so designed that they will maintain acceptable balance characteristics under all permitted flight conditions. Consideration shall be given to the effects of variation of ambient conditions, e.g. pressure, temperature, humidity and icing.

6.3 Stops

6.3.1 Where necessary to prevent damage, including blade contact with the airframe or ground, stops shall be provided to limit movement of the blades.

NOTE: Flight Manual Limitations in respect of wind conditions may also be necessary.

AB

6.3.2 Adequate clearance shall be provided to prevent blades contacting any rigid droop stops except during the starting or stopping of the Rotor or when the Rotor is parked.

6.4 Water Accumulation. The blades shall be designed to prevent water accumulation in any part of the blade.

7 ARRANGEMENT

7.1 The Rotor and Transmission System shall be so arranged that the Rotor System will continue to function satisfactorily after the failure of all Power-units.

7.2 The Transmission System shall incorporate a free-wheel for each Power-unit which will automatically disengage the Power-unit to prevent the Rotor System from driving the Power-unit. The free-wheel shall be so located that failure of any component not part of the Rotor System cannot affect the continued operation of the free-wheel. On multi-engined rotorcraft, the free-wheels of each gear train shall be designed and arranged such that a single failure cannot affect more than one free-wheel.

7.3 The Transmission System of a multi-engined rotorcraft shall be so arranged that, in the event of failure of one or more Power-units, power from the operating Power-units will be supplied to enable the satisfactory functioning of Rotors and other units necessary for the operation and control of the rotorcraft.

8 CLUTCHES

8.1 The Rotor and Transmission System shall be such that any Power-unit can be started without driving the Rotor(s).

NOTE: In the case of turbine engines incorporating a free power-turbine which drives the Rotor and Transmission System, 8.1 need not apply provided it can be shown that the stresses involved in the Rotor and Transmission System during starting are acceptable.

8.2 Normal engagement of any clutch shall not cause excessive stresses in the Rotor and Transmission System. Where inadvertent engagement of any clutch is possible, it shall not produce damaging stresses in the Rotor and Transmission System.

AB 9 ROTOR BRAKE

9.1 Limitations on the use of the rotor brake shall be specified and included in the Flight Manual.

9.2 Means acceptable to the Authority shall be provided to minimise the possibility of a take-off with the brake applied and to preclude the possibility of inadvertent application of the brake in flight.

9.3 The design shall minimise the risk of fires initiated by the rotor brake.

10 EQUIPMENT DRIVES Equipment Drives and mountings shall be designed and located to minimise the possibility of defective equipment affecting the safe functioning of the Transmission System. (See also G4-9 App. Para. 1(b).)

10.1 The design of the Transmission System shall be such that any accessory driven from it has a weak link or other means which will prevent a malfunctioning accessory from applying a dangerously high torque to the system. All other parts of the Transmission System shall be capable of withstanding safely the maximum torque which can result.

10.2 The weak link shall be designed so that its failure will not result in flailing or in loose parts causing damage to the rotorcraft.

10.3 (a) When the power absorbed by a transmission-driven accessory, e.g. electrical generator, is such as to create a hazardous condition in the event of mechanical failure of the accessory in spite of the presence of the weak link in the drive, means shall be provided so that the accessory may be disengaged from the transmission while the transmission is still running.

NOTE: The weak link has to be designed to accommodate the highest peak torque; where the torque on the drive varies considerably with rpm, load, accelerations, etc., especially as in the case of electrical accessories, the weak link may not provide an effective safeguard at the normal torque. In such a case, other means of disconnect would have to be provided to permit disengagement of the equipment with the transmission running.

AB

(b) Where a means for disengagement is provided the conditions under which the accessory may be re-engaged shall be established. If facilities for re-engagement in flight are provided, the technique to be employed shall be declared and demonstrated to be safe.

11 COOLING FANS (See G4-9 App. Para. 4)

11.1 The effects of failures of the cooling fans shall be shown to meet the requirements of the Safety Assessment appropriate to the rotorcraft category having regard to:-

(i) fan integrity;

(ii) loss of cooling.

11.2 Where reliance is placed on cooling fans for continued safe operation, they shall possess integrity of the same order as that of the Rotor System, having regard to all possible failure modes.

12 PROVISION FOR INSTRUMENTS

12.1 All necessary provision shall be made in the Transmission System for the fitment and operation of the mandatory items of equipment prescribed in G6-1. Where in presenting the fault analysis or in complying with any other requirements, dependence is placed on instrumentation which is not otherwise mandatory, approval of the rotorcraft is dependent on the provision of such instrumentation.

NOTE: Additional provision for the instruments necessary in type tests will have to be made on the Rotor and Transmission System or parts thereof submitted for type approval.

12.2 A statement shall be submitted to the Authority by the constructor listing the instruments necessary for satisfactory operation of the Rotor and Transmission System. The overall limits of accuracy required of such instruments for the purpose of enabling the flight crew to control satisfactorily the operation of the systems shall also be stated so that the suitability of the instruments as installed may be assessed. Due regard shall be given to possible inaccuracies in reading the instruments.

NOTE: In determining Rotor and Transmission System operating limitations, account will be taken of the declared overall limits of instrument accuracy.

AB

12.3 Oil pressure gauge and low pressure warning device connections shall be arranged so that the devices indicate the pressure of the oil to the main jets.

12.3.1 The design shall be such as to ensure that the pressure sensors, the associated electrical circuits and the presentation of information on the flight deck for the gauge and warning device, are independent one from the other.

12.3.2 There shall be no relief valve or filter between the pressure gauge/warning device connections and the main jets, other than those of 12.3.3.

12.3.3 Strainers necessary to protect oil jets or metering orifices shall be provided and designed to reduce the possibility of blockage to a reasonable minimum.

12.3.4 Where an auxiliary lubrication system is independent of the main system, provision shall be made for the connection of an additional oil pressure gauge at the nearest practicable point to the parts being supplied with oil.

APPENDIX TO CHAPTER G4-9

ROTOR AND TRANSMISSION SYSTEMS

1 DESIGN (See G4-9, 2.4). It should be evident in the design of the Rotor and Transmission System that the following have been used to maximum advantage.

(a) Location of freewheels, in order to isolate the Rotor System from the maximum amount of the Transmission System.

(b) For both Group A and B rotorcraft, the Rotor system should be as simple as possible and the mounting of accessories on the Rotor System should be avoided, except to provide the services vital for autorotation.

For Group A rotorcraft only, the mounting of accessories on the Transmission System should also be avoided, except to provide for services vital for continued safe flight.

(c) Damage tolerant design principles.

(d) Provision of early warning devices capable of reliable interpretation and reaction in flight or in maintenance procedures.

(e) Provision of adequate clearance, or other means, such that in the event of a gear tooth failure, the debris can be ejected from the meshing area without further damage. Where gear trains are considered vulnerable in this respect, particular attention should be given to minimising the risk of failure.

(f) Reducing to a minimum the number of parts which need to be classified as Critical Parts. (See G4-9, 3.1.)

2 FAILURE ANALYSIS (See G4-9, 4)

2.1 The Failure Analysis should be presented in a way which demonstrates a logical appraisal of all conceivable failure modes, and takes account of past experience with similar equipment.

2.2 Except as permitted by G4-9, 3.2, the probability of failure should be estimated, having regard to the design features, materials and past experience, as well as experience provided by the development programme.

2.3 The Analysis is required down to component level, to identify the following for use in the Safety Assessment:-

(a) All conceivable failure modes for each component.

(b) The expected failure effect of each mode.

(c) The combined effects of consequential failures.

(d) The combined effects of failures where the probability of occurrence of each failure is such that the possibility of a multiple failure has to be considered.

(e) Failures which could be dormant - e.g. involving a hidden malfunction. These will need to be combined with at least one other failure, chosen to represent the worst case, to assess the effect.

(f) The failure modes which could cause Hazardous Effects or Catastrophe.

(g) The predicted rate for each failure mode, or multiple failure which could cause Hazardous Effects or Catastrophe.

3 CONTROL OF CRITICAL PARTS (See G4-9, 5) The manufacturing processes, maintenance and overhaul of all Critical Parts should be such as to ensure they have characteristics essentially similar to those on which the certification of the design was based. To this end, the procedures of 3.1 to 3.6 should be applied.

3.1 All significant manufacturing processes:-

(a) should be essentially identical to those used in producing the parts on which certification was based;

(b) should be recorded in the specification which should include operations, sequence, inspections standards for acceptance and the extent and location of permissible flaws;

(c) should be referenced on the drawing;

(d) should not be changed except by a procedure acceptable to the Authority

3.2 Documentation should be such that the attention of personnel involved is drawn to the fact that a part is 'critical'. All drawings, work sheets, inspection documents etc., should be annotated with the words "Critical Part" in bold letters.

3.3 Concessions should be treated in accordance with the importance of these parts.

3.4 The appropriate Approved Manuals should:-

(a) contain comprehensive instructions for the inspection of such parts;

(b) indicated to operators and overhaulers that unauthorised repairs or modifications could have hazardous consequences; and

(c) emphasise care of handling, accurate control and recording in life etc.

3.5 Sub-contract orders should be endorsed to make sure that any sub-contractors are aware that a part is subject to special procedures to which the order should refer.

3.6 Partnership agreements should include a contractural requirement for partner companies to comply in principle with 3.1 to 3.5.

4 COOLING FANS (See G4-9, 11)

4.1 Compliance with the requirements of G4-9, 11.1(i) may be established by a tri-hub burst containment test.

4.2 Compliance with the requirements of G4-9, 11.1(i) and 11.2 may be established by:-

(a) demonstrating by test that no dangerous resonant conditions can occur in the hub or the complete fan, as appropriate, within the normal range of rpm of the fan; and

(b) demonstrating by test that the hub or the complete fan, as appropriate, can withstand rotation at 1.25 times the fan rpm corresponding, as applicable, to either:-

(i) the declared maximum overspeed for the fan power unit,

(ii) the Rotor Never Exceed RPM, or

(iii) the operating speed of an overspeed limiting device, whichever is the greater; and

(c) establishing a Safe Fatigue Life of the hub or the complete fan, as appropriate, under suitably factored loads; and

(d) applying to the parts concerned a quality control system which is agreed by the Authority.

CIVIL AVIATION AUTHORITY

BRITISH CIVIL AIRWORTHINESS REQUIREMENTS

PAPER NO. G779

7th October 1985

SECTION G
ROTORCRAFT

EMERGENCY ALIGHTING ON WATER

INTRODUCTION

The requirements of this Paper have been agreed by the Rotorcraft Requirements Coordinating Committee, and are made effective upon acceptance of the advice of the Airworthiness Requirements Board.

TEXT OF AMENDMENTS

Material differences between the current requirements of Section G and those of this Paper are indicated with a marginal line.

CHAPTER G4-10 EMERGENCY ALIGHTING ON WATER

Paragraph 2 is amended to read as follows:-

AB 2 GENERAL

2.1 Such design measures as are compatible with the general characteristics of the rotorcraft, shall be taken where these are necessary to ensure as far as possible, that, where an Emergency Alighting on water is made, in accordance with the recommended procedures (see 3),

(a) the behaviour of the rotorcraft in the declared conditions would not be such as to cause injury to the occupants or make it impossible for them to escape from the exits provided;

(b) the flotation time and trim of the rotorcraft in the declared conditions and allowing for damage will allow the occupants to leave the rotorcraft by the exits provided and enter liferafts (see also G4-3, 5).

NOTE: The rotorcraft should float in a stable position for not less than five minutes. This allows time for the deployment of the liferafts and for passengers to transfer from the rotorcraft to the liferafts in severe seas.

AB 2.2 In assessing the general characteristics of the rotorcraft any projecting features, or other factors likely to affect hydrodynamic characteristics , shall be taken into account.

2.3 External doors and windows shall be designed to withstand the probable maximum local water pressures occurring during an alighting on water conducted in accordance with the established technique (see 3.1).

Paragraphs 4 and 5 are amended to read as follows:-

AB 4 FLOTATION AND TRIM (See G4-10 App. 1.2) Satisfactory flotation and trim characteristics shall be demonstrated by investigation and model tests conducted so that the results would be valid in the declared conditions. A sea anchor, or similar device may not be assumed to be used in demonstrating compliance with the requirements of this Chapter, but may be assumed to be used to assist in the deployment of liferafts in accordance with G6-6.

5 PROCEDURES AND LIMITATIONS

5.1 Procedures. The techniques and procedures established in accordance with 3.1 shall be included in the Flight Manual.

5.2 Declared Conditions. These are the conditions in which compliance with the requirements has been demonstrated. If these conditions are less than those detailed in G4-10 Appendix they shall be included in the Flight Manual as limitations.

NOTE: Chapter G4-10 Appendix defines generally applicable criteria. In particular geographical areas more severe criteria will be applicable.

CHAPTER G4-10 APPENDIX

Paragraph 1.2 is amended to read as follows:-

1.2 Flotation and Trim (see G4-10, 4). The flotation and trim characteristics should be investigated under the following conditions:-

(a) in sea states in the range 0 to 6 of Table 1 (G4-10 App.) (but with a maximum wave height of 9.15m (30 ft));

(b) in individual waves with height/length ratios in accordance with (i) or (ii) in all sea states of (a);

(i) 1 : 8 for rotorcraft in Group B;

(ii) 1 : 10 for rotorcraft in Group A.

NOTE: The wave height/length ratio may be changed with the increase in the declared time interval (See G1-2, 8.1) up to a maximum of 1 : 12.5 when there is no limit on the declared time interval.

Table 1 of the Appendix to G4-10 is amended as follows:-

TABLE 1 (G4-10, APP.)

SEA STATE CODE

(WORLD METEOROLOGICAL ORGANISATION)

Sea State Code	Description of Sea	Significant Wave Height	
		Metres	Feet
0	Calm (Glassy)	0	0
1	Calm (Rippled)	0 to 0.1	0 to $\frac{1}{3}$
2	Smooth (Wavelets)	0.1 to 0.5	$\frac{2}{3}$ to $1\frac{2}{3}$
3	Slight	0.5 to 1.25	$1\frac{2}{3}$ to 4
4	Moderate	1.25 to 2.5	4 to 8
5	Rough	2.5 to 4	8 to 13
6	Very Rough	4 to 6	13 to 20
7	High	6 to 9	20 to 30
8	Very High	9 to14	30 to 45
9	Phenomenal	Over 14	Over 45

NOTES: (1) The Significant Wave Height is defined as the average value of the height (vertical distance between trough and crest) of the largest one third of the waves present.

(2) Maximum Wave Height is usually taken to be 1.6 x Significant e.g. Significant Wave Height of 6 metres gives Maximum Wave Height of 9.6 metres.

Paragraph 5.2.7 is amended to read as follows:-

AB

5.2.7 Marking. Emergency exits, together with their means of access and means of opening, shall be adequately marked for the guidance of occupants using the exits in light and in darkness (e.g. by the use of luminous paint or emergency lighting). For rotorcraft in the configuration for overwater flight such marking shall remain adequate if the helicopter is capsized and the cabin submerged. Adequate marking shall also be provided for the guidance of rescue personnel outside the rotorcraft.

Paragraph 5.2.9 is amended to read as follows:-

AB

5.2.9 Ditching Emergency Exits. With the rotorcraft in the configuration for overwater flight, the most adverse static water level(s) shall be established. Emergency exits located above the water level(s) so established shall be provided on each side of the fuselage and the number and size shall be related to the seating capacity as shown in Table 2 (G4-3).

TABLE 2 (G4-3)

Passenger Seating Capacity (inclusive)	Ditching Emergency Exits each side of fuselage	
	Type III	Type IV
1 to 19	1	-
20 to 29	1	1
30 to 39	1	2
40 to 59	2	1
60 to 79	2	2

NOTE: Type IV exits are not to be considered for liferaft deployment and boarding purposes but are required to facilitate egress in the event of a capsize.

CIVIL AVIATION AUTHORITY

BRITISH CIVIL AIRWORTHINESS REQUIREMENTS

PAPER NO. G780

7th October 1985

SECTION G
ROTORCRAFT

ROTORCRAFT CATEGORIES

INTRODUCTION

The requirements of this Paper have been agreed by the Rotorcraft Requirements Coordinating Committee, and are made effective upon acceptance of the advice of the Airworthiness Requirements Board.

TEXT OF AMENDMENTS

Material differences between the current requirements of Section G and those of this Paper are indicated with a marginal line.

FOREWORD

Paragraph 3.2.1 is amended to read as follows:-

3.2.1 Rotorcraft Group System. Traditionally aeroplane Group classifications are determined by performance considerations alone. However, for rotorcraft, engineering standards also result in operational constraints. Thus Rotorcraft Groups determine both the performance and engineering standards required, and are defined in Chapter G1-2, para. 8.

CHAPTER G1-2 DEFINITIONS

Paragraph 7.2 is amended to read as follows:-

7.2 Probability of Occurrences

NOTES: (1) These probabilities are illustrated in G1-2 Figure 2.

(2) Numerical probabilities quoted in terms of rates per hour of flight may be taken to be the same values per flight where this would be more appropriate.

7.2.1 Frequent. Likely to occur often during the operational life of each rotorcraft of the type.

NOTE: Where numerical values are used this may normally be interpreted as more probable than 10^{-3} per hour of flight.

7.2.2 Reasonably Probable. Unlikely to occur often during the operation of each rotorcraft of the type but which may occur several times during the total operational life of each rotorcraft of the type.

NOTE: Where numerical values are used this may normally be interpreted as less probable than 10^{-3} per hour of flight.

7.2.3 Probable. A term embracing the total range of Frequent and Reasonably Probable.

7.2.4 Remote. Unlikely to occur to each rotorcraft during its total operational life, but which may occur several times when considering the total operational life of a number of rotorcraft of the type.

NOTE: Where numerical values are used this may normally be interpreted as less probable than 10^{-5} per hour of flight.

7.2.5 Very Remote. Unlikely to occur when considering the total operational life of a number of rotorcraft of the type, but nevertheless has to be considered as being possible.

NOTE: Where numerical values are used this may normally be interpreted as less probable than 10^{-6} per hour of flight.

7.2.6 Extremely Remote. Unlikely to occur when considering the total operational life of a fleet of rotorcraft of the type, but nevertheless has to be considered as being possible.

NOTE: Where numerical values are used this may normally be interpreted as less probable than 10^{-7} per hour of flight.

7.2.7 Extremely Improbable. So unlikely to occur that it does not have to be regarded as possible.

NOTE: Where numerical values are used this may normally be interpreted as less probable than 10^{-9} per hour of flight.

A new paragraph 8 is added as follows:-

8 ROTORCRAFT GROUPS

A 8.1 Group A. A rotorcraft for which the probability of occurrence of failures from all causes that would prevent safe flight and landing is Very Remote.

B 8.2 Group B. All other rotorcraft.

NOTES: (1) The attainment of a probability less than Very Remote is limited by the state of the art on the design of certain parts of the Rotor and Transmission Systems. It is however intended that other systems affecting safe continuation of flight, including, where possible, the Rotor and Transmission Systems, should attain the level of Extremely Remote in order not to reduce the safety below that reasonably achievable.

(2) See also G4-1, 2* and G4-9, 2.3/.

(3) For rotorcraft with a maximum total weight authorised of less than 6000 lbs, the extent to which the relevant requirements are applicable will need to be discussed with the Authority.

(4) The safe flight and landing referred to in paragraph 8.1 is continued flight followed by a controlled power-on landing at a suitable site.

CHAPTER G4-1 DESIGN AND CONSTRUCTION - GENERAL

Paragraph 2 is amended to read as follows:-

AB 2 FAILURES

NOTE: Failure of Primary Structure and other high integrity parts is dealt with in G3-1, 5. Failures in the Rotor and Transmission Systems are dealt with in G4-9, 2.3.

2.1 The design of rotorcraft shall be such that, with the exception of the Rotor and Transmission Systems, the probability of a Catastrophic Effect from all systems causes is Extremely Remote.

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*As contained in this Paper

/As contained in Blue Paper G778 Rotor and Transmission Systems

A | 2.2 The design of rotorcraft to be certificated in Group A shall be such that, with the exception of the Rotor and Transmission Systems, the probability of a Failure resulting in an Emergency Landing within a specified period of time, which shall be not less than 10 minutes, is not greater than Extremely Remote.

NOTES: (1) The period of 10 minutes has been set as a minimum to allow reasonable time for detection, decision making and effecting a controlled landing.

(2) A rotorcraft with a specified period of time will have to be operated so that a suitable landing site is always available within that period and the Flight Manual annotated accordingly.

CIVIL AVIATION AUTHORITY

BRITISH CIVIL AIRWORTHINESS REQUIREMENTS

CORRIGENDUM NO. 1 TO
BLUE PAPER NO. G780

20th November 1985

SECTION G

ROTORCRAFT

ROTORCRAFT CATEGORIES

Blue Paper G780 introduces amendments to the Performance Group System currently used in Section G.

During the drafting of this Paper, a figure was used to illustrate the use of Probability Terms when applied to failure rates for rotorcraft operation and this figure was deleted, as intended, on publication of the Blue Paper.

However, a reference to this figure was retained in error in Chapter G1-2, para. 7.2 NOTE: 1.

AMENDMENT

Chapter G1-2, 7.2 NOTE: 1

Delete NOTE 1 and retain NOTE 2 as the only NOTE to Chapter G1-2, 7.2.

CIVIL AVIATION AUTHORITY

BRITISH CIVIL AIRWORTHINESS REQUIREMENTS

PAPER NO. G785

7th October 1985

SECTION G
ROTORCRAFT

REVISION OF CHAPTERS G6-6 AND G4-3 LAUNCHING AND BOARDING LIFERAFTS

INTRODUCTION

The requirements of this Paper have been agreed by the Rotorcraft Requirements Coordinating Committee, and are made effective upon acceptance of the advice of the Airworthiness Requirements Board.

TEXT OF AMENDMENTS

Material differences between the current requirements of Section G and those of this Paper are indicated with a marginal line.

CHAPTER G4-3 COMPARTMENT DESIGN AND SAFETY PROVISIONS

Para. G4-3, 5.2.2(b) is amended to read as follows:-

AB

(b) Sufficient additional exits shall be provided to allow evacuation should the rotorcraft come to rest on its side after an Emergency Landing on land or water, unless the probability of this situation can be shown to be Extremely Remote.

The following paragraph is added to 5.2.9 Ditching Emergency Exits*, renumbering the existing paragraph as 5.2.9(a):-

AB

(b) Non-jettisonable doors used as ditching emergency exits shall have means to enable them to be secured in a position in which they do not interfere with egress and remain so secured in all sea states and wave height/length ratios up to the maximum demonstrated to comply with the requirements of Chapter G4-10*.

---

*As contained in Blue Paper G779, "Emergency Alighting on Water"

CHAPTER G6-6 LIFERAFTS

Paragraph 2.2.2 is amended to read as follows:-

AB

2.2.2 The design and location of the installations shall be such that, under emergency conditions, and in all sea states and wave height/length ratios up to the maximum demonstrated to comply with the requirements of Chapter G4-10*, the liferafts can be launched quickly and made ready for use from any of the ditching emergency exits, the right way up, and clear of any obstructions liable to foul or damage them during launching and during boarding. (See G4-10, App.)

NOTE: Sea state and wave steepness, as defined in G4-10 App. are the most significant parameters for ditching considerations. The associated wind speeds also need to be taken into account in respect of launching and boarding liferafts.

Paragraph 2.4.1 is amended to read as follows:-

2.4.1 General. After launching it shall be possible to attach liferafts in such a position that the likelihood of the occupants of the rotorcraft being immersed while boarding them is reduced to a minimum.

G6-6 APPENDIX

"LIFERAFTS" is added to the Title of the Appendix.

The following new paragraph is added:-

2 LOCATION (See G6-6, 2.2.2) For rotorcraft carrying more than 19 occupants it is recommended that liferafts be mounted either externally, or on the ditching emergency exit doors, such as to minimise the physical effort required to release and launch them from either inside or outside the rotorcraft.

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*As contained in Blue Paper G779, "Emergency Alighting on Water"

CIVIL AVIATION AUTHORITY

BRITISH CIVIL AIRWORTHINESS REQUIREMENTS

PAPER NO. G786

7th October 1985

SECTION G
ROTORCRAFT

COMPARTMENT FIRE PRECAUTIONS
CHAPTER G4-3

INTRODUCTION

The requirements of this Paper have been agreed by the Rotorcraft Requirements Coordinating Committee, and are made effective upon acceptance of the advice of the Airworthiness Requirements Board.

TEXT OF AMENDMENTS

Material differences between the current requirements of Section G and those of this Paper are indicated by a marginal line.

The existing G4-3, 9 is replaced by the following:-

9 FIRE PRECAUTIONS (see G4-3, App. No.2)

AB

9.1 General

9.1.1 Whenever lagging is used in compartments in which pipes, tanks or equipment containing Flammable fluids are installed, suitable precautions shall be taken to prevent the wetting of the lagging by Flammable fluids as a result of normal operation, failures of the equipment, or leakage from joints or unions.

9.1.2 Pipes, tanks or equipment containing Flammable fluids shall not be installed in passenger, crew, cargo or baggage compartments, unless adequately shielded or otherwise protected against damage and isolated so that any breakage or failure of such an item would not create a hazard (see also G5-2, 2.4 for requirements covering portions of fuel systems in compartments).

AB

9.1.3 Insulated electrical wire and cable installed in any region of the fuselage shall be self-extinguishing when tested in accordance with the '60°' test of G4-3, App. No.2, or other approved equivalent method. The average flame time after removal of the flame shall not exceed 30 seconds,and the average length of burnt insulation shall not exceed 76mm (3 in). Drippings from the test specimen shall not continue to flame for more than an average of 3 seconds.

9.1.4 Placards shall be placed in all compartments where smoking is not permitted, including all cargo, baggage and toilet compartments, stating that smoking is prohibited.

9.2 Crew and Passenger Compartments

9.2.1 Materials, including finishes and decorative surfaces applied to the materials used in each compartment occupied by the crew or passengers, shall be such that compliance is shown with (a) to (d) as appropriate.

(a) Interior ceiling panels, interior wall panels, partitions, galley structure, large cabinet walls, structural floorings and the materials used in the construction of stowage compartments (other than underseat stowage compartments and compartments for stowing small items such as maps and magazines) shall be self-extinguishing when tested in accordance with the 'Vertical' test of G4-3, App. No. 2* or other approved equivalent method. The average burn length shall not exceed 150 mm (6 in.) and the average flame time shall not exceed 15 seconds from the removal of the test flame. Drippings from the test specimen shall not continue to flame for more than an average of 3 seconds after falling.

(b) Floor coverings, textiles (including draperies and upholstery), seat cushions, padding, decorative and non-decorative coated fabrics, leather, trays and galley furnishings, transparencies (with the exception of those in (c)), electrical conduit, moulded and thermoformed parts, thermal and acoustical insulation and insulation covering, air-ducting, joint and edge covering,trim strips (decorative and chafing), cargo compartment liners, cargo insulation blankets and cargo covers, that are constructed of materials that are not covered in (c) shall be self-extinguishing when tested in accordance with the 'Vertical' test of G4-3, App. No. 2* or other approved equivalent method. The average burn length shall not exceed 200 mm (8 in), and the average flame time shall not exceed 15 seconds. Drippings from the test specimen shall not continue to flame for more than an average of 5 seconds after falling.

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*As contained in this Paper

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(c) Acrylic windows and signs, parts (see (d) for small parts) constructed wholly or in part of elastomeric materials, edge lighted instrument assemblies consisting of two or more instruments in a common housing, seat belts, shoulder harnesses, cargo and baggage securing equipment including containers, bins, pallets etc. used in passenger or crew compartments shall not have an average burn rate greater than 64 mm/min (2.5 in/min) when tested in accordance with the 'Horizontal' test of G4-3, App. No.2*or other approved equivalent method.

(d) Except for electrical wire and cable insulation and small parts (such as knobs, handles, rollers, fasteners, clips, grommets, rub strips, pulleys, small electrical parts) which the Authority agrees would not contribute significantly to the propagation of fire, materials in items not specified in (a), (b) or (c) shall not have an average burn rate greater than 100 mm/min (4 in/min) when tested in accordance with the 'Horizontal' test of G4-3, App. No. 2* or other approved equivalent method.

NOTE: As far as practicable materials should be chosen to minimise the production of smoke or noxious fumes when overheated or burned.

9.2.2 Receptacles for used towels, paper and waste shall be constructed of materials resistant to fire. The receptacles shall incorporate covers or other provisions for containing a fire in the receptacle and fire containment shall be established by demonstration. (see G4-3, App. No.3*).

9.2.3 Suitable ash containers, capable of being cleaned easily, shall be provided to give adequate service in compartments where smoking is permitted.

9.2.4 In each passenger compartment in which smoking is generally permitted and which is separate from the flight crew compartment, at least one indicator shall be provided, operable by the flight crew and visible from each passenger and cabin attendant seat, to indicate when smoking is prohibited.

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*As contained in this Paper

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9.3 Toilet Compartments

9.3.1 Toilet compartments shall be considered as non-smoking compartments.

9.3.2 In addition to the placard required by 9.1.4 to be placed inside the toilet compartment, a placard indicating that smoking is prohibited inside the toilet compartment shall be placed outside this compartment at the point of entry.

9.3.3 An ash container shall be provided adjacent to each placard required by 9.1.4 and 9.3.2.

9.4 Cargo and Baggage Compartments

9.4.1 Compartments not occupied by passengers or crew shall be constructed of, or lined with, materials that have a resistance to fire at least equivalent to aluminium alloy.

9.4.2 Compartments inaccessible in flight shall be designed and sealed such that fires will be contained until a safe landing can be made, or equipped with fire detecting, indicating and extinguishing apparatus.

NOTE: Where it can be demonstrated that the presence of fire will be made known immediately, fire detecting and indicating devices may be omitted.

9.4.3 Instructions for the use of extinguishing apparatus fitted in compliance with 9.4.2 shall be placarded at the appropriate crew member's station.

9.4.4 It shall be shown by analysis and/or tests that there are adequate means to prevent hazardous quantities of smoke, flame, extinguishing agents or other noxious gases produced as a result of a fire in a cargo or baggage compartment from entering any crew or passenger compartment. Compliance with this requirement in respect of smoke, extinguishing agents or other noxious gases shall be shown by flight test, unless the sealing of the cargo or baggage compartment is such as to completely contain the fire and its combustion products, as required by 9.4.2.

9.4.5 Sources of heat within compartments shall be shielded and insulated to prevent the ignition of baggage or cargo.

A new Appendix No. 2 to Chapter G4-3 is added as follows:-

APPENDIX NO.2 TO CHAPTER G4-3

FLAME RESISTANCE TESTING FOR ROTORCRAFT INTERIOR MATERIALS

1 INTRODUCTION (see G4-3,9)

1.1 Paragraphs 1 to 6 inclusive of this Appendix contain test methods acceptable to the CAA for flame resistance testing for materials used in passenger, crew, baggage and cargo compartments. Should the Applicant elect to use any part of these paragraphs 1 to 6 then all the relevant paragraphs will then become mandatory as these paragraphs will only provide the intended level of airworthiness when used as a whole. The standards are associated with three types of test, and an acceptable method for each is detailed.

1.2 The tests are:-

(a) A 'Vertical' test for materials which, because of their method of use in the rotorcraft require a high degree of flame resistance.

(b) A 'Horizontal' test for materials, which because of their method of use in the rotorcraft do not require such a high degree of flame resistance.

(c) A '60^{o}' test for insulated electrical wire and cable.

1.3 The methods detailed in this Appendix determine the resistance of materials to flame and glow propagation. They are written in detail in order to reduce the variability of flame resistance testing technique and results.

NOTE: The test methods detailed in JAR 25 Appendix F are accepted as equivalent.

2 SPECIMENS

2.1 Conditioning. Specimens must be conditioned to 70°F, ±5°, and at 50%, ±5%, relative humidity until moisture equilibrium is reached or for 24 hours. Only one specimen at a time may be removed from the conditioning environment immediately before subjecting it to the flame.

2.2 Configuration

2.2.1 Except as provided for materials used in electrical wire and cable insulation and in small parts, materials must be tested either as a section cut from a fabricated part as installed in the rotorcraft or as a specimen simulating a cut section, such as: a specimen cut from a flat sheet of the material or a model of the fabricated part. The specimen may be cut from any location in a fabricated part; however, fabricated units, such as sandwich panels, may not be separated for test.

2.2.2 The specimen thickness must be no thicker than the minimum thickness to be qualified for use in the rotorcraft, except that:-

(a) thick foam parts, such as seat cushions, must be tested in ½ inch thickness;

(b) when showing compliance with G4-3, 9.2.1(d) for materials used in small parts that must be tested, the materials must be tested in no more than 1/8 inch thickness;

(c) when showing compliance with G4-3, 9.1.3 for materials used in electrical wire and cable insulation, the wire and cable specimens must be the same size as used in the rotorcraft.

2.2.3 In the case of fabrics, both the warp and weft direction of the weave must be tested to determine the most critical flammability condition.

2.2.4 When performing the tests prescribed in paragraphs 3 and 4 of this Appendix, the specimen must be mounted in a metal frame so that:-

(a) in the vertical tests of paragraph 3, the two long edges and the upper edge are held securely;

(b) in the horizontal test of paragraph 4, the two long edges and the edge away from the flame are held securely;

(c) the exposed area of the specimen is at least 2 inches wide and 12 inches long, unless the actual size used in the rotorcraft is smaller; and

(d) the edge to which the burner flame is applied must not consist of the finished or protected edge of the specimen but must be representative of the actual cross-section of the material or part installed in the rotorcraft.

3 VERTICAL TEST (See G4-3, 9.2.1 (b))

3.1 A minimum of three specimens must be tested and the results averaged. For fabrics, the direction of weave corresponding to the most critical flammability conditions must be parallel to the longest dimension. Each specimen must be supported vertically. The specimen must be exposed to a Bunsen or Tirrill burner with a nominal 3/8 inch inside diameter tube adjusted to give a flame of $1\frac{1}{2}$ inches in height. The minimum flame temperature measured by a calibrated thermocouple pyrometer in the centre of the flame must be 1550°F. The lower edge of the specimen must be $\frac{3}{4}$ inch above the top edge of the burner. The flame must be applied to the centreline of the lower edge of the specimen. For materials covered by G4-3, 9.2.1 (a), the flame must be applied for 60 seconds and then removed. For materials covered by G4-3, 9.2.1 (b), the flame must be applied for 12 seconds and then removed. Flame time, burn length, and flaming time of drippings, if any, must be recorded. The burn length determined in accordance with paragraph 6 of this Appendix must be measured to the nearest 1/10 inch.

3.2 Apparatus. Tests shall be conducted in a draught-free cabinet constructed of sheet metal and fitted out in accordance with Figure 1 (G4-3 App. No.2). The inside wall, opposite the glass panelled door, shall be painted black to facilitate the viewing of the test specimen. Means shall be provided for the withdrawal and extinction of the burner from the test specimen, in order to observe the after-flame and after-glow characteristics without opening the cabinet door. The cabinet shall be equipped such that the centre of the lower edge of the specimen is 19 mm ($\frac{3}{4}$ in) above the centre of the top edge of the burner. Means shall be provided for clamping and supporting the specimen in a vertical position in a metal frame so that the two vertical edges and the upper edge are held securely. The exposed area shall be at least 50 mm (2 in) wide and 305 mm (12 in) long. An acceptable frame size and position in the cabinet is illustrated in Figure 1 (G4-3 App. No.2).

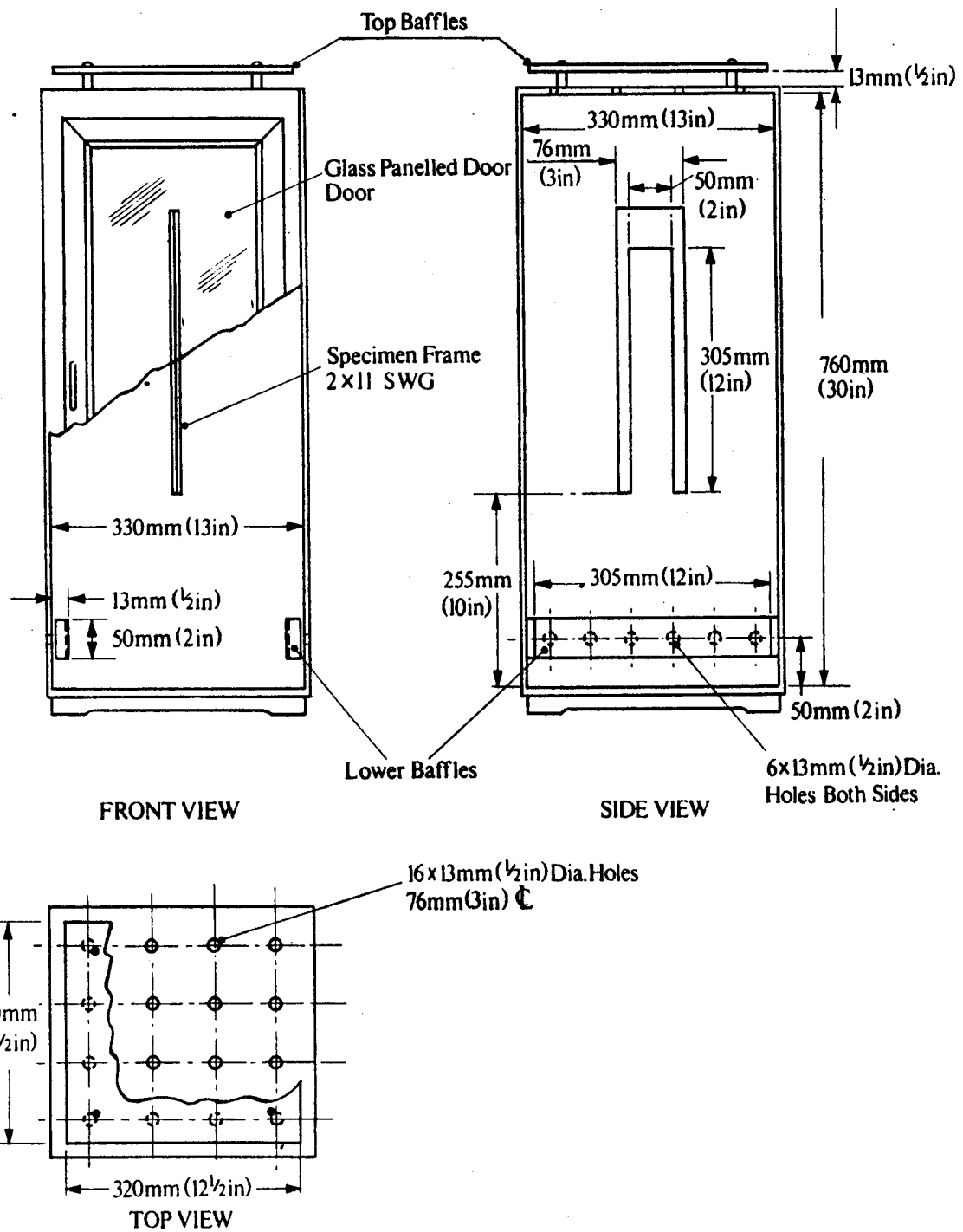
4 HORIZONTAL TEST (see G4-3, 9.2.1 (c) and (d))

4.1 A minimum of three specimens must be tested and the results averaged. Each specimen must be supported horizontally. The exposed surface when installed in the aeroplane must be face down for the test. The specimen must be exposed to a Bunsen burner or Tirrill burner with a nominal 3/8 inch inside diameter tube adjusted to give a flame of $1\frac{1}{2}$ inches in height. The minimum flame temperature measured by a calibrated thermocouple pyrometer in the centre of the flame must be $1550^{o}F$. The specimen must be positioned so that the edge being tested is $\frac{3}{4}$ inch above the top of, and on the centreline of, the burner. The flame must be applied for 15 seconds and then removed. A minimum of 10 inches of the specimen must be used for timing purposes, approximately $1\frac{1}{2}$ inches must burn before the burning front reaches the timing zone, and the average burn rate must be recorded.

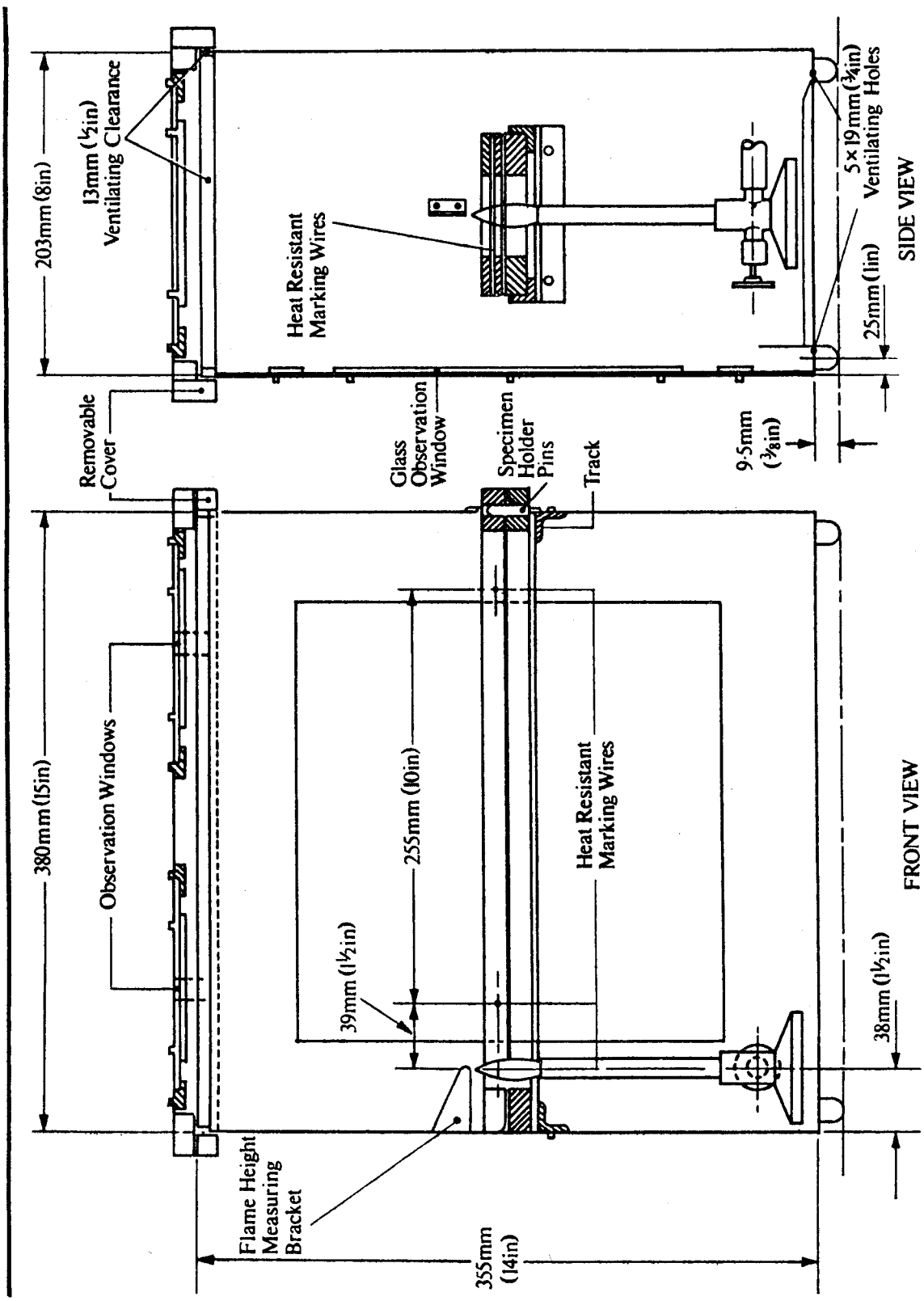
4.2 Apparatus

4.2.1 Tests shall be conducted in a draught-free cabinet constructed of sheet metal and fitted out in accordance with Figure 2 (G4-3 App. No.2).

4.2.2 The cabinet shall be 203 mm (8 in) wide, 380 mm (15 in) long and 355 mm (14 in) high, with a glass observation window in the front. It shall have a removable cover which contains two heat resistant glass observation windows one near each end of the cabinet, with a 13 mm ($\frac{1}{2}$ in) ventilating clearance all around. Each corner of the base shall have a support so that the floor of the cabinet is raised 9.5 mm(3/8 in)above the surface upon which it is placed. The base of the cabinet shall have five equally spaced 19 mm ($\frac{3}{4}$ in) ventilating holes along both longer sides of the cabinet. The cabinet shall have a slot in one end and a horizontal supporting track, such that when the specimen holder is positioned on the track the centre of the end of specimen will be 19 mm ($\frac{3}{4}$ in) above the burner top.



VERTICAL FLAME TEST CABINET
Fig. 1 (G4—3 App. No. 2)



HORIZONTAL FLAME RESISTANCE APPARATUS
Fig. 2 (G4—3 App. No. 2)

5 60^{o} TEST (see G4-3, 9.1.3)

A minimum of three specimens of each wire specification (make and size) must be tested. The specimen of wire or cable (including insulation) must be placed at an angle of 60^{o} with the horizontal in the cabinet specified in paragraph 4 of this Appendix with the cabinet door open during the test or must be placed within a chamber approximately 2 ft high x 1 ft x 1 ft, open at the top and at one vertical side (front), and which allows sufficient flow of air for complete combustion, but which is free from draughts. The specimen must be parallel to and approximately 6 inches from the front of the chamber. The lower end of the specimen must be held rigidly clamped. The upper end of the specimen must pass over a pulley or rod and must have an appropriate weight attached to it so that the specimen is held tautly throughout the flammability test. The test specimen span between lower clamp and upper pulley or rod must be 24 inches and must be marked 8 inches from the lower end to indicate the central point for flame application. A flame from a Bunsen or Tirrill burner must be applied for 30 seconds at the test mark. The burner must be mounted underneath the test mark on the specimen, perpendicular to the specimen and at an angle of 30^{o} to the vertical plane of the specimen. The burner must have a nominal bore of 3/8 inch, and must be adjusted to provide a 3 inch high flame with an inner cone approximately one third of the flame height. The minimum temperature of the hottest portion of the flame, as measured with a calibrated thermocouple pyrometer, may not be less than $1750^{o}F$. The burner must be positioned so that the hottest portion of the flame is applied to the test mark on the wire. Flame time, burn length, and flaming time of drippings, if any, must be recorded. The burn length determined in accordance with paragraph 6 of this Appendix must be measured to the nearest 1/10 inch. Breaking of the wire specimens is not considered a failure.

6 BURN LENGTH Burn length is the distance from the original edge to the farthest evidence of damage to the test specimen due to flame impingement, including areas of partial or complete consumption, charring, or embrittlement, but not including areas sooted, stained, warped, or discoloured, nor areas where the material has shrunk or melted away from the heat source.

A new Appendix No. 3 to G4-3 is added as follows:-

APPENDIX NO.3 TO CHAPTER G4-3

TESTING FOR CORROSIVE IMPURITIES IN TEXTILES

1 GENERAL

1.1 It is recommended that all textile materials should be tested to ensure they are not liable to seep corrosive elements which might affect the rotorcraft structure.

1.2 There are several processes by which non-flame-resistant materials can be made flame-resistant. Care should be taken, when choosing a process, to ensure that it will not cause corrosion by seepage when used in the vicinity of metal structure.

1.3 Compounds used for flame resistance, whether added during the manufacture of the material, or by application to the surface, should not accelerate corrosion of the metal against which the material is placed.

2 Chemical Seepage Tests. One such test which is acceptable for this purpose is that described in British Standard Specification F 100 Inspection and Testing Procedures and Certain Basic Requirements for Textiles for Aeronautical Purposes,* and the test should also comply with 2.1 to 2.3.

2.1 The pH value of the aqueous extract should be not less than 5 and not greater than 8.

2.2 There should be not more than 0.1% of water soluble chlorides expressed as Sodium Chloride, NaCl.

2.3 There should be not more than 0.25% of water soluble sulphates expressed as Sodium Sulphate, Na_2SO_4.

*Obtainable from the British Standards Institution, British Standards House, 2 Park Street, London, W1A 2BS.

A new Appendix No. 4 to G4-3 is added as follows:-

APPENDIX NO.4 TO CHAPTER G4-3

WASTE RECEPTACLE FIRE PRECAUTIONS (see G4-3, 9.2.2)

1 MATERIALS

Receptacles should be constructed of materials, which are flame resistant (see G4-3, App. No.2), and which in addition, retain sufficient mechanical properties to contain a fire as may develop by burning of such material as paper towels within the receptacle. (It should be noted that a thermoplastic material may be flame resistant but will not necessarily retain adequate mechanical properties in case of a fire).

2 CONSTRUCTION

2.1 The receptacle should be completely enclosed with the exception of a self closing entry flap or door, which itself should be rigid and when closed form as airtight a seal as is practicable. Entry flaps or doors should be designed so that they remain self closing even after exposure to fire within the receptacle.

2.2 The receptacle may be open topped provided that it is mounted in a cabinet which itself complies with 1 and 2.1. In this case, the door of the cabinet should be of robust construction, ensures an adequate seal, and withstand misuse in service. Such cabinets should not contain other flammable materials, potential fire sources (e.g. electrical apparatus) or apertures which would either allow air to feed a fire or permit a fire to spread beyond the cabinet (e.g. through apertures provided for services).

2.3 It is recognised that some receptacles, e.g. paper towel dispensers, cannot readily be designed in accordance with 2.1 and 2.2. In such cases, they should be designed and positioned within the compartment to ensure that:-

(a) cigarette ends etc. are not likely to be deposited into the receptacle, and

(b) a fire, which could be expected to start in another container, cannot readily spread to them; for example, a paper towel dispenser should not be positioned adjacent to, or immediately above, either the entry flap or door of a waste container or an ash tray provided in the compartment.

CIVIL AVIATION AUTHORITY

BRITISH CIVIL AIRWORTHINESS REQUIREMENTS

PAPER NO. G805

SECTION G
ROTORCRAFT

14th July, 1988.

CRASH LANDING - PROTECTION OF OCCUPANTS

INTRODUCTION

The requirements of this Paper have been agreed by the Rotorcraft Requirements Co-ordinating Committee, and are made effective upon acceptance of the advice of the Airworthiness Requirements Board.

TEXT OF AMENDMENTS

Material differences between the proposals of this Paper and the current requirements of Section G are indicated with a marginal line.

(1) Add the following definition of Local Attachments to Chapter G1-2, as paragraph 6.7.

6.7 Local Attachments. This term is used in connection with the crash landing conditions (see Chapter G3-8) of the requirements. It includes those attachment devices, e.g. bolts, fasteners, lugs, seat rails etc., and adjacent structure (both of the item of equipment under consideration and of the rotorcraft) which by their nature are liable to fail (and hence allow detachment of the item) rather than to yield in a crash landing.

(2) Add the following consequential editorial amendments to G4-4. 2.3.5 Seat Strength and G4-4, 3.3.2 Safety Belt and Harness Strength, respectively, deleting existing 2.3.5 and 3.3.2:-

2.3.5 The seat Local Attachments shall achieve a factor of 1.33 on the crash landing inertia loads prescribed in G3-8, 2.1.

3.3.2 Local Attachments restraining the occupants in a crash landing shall achieve a factor of 1.33 on the crash landing inertia loads prescribed in G3-8, 2.1.

(3) Replace the existing Chapter G3-8 and its Appendix by the following:-

CHAPTER G3-8 CRASH LANDING CONDITIONS

A.B 1 **INTRODUCTION** The requirements of this Chapter are intended to ensure that in the event of a rotorcraft making a crash landing in which inertia forces up to the prescribed maxima occur, the safety of the occupants has been fully considered.

2 GENERAL (see G3-8 Appendix) The design of the rotorcraft shall be such that there will be every reasonable chance that the occupants will avoid injury in the event of a crash landing in which inertia forces up to the maxima prescribed in 2.2 are developed.

2.1 Inertia Forces. All combinations of those inertia forces prescribed below shall be considered excepting those giving a resultant exceeding 6 g. The prescribed forces are expressed in terms of ultimate accelerations. The direction of the forces shall be taken as relative to the rotorcraft.

6 g downwards to 3 g upwards
4 g forwards to 3 g backwards
zero to 3 g sideways

2.2 Equipment. Items of equipment shall, so far as is practical, be positioned so that if they break loose they are unlikely to cause injury to the occupants, or to nullify any of the escape facilities provided. When such positioning is not practical, Local Attachments shall achieve a factor of 1.33 on the inertia forces of 2.1.

2.3 Engines and Gear Boxes. The Local Attachments of any engines, gear boxes or auxiliary power units which would pass through any part of the normal passenger or crew accommodation, or the fuel tanks, when subjected to any combination of inertia forces prescribed in 2.1 shall be such as to achieve a factor of 1.33 on those forces.

APPENDIX TO CHAPTER G3-8

CRASH LANDING CONDITIONS

1 DESIGN (See G3-8,2) In considering design for crash landing conditions the following requirements should be addressed:-

(a) Cargo and Baggage Compartments. Positioning and security of cargo and baggage, see G4-3, 3.3.

(b) Emergency Exits. Damage to exits during a crash landing and location of exits to avoid passengers leaving the rotorcraft in regions of spilt fuel, hot engine parts etc., see G4-3, 5.2.2. Avoidance of jamming see G4-3, 5.1.5 and G4-3, 5.2.6.

(c) Seats

(i) Design and strength for crash landings, see G4-4, 2.2 and 2.3.

(ii) Installation, access to essential emergency equipment or exits, see G4-4, 2.4.

(d) Safety Belts and Harnesses. Strength and attachment, see G4-4, 3.3 and 3.4.

(e) Fuel Tanks. Crash protection, see G5-2, 2.9.

(f) Fire Precautions. Crash conditions, fire hazard, see G5-8, 3.4. Shut-off means, flammable liquids, see G5-8, 4.3.5.

(g) Oil Tanks Installation, see G5-3, 3.2.5(a).

(h) Exhaust Systems See G5-6, 2.2.

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CIVIL AVIATION AUTHORITY

BRITISH CIVIL AIRWORTHINESS REQUIREMENTS

SECTION G
ROTORCRAFT

PAPER NO. G809

5TH SEPTEMBER 1986

SUB-SECTION G7 - ROTOR AND TRANSMISSION SYSTEM TESTS

CHAPTER G7-4 GROUND AND FLIGHT TESTS - MULTI-TURBINE ENGINE INSTALLATIONS

INTRODUCTION

The requirements of this Paper have been agreed by the Rotorcraft Requirements Co-ordinating Committee, and are made effective upon acceptance of the advice of the Airworthiness Requirements Board.

TEXT OF AMENDMENTS

Material differences between the current requirements of Section G and those of this Paper are indicated with a marginal line.

Existing Chapter G7-4 is deleted and replaced by the following:-

SUB-SECTION G7 ROTOR AND TRANSMISSION SYSTEM TESTS

CHAPTER G7-4 GROUND AND FLIGHT TESTS - MULTI TURBINE ENGINE INSTALLATIONS

AB 1 INTRODUCTION This Chapter prescribes requirements and tests for helicopters with more than one turbine engine. See also G7-1 and G7-2 for the general requirements and conditions applicable to this Chapter G7-4.

NOTES: (1) When reviewing the results of these tests the Authority will also take into consideration the development history of the Rotor and Transmission System.

(2) Where modifications are introduced as a result of any of these tests, or if modifications are incorporated in the helicopter which could affect the conditions of operation of the Rotor and Transmission System, all the tests already completed will need to be repeated with the modifications embodied in the helicopter unless otherwise agreed by the Authority.

2 GENERAL

2.1 Test Helicopters. The tests shall be made on helicopters which are representative of the helicopter type for which certification is sought, unless otherwise agreed by the Authority.

2.2 The Rotor and Transmission System operating limitations shall be determined having regard to the values demonstrated during the type tests, due allowance having been made for the overall limits of accuracy of the instrumentation declared for use in service, and shall conform to the following:-

(a) Rotor Speed.

(i) Rotor Maximum RPM (power off) (autorotation) shall not exceed 95% of the lesser of the maximum rpm shown during the type tests or the maximum design rpm.

(ii) Rotor Minimum RPM (power off) shall be not less than 105% of the greater of the minimum rpm shown during the type tests or the minimum design rpm.

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(iii) Maximum RPM (power on) shall be the time weighted mean value demonstrated during the ground endurance tests, appropriate to each condition in 2.2(b) and 5.2.

(iv) Rotor Minimum RPM (power on) shall be not less than the minimum shown during the ground endurance test appropriate to each condition in 5.2 parts 4 and 6.

NOTE: Where Rotor Speed limitations for ground running are outside these values, they should be declared and substantiated.

(b) Torque. Each declared transmission torque limitation shall be based on the mean values recorded during the appropriate tests.

NOTE: Torque is intended to mean engine output Torque, with the assumption that this is obtained equally from all operating engines (unless some other proportion has been declared and adequately demonstrated).

(c) Oil Temperature and Pressure. The operating limitations shall be based on the time weighted mean values recorded during the appropriate periods of the endurance test or equivalent rig tests. (Ref 5.1.6 and 5.1.7)

NOTE: Any short period temperature limitation may be substantiated by variation of the endurance test or supplementary rig tests.

2.3 Following each of the tests prescribed in paragraph 5 through 14 the Rotor and Transmission System shall be dismantled sufficiently to identify by inspection any deterioration or change caused by the test conditions. Except where stated otherwise the condition of the parts shall be serviceable.

NOTE: The applicant may choose to combine tests (except that prescribed in 5.2) without intermediate inspection. However, such actions might disqualify each test in the event of a failure.

3 VIBRATORY STRESS SURVEY *

3.1 A vibratory stress survey shall be carried out on the Rotor and Transmission System in a representative helicopter to provide in flight stress measurements for the strength analysis and to provide the basis for the test conditions incorporated in the ground endurance test schedule.

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* NOTE: The survey is an integral part of the flight strain survey; refer to G3-1 Appendix 2 para. 4 for additional detail.

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3.2 The Rotor and Transmission System shall be equipped with sufficient strain measurement devices on sufficient components to provide a basis for reliably estimating all the loads acting in the Rotor and Transmission System. Critical components shall normally be equipped with strain measurement devices.

3.3 The vibratory stress survey shall be made over the full range of both ground and flight conditions. The effects of ambient temperatures and other atmospheric conditions (e.g. gusts) shall be taken into account. Investigation of the effects of operating with each engine stopped under all conditions up to Rotor Maximum Contingency Torque, shall be included. The interactive effects of control system characteristics and control displacements shall be included. Adequate damping or frequency separation shall be confirmed in respect of the engine fuel control system frequency response and the transmission first order torsional vibration characteristics.

3.4 It shall be demonstrated that no dangerous torsional or flexural vibrations occur at any permissible torque and at any rotational speed up to

(a) 105% of the Rotor Maximum RPM (Power On)

(b) 105% of the Rotor Never Exceed RPM

and down to

(a) 95% of the Rotor Minimum RPM (Power On)

(b) 95% of the Rotor Minimum RPM (Power Off).

3.5 The survey shall cover likely combinations of such conditions as:-

(a) starting and stopping the engine(s) and rotors at any permissible control setting on the ground or as applicable in flight,

(b) rotor out of balance,

(c) the most critical cases of clutch/freewheel and rotor brake operation,

(d) transient rotor speeds and torques.

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3.6 Shafts - Critical Speeds. The critical speeds of all shaft systems shall be determined by test or by calculation if reliable methods of analysis are available for the particular design, to demonstrate the absence of hazardous resonant conditions, with appropriate margins.

3.6.1 Where the speeds are determined by test, it shall be demonstrated that no dangerous vibrations occur at any rotational speed up to:-

(a) in the case of the Rotor System:-

105% of the Rotor Never Exceed RPM

(b) in the case of the remaining parts of the Transmission System:-

105% of the Rotor Maximum RPM (Power On)

in association with the most adverse torque.

NOTE: A representative test rig may be used.

3.6.2 Where the speeds are determined by calculation, and a critical speed lies within or close to the operating ranges for idling, power on or autorotation conditions, it shall be established by test that the stresses are within safe limits. The margin between the calculated critical speed and the allowable operating range shall be sufficient to allow for possible variation between the calculated and actual value for a nominal shaft. (A minimum margin is normally 30%).

4 REFERENCE VIBRATION LEVELS At specific reference stations in the helicopter, the levels of vibration shall be established using accelerometers and shall be:-

(a) comparable to the measured values obtained during the vibratory stress survey of para.3,

(b) representative of the qualitative vibration characteristics of the aircraft as accepted for type certification.

NOTE: The values obtained are to be published in the appropriate manual and used for comparison with the vibration levels on series helicopters when new, in service and after major rework.

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5 ENDURANCE TESTS

5.1 Conditions.

5.1.1 Detail Inspections. Prior to assembly for the test, the Rotor and Transmission System shall be subjected to a complete detailed inspection and a record shall be made of those dimensions liable to change by reason of wear and/or distortion. The process shall be repeated on completion of the test. Following the test, all parts shall be capable of further functioning.

5.1.2 Torque Calibration. The torque measuring systems shall be suitably calibrated before and after the completion of the Ground Endurance Test so that an accurate assessment of the power developed during the test may be made. Points at which the torque is to be measured shall be defined and the limitations presented to the flight crew shall be derived from these points.

5.1.3 Restraint. The method of restraint for the test shall be to the satisfaction of the Authority.

5.1.4 Rotor Balance. The degree of out of balance before, during and at the conclusion of the test shall be recorded, and taken into account in preparing the maintenance instructions regarding rotor balancing.

5.1.5 Change of Power Settings. The time taken in changing power settings during the test shall not be deducted from the prescribed periods at higher settings.

5.1.6 Oil Pressure. Nineteen stages of the test shall be run with the transmission oil pressure(s) set to give the declared normal operating pressure at Maximum Continuous conditions. One stage shall be run with the pressure set to give the declared minimum operating pressure at Maximum Continuous conditions. Alternative evidence in respect of minimum operating pressure from representative rig testing may be accepted by the Authority.

5.1.7 Oil Temperature. All of Parts 2, 4, and 7 of the test shall be run at the appropriate declared maximum transmission oil temperatures. If this is not possible, additional testing on the declared transmission may be completed on test rigs at the appropriate oil temperature.

AB

5.1.8 Rotor Starts, Accelerations/Decelerations, Clutch and Brake Engagements.

(a) If clutches are fitted, they shall be engaged using the technique recommended by the helicopter manufacturer. Each engine deceleration shall be made as quickly as possible. If necessary the engine(s) shall be stopped in order to bring the Rotor System to rest. If a rotor brake is fitted it shall be applied on each occasion the rotor is stopped at the speed and using the technique recommended by the manufacturer. If, however, the vibration survey of Para.3 shows that the free run down is more severe, a representative number of stops shall be made without using the rotor brake. The number of clutch engagements and braked stops must each total at least 400. In the accelerations prescribed in 5.2 Part 1, the rotor pitch shall be set or controlled to give acceleration conditions at least as severe as those which can occur during the operation of the helicopter.

(b) Ten of the accelerations in Para.5.2 Part 5 shall be carried out with the transmission lubricating system at the declared minimum temperature for exceeding rotor ground idling conditions. If, because of unsuitable prevailing ambient conditions, a low enough clearance cannot be obtained by this method, suitable rig tests on the critical components may be accepted as an alternative.

5.1.9 Rotor Controls. Nine hundred complete cycles of control movements, each cycle being as prescribed in (a) and (b), shall be made at agreed intervals during the periods at Maximum Continuous conditions prescribed in 5.2 Part 2. Two hundred similar control movements shall be made with each engine shut down in sequence for equal periods, during the period at Intermediate Contingency conditions prescribed in 5.2 Part 4. Each control movement shall be at least as rapid as for normal operation, and held at the position producing the maximum transient loads for a period at least double that encountered in flight, or 10 seconds, whichever is less. In all cases the control movements need not produce loads or flapping motions exceeding the maximum loads or motions encountered in flight.

(a) The controls shall be operated up to the position of full vertical thrust, maximum forward thrust component, maximum aft thrust component, maximum left thrust component and maximum right thrust component.

(b) The directional controls shall be operated up to the extreme of maximum right turning torque and maximum left turning torque, through neutral turning torque.

AB

(c) When the rotor controls are not being cycled as prescribed in (a) the controls must be set to produce the maximum stabilised thrust for each of the directions indicated for the following percentages of test times specified in each part of the endurance test. For those parts of the test specifying transmission powers higher than maximum continuous ratings, the control shall be displaced for vertical thrust combined with the maximum mast or hub bending encountered in a stabilised hover.

Full vertical thrust	20%
Forward thrust components	50%
Right thrust components	10%
Left thrust components	10%
Aft thrust components	10%

(d) The directional controls shall be set to the torque required to react the main rotor torque at representative flight conditions throughout para.(c).

5.1.10 Test Running.

(a) The test shall be run as detailed in 5.2. Each stage shall be run as far as possible in non-stop periods.

(b) The observations referred to in G7-2, 2.1 are to be made during each part of the test:

(i) at every change of condition. During acceleration/deceleration the transient speeds and torques shall be noted,

(ii) on first establishing steady running conditions, and thence during periods of continuous steady running at approximately 30 minute intervals, and immediately prior to changing the conditions,

(iii) during cyclic conditions, sufficient observation shall be made to establish transient speeds and torques.

5.1.11 Critical Loads. Any components which can be subjected to critical loading conditions not adequately covered by the standard test conditions, e.g. bearings which can be off loaded by gear reaction or pre-loading, shall be tested by variations of the Ground Endurance Test or by additional tests acceptable to the Authority.

AB

5.2 Endurance Test Schedule. The Ground Endurance Test shall be as prescribed in this paragraph and shall consist of twenty stages, each stage comprising:-

Part	Condition	Engine	Duration	Procedure
1	Rotor Take-off Torque	All	2 hours	12 periods, each comprising: Accelerate rotor from rest to Maximum take-off torque and Maximum RPM (Power On). Maintain 5 minutes at this condition followed by 5 minutes at rotor idle RPM. Decelerate rotor to rest, using rotor brake where applicable. Acceleration and deceleration shall be at the maximum rate. Ref. para. 5.1.8.
2	Rotor Max. Continuous Torque	All	3 hours	Combine Rotor Maximum Continuous Torque with Rotor Maximum RPM (Power On). Accelerate rotor from rest at the maximum rate to Maximum Continuous Torque and speed. Decelerate the rotor to rest at the maximum rate, using rotor brake where applicable. Ref. para. 5.1.8.
3	Rotor Maximum Contingency Torque	One Engine Inoperative		Modify part 1: 2 of the 12 periods shall be run as follows:- (i) 5 mins at Rotor Maximum Take-off Torque and Maximum RPM (Power On) followed by,

AB

				(ii) $2\frac{1}{2}$ mins at Rotor Maximum Contingency Torque at Rotor RPM (Power On) alternated with:- $2\frac{1}{2}$ mins at rotor idle RPM. (iii) Repeat (ii) with each engine shut down in sequence.
4	Rotor Intermediate Contingency Torque	One Engine Inoperative	1 hour X No. of Engines	Accelerate rotor from rest to the Intermediate Contingency Torque. With each engine shut down in turn, 1 hour at Intermediate Contingency Torque, half at Rotor Maximum RPM (Power On) and half at Rotor Minimum RPM (Power On). Decelerate rotor to rest at the maximum rate using the rotor brake where applicable. Ref. para. 5.1.8.
5	Acceleration/ Deceleration cycles. (See para 5.1.8(a))	All		3 cycles each comprising:- (a) Accelerate rotors from rest to Rotor Maximum RPM (Power On) - at maximum rate in flat pitch. (b) Increase pitch at the maximum rate to Rotor Maximum Continuous Torque and maintain for 1 minute. (c) Decrease to flat pitch at the maximum rate, and stop the rotor.
6	Incrementals	All	3 hours	The test may be arranged such that the running time for each condition is accumulated over the 20 stages.

AB

				% Max. Cont.Tq. total time 10 2 hrs 30 mins 20 " " 30 " " 40 " " 50 " " 60 " " 70 15 hrs 00 mins 80 " " 90 " " ½ of each period at Rotor Maximum RPM (Power On). ½ at Rotor Minimum RPM (Power On). Accelerate rotor from rest to the test condition at the maximum rate. Decelerate the rotor to rest at maximum rate using the rotor brake where applicable. Ref. para 5.1.8.
7	Overspeed (Maximum Continuous Torque)	All	1 hour	Maximum Rotor overspeed RPM (Power On), expected in service assuming speed limiting devices function properly. Accelerate the rotor from rest to the test condition at the maximum rate. Decelerate the rotor to rest at the maximum rate using the rotor brake where applicable. Ref. para 5.1.8.

NOTES: (1) Rotor idle RPM is the minimum rotor RPM in flat pitch for ground running.

(2) If because of governor 'droop' characteristics, the rotor RPM varies with torque, the speeds for these tests shall be the maximum associated with the prescribed torques.

AB

(3) For helicopters not requiring a take-off rating, additional testing will be included in Part 2.

(4) When ambient conditions preclude the combination of maximum torque and maximum speed, additional periods at maximum speed or maximum torque will be required.

6 FLIGHT ENDURANCE TEST The requirements of 6.1 and 6.2 may be met by a separate flight test programme, or combined with other tests.

6.1 It shall be confirmed by flight test that the proposed Rotor and Transmission System operating limitations are compatible with the satisfactory functioning of these systems over the range of operating conditions and flight envelope for which certification is required.

6.2 Prior to certification, the condition of at least one Rotor and Transmission System which has completed a minimum of 150 hours shall be shown to be satisfactory. The 150 hours shall be representative of operational use and incorporate the entire flight spectrum.

7 FREE WHEEL TESTS If any severe engagement conditions can occur as a result of engine malfunctioning, mishandling or carelessly applied engagement techniques etc, tests shall be carried out to show that there is no detrimental effect on the continued satisfactory operation of the free-wheel mechanism.

8 ROTOR BRAKE ABUSE TESTS If the rotors can be started with the rotor brake applied in spite of warning devices or through a fault developing, ground tests shall be made to establish that no hazard would be introduced under these conditions.

9 OVER-TORQUE TESTS

9.1 The Rotor and Transmission System shall be subjected to a 15 minute test at the declared Rotor Maximum Over-Torque at the associated maximum rotor rpm with power on appropriate to that torque. More than one test may be involved in order to cover all parts of the Transmission System, e.g. synchronising shaft, input gear train. The tests shall be run at the most critical lubrication conditions either in the helicopter or using rigs if they are sufficiently representative.

9.2 The Rotor and Transmission System shall be subjected to a 5 minute test in accordance with 9.2.1 or 9.2.2. The test shall be run with all engines operating at the rotor speed appropriate to the torque. The test shall be run either in the helicopter or using rigs if they are sufficiently representative.

AB

9.2.1 Where a torque limiting device is fitted, the test shall be run at the maximum torque attainable under abnormal operating conditions, assuming the limiting device functions properly.

9.2.2 Where a torque limiting device is not fitted, the test shall be run at the maximum torque that could be attained under abnormal operating conditions.

9.2.3 After the tests in 9.2.1 and 9.2.2 the Rotor and Transmission Systems may be unserviceable, provided a hazardous failure has not occurred.

NOTE: Unserviceability would necessitate publication of appropriate actions in the Maintenance Manuals

10 OVERSPEED TEST

10.1 A test shall be carried out on the Rotor and Transmission System comprising twenty cycles, each cycle being of one minute duration involving:-

(a) one half minute at Rotor Maximum RPM (Power On) and Rotor Maximum Continuous Torque,

(b) one half minute at:-

(i) 5% in excess of the declared Rotor Never Exceed RPM,

or (ii) the highest speed permitted by the overspeed limiting device, whichever is the greater, and at the minimum power necessary.

10.2 Before assembly for this test and after dismantling following completion of the test, the Rotor and Transmission System shall be inspected and a record shall be made of those dimensions liable to change by reason of wear and/or distortion. After completion of this test, the Rotor and Transmission System shall still be in serviceable condition.

11 LOSS OF LUBRICATION TEST It shall be shown by test that after the total loss of oil in any part of the Rotor and Transmission primary oil systems, the following can be achieved:-

NOTE: Credit may be given for auxiliary lubrication systems, provided the loss of primary oil pressure is apparent.

(a) Group A Rotorcraft

A minimum flight duration of 10 minutes comprising forward flight cruise at a declared airspeed, followed by a power-on landing.

AB

NOTE: The condition of the Rotor and Transmission System and the actual duration demonstrated should be taken into account to determine any Flight Manual limitations in respect of a declared time interval (G4-9 para. 2.3(b)*) and power spectrum. The declared time will not normally exceed half the demonstrated time.

(b) Group B Rotorcraft

A minimum of fifteen minutes autorotation, with the integrity necessary to complete a safe landing.

12 OIL SYSTEM PRESSURE TESTS

12.1 All parts of the oil system of a representative Rotor and Transmission System, including oil pipes and integral oil passages and tanks, but excluding separate oil tanks, shall be pressure tested in accordance with this paragraph 12 and during the tests no unacceptable leaks shall occur from joints required to be liquid tight. The parts shall be capable of supporting the loads imposed during the tests without permanent distortion.

12.2 The parts shall be tested at the temperature associated with the most critical stressing case unless it is agreed by the Authority that the test pressure differential may be increased to simulate the loss of strength as a result of the temperature and account is taken of any thermal stresses that would occur.

12.3 All parts, excluding integral oil tanks, shall be pressure tested to at least 1.5 times the maximum operating pressure of the particular part, or 2.0 times the normal operating pressure, whichever is the greater. Oil tanks which are an integral part of the Rotor and Transmission System shall be pressure tested to a pressure of 1.5 times the maximum operating differential pressure or 5 lb/sq.in. more than the maximum operating differential pressure, whichever is the greater.

NOTE: Equivalent pressure tests carried out in the approval of components such as pumps, filters, etc, may be accepted as demonstrating compliance with this requirement.

13 MINIMUM OIL TEMPERATURE (see also para. 5.1.8(b))

13.1 The minimum oil temperature for starting shall be determined by test, together with any associated limitations e.g, time, pressure. The tests shall be arranged so that all parts of the transmission and the oil, are cold soaked to the same temperature. A minimum of 10 starts shall be completed.

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* As contained in Blue Paper G778.

AB

13.2 Where an accessory drive facility is provided, the associated minimum oil temperature for operation shall be established.

13.3 Where applicable the minimum oil temperature that must be attained before increasing the rotor speed up to the maximum or the application of power shall also be determined.

14 ROTOR BLADE "SAILING" If rotor blade "sailing" can occur, the Authority shall require either a demonstration that no damage to the Rotor or Transmission System can be caused, or the promulgation of an adequate inspection procedure in the appropriate manual.

15 FAULT DETECTION AND SAFETY DEVICES - TESTS

15.1 It shall be demonstrated by tests, or other means acceptable to the Authority, that those fault detection devices for which credit is given in the Safety Assessment for providing an early warning of the impending failure of a part, give adequate and reliable warning of the fault so that appropriate action can be taken before a hazardous condition arises.

15.2 In addition to the tests in 15.1 all such devices should be functional throughout the tests prescribed in this chapter.

15.3 All safety devices, including devices for increasing engine power if another engine fails, shall be fitted throughout the endurance test. Additional functional tests shall be made to demonstrate the reliability of the devices. Any limitations on the use of the devices shall be established.

CIVIL AVIATION AUTHORITY BRITISH CIVIL AIRWORTHINESS REQUIREMENTS

SECTION G

ROTORCRAFT

PAPER NO: G811

24th January 1989

HEALTH MONITORING

INTRODUCTION

The requirements of this Paper have been agreed by the Rotorcraft Requirements Co-ordinating Committee, and are made effective upon acceptance of the advice of the Airworthiness Requirements Board.

TEXT OF AMENDMENTS

Material differences between the current requirements of Section G and those of this Paper are indicated with a marginal line.

CHAPTER G1-2

Add the following new definition as 1.19 Health Monitoring:-

1.19 Health Monitoring. Equipment, techniques and procedures for measuring, extracting and acting upon information relative to the mechanical or functional condition of a system in order to detect incipient failure or degradation which could lead to failure.

CHAPTER G4-1

Add the following new paragraph as 8 Health Monitoring, and re-number subsequent paragraphs accordingly:-

8 HEALTH MONITORING Where credit is claimed for Health Monitoring techniques in establishing compliance with the Safety Assessment criteria, the design of the rotorcraft shall provide for the application of such techniques.

8.1 Critical Parts whose required safety cannot be reliably controlled throughout the life of the rotorcraft, because failures of such parts are not directly time/cycle related, shall be designed to have damage tolerant characteristics and an effective Health Monitoring technique shall be established.

8.2 For Critical Parts where a safe line has been declared, a Health Monitoring technique shall be established to monitor deterioration in service, such as to confirm that the substantiation of the declared life remains valid.

8.3 Where absolute proof of the airworthiness credit claimed for Health Monitoring is not possible, the credit shall be substantiated on the basis of previous experience, sound design and test philosophies and engineering judgement.

8.4 In establishing the airworthiness credit for Health Monitoring the qualification and reliability of the Health Monitoring equipment shall be taken into account.

CIVIL AVIATION AUTHORITY

BRITISH CIVIL AIRWORTHINESS REQUIREMENTS

PAPER NO. G815

20th November 1985

SECTION G
ROTORCRAFT

RADIO ALTIMETERS

INTRODUCTION

The requirements of this Paper have been agreed by the Rotorcraft Requirements Co-ordinating Committee, and are made effective upon acceptance of the advice of the Airworthiness Requirements Board.

TEXT OF AMENDMENTS

Material differences between the current requirements of Section G and those of this Paper are indicated with a marginal line.

CHAPTER G6-1

A new paragraph 5.8 is added as follows:-

A

5.8 Flights during which the Air Navigation Order requires a Radio Altimeter to be carried

5.8.1 A radio altimeter, together with indication within the normal scan of each pilot, capable of giving audible and visual warning of descent below a preset height above the surface.

5.8.2 The design and installation of radio altimeter height warning systems shall be such that:-

(a) An audio voice warning is provided when the rotorcraft descends below a preset height above the surface. It shall not be possible to alter this height datum in flight.

NOTE: It is recommended that the audio warning should be capable of being set to a height of approximately 150 ft.

(b) The audio voice warning is of short duration.

(c) Visual warning is provided when the rotorcraft descends below a height above the surface set by the flight crew.

5.8.3 The radio altimeter provided in accordance with 5.8.1 shall comply with the instrument installation requirements of Chapter G6-1.

CIVIL AVIATION AUTHORITY BRITISH CIVIL AIRWORTHINESS REQUIREMENTS

PAPER NO.G816

SECTION G
ROTORCRAFT

31st August, 1988

ENGINE AND TRANSMISSION SYSTEMS

GEARBOX FATIGUE TESTS

INTRODUCTION

The requirments of this Paper have been agreed by the Rotorcraft Requirements Co-ordinating Committee, and are made effective upon acceptance of the advice of the Airworthiness Requirements Board.

TEXT OF AMENDMENTS

Material differences between the proposals of this Paper and the current requirements of Section G are indicated with a marginal line.

1) Delete G3-4, and the Appendix para-1, and replace by the following:-

"SUB SECTION G3 - STRUCTURES

A.B

G3-4 ENGINE AND TRANSMISSION SYSTEM

3. FATIGUE TESTS. Parts of the Transmission System shown by the Safety Assessment of G4-9 to require a Safe Fatigue Life shall be fatigue tested to establish the safe life to the satisfaction of the Authority.

3.1 Substantiation of a Safe Fatigue Life for the Transmission Parts, shall be accomplished in accordance with G3-1 but the critical gears shall be subject to the following additional requirements:-

3.1.1 The gear tooth fatigue strength shall be substantiated by test and analysis, using safety factors acceptable to the Authority. The tests shall include running as a gear train, at appropriate maximum power levels associated with normal and one engine inoperative conditions. (See G3-4, App.).

3.1.2 Any fatigue damage other than tooth fatigue, resulting from this test must be considered and the integrity of the affected part confirmed, using appropriate load and scatter factors (given in G3-1) to establish a Safe Fatigue Life.

3.2 Procedures must be declared at the time of certification to ensure that the fatigue properties are adequately maintained throughout the life of the rotorcraft.

APPENDIX TO CHAPTER G3-4
ENGINE AND TRANSMISSION SYSTEM

1 FATIGUE TESTING OF GEARS

1.1 The tests may be conducted with the gearbox mounted on a rig, but the mast thrust and bending loads should be representative of the rotorcraft for which certification is sought. The maximum loading should be adjusted to compensate for the differences in vibratory loading experienced in the rotorcraft and on the rig. Due allowance should be made for the accuracy of torque measuring instrumentation on the aircraft.

1.2 Acceptable methods are:-

1.2.1 Single load level testing

(a) The test torque should be the maximum steady state torque for each gear multiplied by a stress factor.

NOTES: (1) Normally a stress factor of 2 is required (G3-1 App.2). The Authority is prepared to accept that adequate fatigue strength of steel gears of conventional design can be demonstrated by the use of a stress factor of 1.4 for a single test, or 1.3 for four or more tests.

In the latter case, the test specimens should be selected so that the gears do not have a common batch origin, or heat treatment.

(2) Where it can be shown that factored engine torques cause unrepresentative effects, e.g. excessive casing deflections with one engine inoperative, a reduced factor may be used for testing, however, the calculated life should be based on the fully factored endurance limit.

(b) Unless torque is measured and displayed on the flight deck, an additional scatter factor of 1.2 will normally apply. This can be included in the test torque, or allowed for when Working Endurance Limit is calculated.

(c) The test should be continued such that each part is subjected to sufficient cycles to establish either failure or freedom from fatigue damage. (Typically 10^7 cycles for steel).

(d) In the event of a test failure, the life of the gear should be calculated, having regard to the declared power spectrum and the S-N curve for the gear.

1.2.2 Spectrum Testing

(a) The test torques for each gear may be arranged to represent various levels defined by the flight spectrum multiplied by the factors in 1.2.1(a) and 1.2.1(b) with each torque applied for a representative period.

(b) The test should continue until failure, or an adequate gear life is substantiated. The procedure normally involves:-

(i) Calculation of the Mean Endurance Limit from the test results.

(ii) Calculation of the Working Endurance Limit using stress factors in 1.2.1.

(iii) A cumulative damage summation based on the flight spectrum and the S-N curve from (ii).

1.3 It is recognised that the stress factor used to account for fatigue strength scatter in the population can cause unrepresentative conditions, by virtue of distortion and lubrication film breakdown. To counteract these effects, it is permissible to modify parts, for example tooth profiles, to produce the normal tooth contact patterns for the rating. Furthermore, it is permissible to propose the best oil and oil temperature for the test, provided there is proof that such changes will not result in unrepresentative fatigue lives in relation to in-service conditions.

2 EVALUATION OF SERVICE WEAR/DAMAGE (SEE G3-4, PARA 3.1.1). Procedures are necessary to ensure that the fatigue properties of the gears are adequately maintained after certification throughout the life of the rotorcraft. It will, therefore, be necessary for the applicant to declare and initiate methods to achieve this purpose. Such methods will usually take the form of:-

(a) adequate inspection;

(b) evaluation of the effects of wear and damage on fatigue strength (including fatigue testing of worn parts);

(c) limiting lives of transmission components as necessary to preserve the fatigue properties of the gears; and

(d) exploitation of health monitoring technigues."

2) Add the following as G4-9, 3.4(b)* and re-number subsequent paragraphs accordingly:-

"(b) Damage tolerance, as an alternative to a safe fatigue life. (The method of substantiation shall be agreed with the Authority.)"

* As contained in Paper No. G778

SECTION G
ROTORCRAFT

PAPER NO. G 832

31st October 1989

PERFORMANCE GROUP A (RESTRICTED) WAT CURVES

INTRODUCTION

The requirements of this Paper have been agreed by the Rotorcraft Requirements Co-ordinating Committee and are made effective upon acceptance of the advice of the Airworthiness Requirements Board.

TEXT OF AMENDMENTS

Material differences between the current requirements of Section G and those of this Paper are indicated with a marginal line.

1) The existing G2-4,3 is amended to read:-

AB | 3 WAT CURVE (see G2-4 App.1 and 2) The Maximum Weight appropriate to the Altitude and Temperature shall be determined and scheduled, and for each altitude and temperature condition for which data is established it shall not exceed the Maximum Take-off or Landing Weight, as appropriate, and shall, at each altitude and temperature condition, allow compliance with the climb performance minima of paragraph 4 or 5 as appropriate.

2) G2-4,3.1,3.2 and 3.3 and the associated references have been re-designated as follows:-

A | 4 GROUP A

4.1 (As existing 3.1)

4.2 (As existing 3.2)

4.3 (As existing 3.3)

3) The introductory paragraph to G2-4,4 is deleted and G2-4,4.1,4.2,4.3 and 4.4 and the associated references have been re-designated as follows:-

B

5 GROUP B

5.1 (As existing 4.1)

5.2 (As existing 4.2)

5.3 (As existing 4.3)

5.4 (As existing 4.4)

4) A new G2-4,6 is added as follows:-

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6 The Applicant may also determine and schedule maximum weights for altitude and temperature, for public transport helicopters classified as helicopters of Performance Group A (Restricted) (see SI 1985/528 - Regulation 20), for each weight, altitude, temperature condition for which data is established. They shall not exceed the Maximum Take-off or Landing Weight, as appropriate, and shall, at each weight, altitude, temperature condition, enable compliance with the climb performance minima prescribed below.

At a height of 1000 feet above the Take-off or Landing Surface, the gross rate of climb, at a speed selected by the Applicant, must be not less than 150 feet per minute, with:-

a) The critical engine inoperative and the remaining engines at maximum continuous power or (for helicopters for which certification for the use of Intermediate Contingency Power is requested), at Intermediate Contingency Power;

b) The landing gear retracted.

5) Existing paragraph 5 and subsequent paragraphs are re-numbered accordingly.

CIVIL AVIATION AUTHORITY

BRITISH CIVIL AIRWORTHINESS REQUIREMENTS

SECTION G
ROTORCRAFT

PAPER NO. G839

24th January 1989

HELICOPTER HOISTS

INTRODUCTION

The requirements of this Paper have been agreed by the Rotorcraft Requirements Co-ordinating Committee and are made effective upon acceptance of the advice of the Airworthiness Requirements Board.

TEXT OF AMENDMENTS

Material differences between the current requirements of Section G and those of this Paper are indicated with a marginal line.

CHAPTER G4-12

Add the following new paragraph 3 Hoist Installations, and re-number subsequent paragraphs accordingly:-

3 HOIST INSTALLATIONS

AB

3.1 **General**

3.1.1 The requirements of this paragraph 3 apply to all equipment used for raising and lowering loads, including persons, independent of the vertical movement of the rotorcraft itself. A rotorcraft carrying a load on a hoist is classified as a Class B rotorcraft/load combination. See also paragraph 4 (existing paragraph 3) for other requirements relating to load release devices.

3.1.2 All hoist equipment shall be of an approved type.

3.2 **Hoist Cables**

3.2.1 The hoist cable shall be positively attached to the hoist drum.

3.2.2 A suitable length of the cable nearest the attachment to the hoist drum, dependent on the maximum extension speed of the cable, shall be marked to indicate to the hoist operator that the cable is nearing full extension.

3.2.3 Means shall be incorporated to automatically stop cable movement when the operational limits of extension and retraction are reached.

A

3.3 Personnel Hoisting

3.3.1 If approval of the hoist installation for raising and lowering persons is required, the hoist installation shall:-

(a) be operable by a crew member who has no other duties during the operation, and who is in direct communication with the pilot.

(b) include a hoist operator's station which allows direct vision by the hoist operator of all phases of the hoisting operation, and which is provided with suitable restraint means.

(c) allow operation of the cable emergency release by the hoist operator, and

(d) be such that the probability of inadvertent operation of the emergency release, or of it not operating when required, is Extremely Remote.

NOTE: In addition to the general strength requirements (see paragraph 2.2.1), appropriate fitting factors should be used for joints subject to wear, vibration and disassembly, and cable factors appropriate to cable operated flying controls subject to wear and flexing should be applied to the hoist cable.

3.3.2 No Failure, including Critical Power-unit failure, which is not Very Remote, shall result in an effect such as a manoeuvre or change in rotorcraft position which could hazard any person suspended from the hoist.u

AB

3.4 Control of Rotorcraft from Hoist

3.4.1 Where a facility for controlling the rotorcraft for the purpose of minor position adjustment during hoist operations is provided at or adjacent to the hoist position, this facility shall:-

(a) comply with G4-8 if it is part of the mechanical flight control system, or G6-4 if it is part of the automatic flight control system,

(b) be of limited authority, and shall not be capable of demanding excessive rotorcraft attitude changes.

NOTE: It is recommended that the control should not be capable of demanding an acceleration of more than 3.5 ft/sec^2 in any horizontal direction.

(c) be such that the pilot can override any control inputs from the facility at all times, including subsequent to any Failure that is more probable than Extremely Remote, and

(d) be such that it can be isolated by the pilot in flight from the primary control system.

Add the following cross reference to the heading of paragraph 3.2 (now 4.2):-

A 3.2 (now 4.2) **Release Devices** (See paragraph 3.3 for requirements relating to release devices for hoist installations approved for the raising and lowering of persons).

Add the following new paragraph 8(b)(iv) after current paragraph 7(b)(iii) (now 8(b)(iii)).

A (iv) For approval for the raising and lowering of persons, the Maximum Weight at which, following failure of the Critical Power-unit, an out-of-ground-effect hover can be maintained.

Delete the following words from paragraph 7(d) (now paragraph 8(d)):-

(in relation to ground personnel)

SECTION G

Issue 9 16th August, 1982

EXPLANATORY NOTE

1 INTRODUCTION The changes introduced into Issue 9 of Section G are listed in this Note. The full extent of amendments to any particular Chapter or Appendix can be determined by reference to the marginal lines in the appropriate Chapter or Appendix.

2 TECHNICAL CHANGES

2.1 **Instrument Flight.** Amendments have been made to the following Chapters and Appendices to add requirements necessary for certification for instrument flight.

Chapter G1—1 General
Chapter G2—6 Handling—General
Chapter G2—8 and Appendix Handling—Controllability
Chapter G2—9 Handling—Ability to Trim
Chapter G2—10 and Appendix Handling—Stability
Chapter G6—1 Equipment Installations—General

2.2 **Chapter G5—2, Fuel Systems.** Requirements for the reliability of jettisoning systems installed to meet operational performance requirements have been added.

2.3 **Chapter G6—4, Automatic Flight Control and Stability Augmentation Systems.** A new Chapter on this subject has been added giving requirements to provide the desired level of dynamic stability necessary for satisfactory instrument flight.

2.4 **Chapter G6—10, Attitude Display Systems.** A new Chapter on this subject has been added giving the requirements necessary for instrument flight.

3 FURTHER AMENDMENTS The changes given below are brought to the attention of the reader, who may wish to make the amendments by hand.

3.1 The last line of G2—7, 4.1 should be amended to read "of sea state as defined in G4—10 App. Table 1."

3.2 In the footnote, G3—2 page 2 "G1—1, 5(b)" should be amended to read "G1—1, 5".

3.3 In line 4 of G3—13, 2.1, the word, "if" should be amended to read "of".

3.4 In line 3 of G6—7, 5.2, "0·05" should be amended to read "0·5".

3.5 In line 4 of G8—2 App., 1.1 "Section D, Chapter D6—4" should be amended to read "G6—4".

4 EDITORIAL

4.1 **Papers Incorporated.** The following Blue Papers have been incorporated in this Issue 9 of Section G.

No. 612 Instrument Flight

No. 615 Automatic Flight Control and Stability Augmentation Systems. Chapter G6—4

No. 722 Chapter G6—10 Attitude Display Systems

No. 744 Fuel Jettisoning Systems—Chapter G5—2.

British Civil Airworthiness Requirements

Section G
Rotorcraft

Issue 9

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FOREWORD—SECTION G

Revised, 16th August, 1982

1 PURPOSE British Civil Airworthiness Requirements (hereinafter referred to as the "Requirements") of which Section G is a constituent part, are published by the Civil Aviation Authority (hereinafter referred to as the "Authority"—except in Chapters published prior to 20th January, 1975, where reference is to the "Board"). They comprise minimum requirements and constitute the basis for the issue of approvals and certificates required by the Air Navigation Order 1972, as amended.

2 INTERPRETATION

2.1 The Requirements, with or without explanatory matter, should not be regarded as constituting a text-book of current aeronautical knowledge; interpretation of the Requirements against a background of such knowledge is essential.

2.2 Where necessary, the Requirements are supplemented by Appendices printed in blue for easy recognition. Generally these Appendices take the form of acceptable interpretations of requirements, or state recommended practices, or give supplementary information.

2.3 Mandatory clauses are invariably denoted by the use of "shall"; "should" or "may" are used in the text to introduce permissive or recommended clauses.

2.4 It is implicit in requirements expressed qualitatively (e.g. "readily visible", "adequately tested") that the Authority will adjudicate in cases where doubt exists.

3 PRESENTATION

3.1 **Arrangement of Requirements.** This Section G is so arranged that requirements of general applicability are presented at the beginning of appropriate parts of the Section (For example **G1—1** "General" states "Adequate notice of intention to make tests shall be given to the Authority and facilities shall be provided for the tests to be witnessed by a representative of the Authority", Chapter **G5—1** "Power-Plant Installations—General" states "Pipes and ducts connected to components of the aeroplane between which relative motion might occur shall incorporate provision for flexibility.") This arrangement avoids the need for frequent repetition of such generally applicable requirements, (which would necessitate an increase in the size of the Section) and simplifies the amendment processes. Thus—

(a) Sub-section G1, General and Definitions (Chapters **G1—1, G1—2** and **G1—3**) is applicable to the whole of Section G.

(b) The first Chapter of each Sub-section is a General Chapter which serves not only to introduce the Sub-section but contains requirements generally applicable to the subject matter thus avoiding the need for repetition in the various Chapters.

(c) Where the subject matter does not prevent it, general requirements are placed at the beginning of each Chapter, thus avoiding the need for repetition in the various paragraphs.

Hence, to avoid any oversight and to obtain full benefit of the presentation, a reader, even though only concerned with a specific subject, should be familiar with the Foreword, the requirements and definitions of Sub-section G1 and at least the General Chapter for the Sub-section in which the particular requirements in which he is interested appear.

NOTE: The General Chapter to Sub-section G4 "Design and Construction" has an applicability wider than its Sub-section, and it is advisable for the reader to be familiar with the general requirements of this Chapter as well.

3.2 Technical

3.2.1 **Performance Group System.** The requirements of Section G distinguish between the following groups.

(a) **Group A.** Rotorcraft with more than one Power-unit, with performance such that, in the event of the failure of one Power-unit, it is possible either to continue the flight or to land back on the take-off area.

(i) **Group A1.** Group A rotorcraft, having engineering standards such that the probability of an Emergency Landing may be considered as Remote.

(ii) **Group A2.** Group A rotorcraft, having engineering standards such that the probability of an Emergency Landing may be considered as Reasonably Probable.

(b) **Group B.** Rotorcraft with performance such that, in the event of the failure of one Power-unit at any point en-route, a landing has to be made.

3.2.2 **Agricultural Rotorcraft.** Where a rotorcraft is intended to be used for agricultural purposes the requirements applicable to the agricultural equipment are contained in **G4—11.** Requirements applicable to the rotorcraft are contained in the appropriate parts of the Section.

3.2.3 **Engines**

(a) Those Chapters which have been "Issued" or "Revised" subsequent to the 1st January, 1954, take into account the needs of rotorcraft fitted with turbine engines. Hence, except where the applicability according to type of engine is specifically stated in the particular Chapter, these Chapters apply equally to rotorcraft fitted with piston or turbine engines.

(b) Those Chapters which were "Issued" on 1st January, 1954, were not prepared to take account of rotorcraft fitted with turbine engines. Chapters which have been "Revised in Part" subsequent to 1st January, 1954, have not necessarily been prepared to take account of rotorcraft fitted with turbine engines. Much of the contents of these Chapters will be clearly applicable irrespective of the type of engine but where there is doubt the Authority shall be consulted; appropriate changes to extend the applicability will be made as these Chapters are amended in future issues.

3.3 Editorial

3.3.1 Section G is divided by subjects into Sub-sections numbered consecutively. The Sub-sections are further divided into Chapters, the number of each Chapter being associated with its Sub-section (e.g. Sub-section G2 contains Chapters G2—1, G2—2, G2—3, etc., up to G2—10).

3.3.2 A list of the subjects covered by the Sub-sections and Chapters is given in the CONTENTS. In addition, the subjects of individual paragraphs are included in the INDEX.

3.3.3 A system of progressive paragraph numbering is used but the number of digits is kept to a maximum of three by associating the system with paragraph headings. A paragraph heading applies to all succeeding paragraphs until another titled paragraph with the same, or a smaller number of digits occurs.

3.3.4 In the absence of any indication to the contrary (see, however, 3.3.5 and 3.3.6), requirements and recommendations are applicable to all rotorcraft.

3.3.5 The method of indicating the applicability of the requirements in terms of Performance Groups is by printing in the margin the symbols A, A1, A2 or B, signifying Performance Groups A, A1, A2 or B respectively. Each marginal designation applies to all paragraphs up to the next marginal designation; for convenience, however, the marginal designation is repeated at the top of each page. The system does not apply to the Appendices, in which the necessary distinction is made in the text. The Chapters which have been revised on, or after 20th January, 1975 have been amended in accordance with this system. However, Chapters issued earlier than 20th January, 1975 will not show this distinction, although Chapters dated between 1st January, 1954 and 20th January, 1975, do differentiate between Groups A and B; the full marginal designations (i.e. A1 and A2) will be added, as appropriate, when the Chapters are amended in future issues. In general, requirements in unamended Chapters will apply to all groups; the Authority will adjudicate where doubt exists.

3.3.6 The method of indicating that a requirement is applicable only to rotorcraft of a specific weight range, to special conditions of certification or to rotorcraft having specified technical features, is an appropriate reference in the paragraph title or text.

3.3.7 Where for the purposes of the requirements, terms must carry a particular meaning, definitions are given in appropriate places throughout this Section G. Thus, where the defined meanings apply throughout the Section, the definitions appear in Chapter **G1—2**; where they apply only in a particular Sub-section, they appear in the General Chapter of the Sub-section, and so on, in accordance with the arrangement described in 3.1. Definitions of other terms are, in the main, consistent with the Glossary of Aeronautical Terms published by the British Standards Institution as BS 185. Those terms, a definition of which appears in this Section G, are distinguished by initial capital letters, e.g. Maximum Weight, and reference to the Index will give the location at which a definition of the term can be found.

NOTE: Definitions associated with engine limitations (e.g. Maximum Take-off Power) are contained in **Section C,** Chapter **C1—2.**

3.3.8 The probability terms now defined in **G1—2** will also have initial capital letters to be consistent with 3.3.7; however, some of these terms such as "extremely remote" have been used in the Requirements for a considerable period of time in the past although not necessarily carrying the precise meanings now defined in **G1—2.** In future, as the requirements are revised, such terms will be amended to be consistent with the defined probability terms and initial capital letters will then be used; in the meantime, such terms as "extremely remote" will continue to appear with initial small letters and retain their original meaning.

3.4 S.I. Units

3.4.1 "S.I." is the accepted symbol for "Systeme International d'Unités" (International System of Units) and this system is being introduced into the Requirements as and when new or revised Chapters are published.

NOTE: Strict observance of the S.I. system is not compatible with current international practice for units in which data are scheduled in Flight Manuals. Consequently, variations from the S.I. system will be found in Sub-section G2.

3.4.2 In general, where a unit in the current text has been converted to an S.I. Unit a conveniently rounded-off value of the S.I. Unit is used. In this case and where a new requirement is introduced an S.I. Unit is used and an equivalent value expressed in the existing unit is also shown, e.g. "10 m (33 ft)". Where S.I. Units already appear in the Requirements, e.g. "20°C", equivalent non-S.I. Units (in this example "°F") will not be added.

3.4.3 Imperial units in the Air Navigation Order, Air Navigation (General) Regulations and other Statutory Instruments have been replaced by S.I. Units but in a number of cases not with a direct equivalent of the unit replaced. Where in the Requirements a discriminant derived from a Statutory Instrument is used, this will be expressed in S.I. Units and an equivalent Imperial unit will not be shown.

4 ISSUE AND AMENDMENT

4.1 The printed version of the Section, which is identified by an Issue No. and date (e.g. Issue 10, dated 22nd March, 1977) will be deemed to be amended by each BCAR Blue Paper, appropriate to the Section, which is issued subsequent to the date of Issue of the printed version. The effective date of each BCAR Blue Paper is marked on the first page of the Paper. (See also **5.**)

4.2 The BCAR Blue Papers will, at convenient intervals, be consolidated into the printed version of the Section, whereupon the Issue No. of the Section will be raised and the date will be changed. Advice of this consolidation will be given in the Explanatory Note associated with the new issue of the Section.

4.3 A suitable announcement will be made in the Aeronautical Press whenever BCAR Blue Papers are consolidated into the printed version of the Section.

4.4 In both printed version and BCAR Blue Papers alike, in each Chapter or Appendix, material differences from the previous issue of that Chapter or Appendix are indicated with a marginal line. However, in order to facilitate recognition, a Chapter or Appendix will be marginally lined throughout when it is first issued.

4.5 The issue or revision date is shown on the title page of each Chapter and Appendix. The significance of the wording is as follows:—

(a) *Issued*—the first version to appear in the Section.

(b) *Revised*—the whole Chapter or Appendix has been reviewed, and is considered to be amended and up-to-date at the time of publication as a revised Chapter or Appendix.

NOTE: In some instances although a Chapter has been revised and is annotated accordingly it may not have been necessary to make any amendments to its Appendix; conversely, an Appendix may be revised without an amendment to the Chapter. In such cases the Chapter and its Appendix would bear different dates.

(c) *Revised in part*—only those paragraphs carrying text annotated with a marginal line have been reviewed and amended; the whole Chapter or Appendix has not been reviewed. It is not to be assumed, however, that paragraphs not annotated with a marginal line are out of date.

5 EFFECTIVE DATE New requirements and amendments promulgated in BCAR Blue Papers are effective from the date printed on them. Thus for any application made on or after the date of issue of a printed version of the Section, the effective requirements will be made up of those in the printed version of the Section together with those in any appropriate BCAR Blue Papers which are current at the time the application is made.

6 RELATIONSHIP TO INTERNATIONAL STANDARDS No technical International Standards exist for rotorcraft. Compliance with the Authority's procedures will ensure compliance with the Administrative Standards applicable to rotorcraft contained in Part II of ICAO Annex 8 "International Standards—Airworthiness of Aircraft".

7 APPLICATIONS AND ENQUIRIES Applications for further copies of this Section should be addressed to the Civil Aviation Authority, Printing and Publication Services, Greville House, 37 Gratton Road, Cheltenham, Glos., GL50 2BN. Applications for permission to reproduce any part of the Requirements and any enquiries regarding their technical content should be addressed to the Civil Aviation Authority, Airworthiness Division, Brabazon House, Redhill, Surrey, RH1 1SQ.

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SUB-SECTION G1—GENERAL AND DEFINITIONS

CHAPTER G1—1 GENERAL

Revised in part, 16th August, 1982

A.B **1** INTRODUCTION

1.1 The requirements of this Chapter are those of a general nature applicable to Section G as a whole.

1.2 General technical requirements relating to the design and construction of the rotorcraft as a whole are given in **G4—1** and, except where inappropriate, refer to all other Sub-sections.

1.3 Reference to features such as retractable landing gear, auxiliary rotors, does not necessarily imply that such features are expected to be incorporated in the rotorcraft; the method of applying each requirement in cases where such devices are not fitted is, in general, self evident. In doubtful cases, however, reference shall be made to the Authority at an early stage in the design.

1.4 In certain cases it is not yet possible to prescribe requirements, compliance with which would necessarily establish that a rotorcraft had safe characteristics under all conditions likely to be encountered. The Authority, therefore, reserves the right to withhold approval when, in its opinion, a rotorcraft has unsafe characteristics, even though the rotorcraft complies literally with the text of the requirements. The Authority may also limit approval until sufficient experience of the rotorcraft has been accumulated to establish that the rotorcraft will have safe qualities in service.

2 WEIGHT-ALTITUDE-TEMPERATURE RANGES The Applicant shall choose the ranges of weight, altitude and temperature in which the rotorcraft is to operate. (See **G1—2,** 1.4, and **G2—2, 3.**)

3 CALCULATIONS AND TESTS

3.1 Calculations and tests shall be to the satisfaction of the Authority. Full details of the methods of calculation, the design criteria employed, and the grounds on which it is claimed that these are reliable, shall be available to the Authority for examination. Adequate notice of intention to make tests shall be given to the Authority and whenever the Authority requires to witness the tests, suitable facilities shall be provided.

3.2 All test equipment used shall be acceptable to the Authority. All measuring equipment used for the tests shall be calibrated periodically to the satisfaction of the Authority.

4 VARIATIONS FROM REQUIREMENTS

4.1 When the issue of a Certificate of Airworthiness is sought, it is necessary to comply with the relevant requirements of this Section or with variations therefrom which, taking account of compensating factors, are agreed by the Authority to give at least the intended level of safety.

A.B 4.2 The Authority shall be informed of each case where compliance with a variation in detail is claimed. In a few instances an indication is given in the text of the kind of variation acceptable to the Authority.

4.3 The requirements have been written in the main in terms of rotorcraft of conventional design and thus, in certain cases, will only be directly applicable to particular types of design; in some cases this restriction of applicability is recognised in the text. However, in other cases the subject is such that it will be clear that the requirements can be applied to foreseeable future developments. In the case of the former type of requirement, the Authority should be consulted regarding its applicability to any design which is unconventional in relation to the way in which the requirement has been written. Such consultations should be made at a sufficiently early stage for due account to be taken of any revised or additional requirements which are agreed.

A 5 CERTIFICATION FOR INSTRUMENT FLIGHT Approval for instrument flight shall be dependent on meeting the applicable requirements for instrument flight and those for Group A performance of Sub-section G2. The increase in gust velocities for instrument flight shall be agreed with the Authority; the gust requirements of **G3—2** are only intended to cover flight in clear air.

A.B 6 WEIGHT AND LOADING

6.1 **Maximum and Minimum Weight.** The following limitations shall be established in the manner prescribed:—

6.1.1 **Maximum Weight.** This weight shall be not higher than the lowest of the following:—

(a) a weight selected as such by the Applicant;

(b) the maximum weight for which compliance with the structural and engineering requirements has been shown;

(c) the maximum weight for which compliance with the handling requirements has been demonstrated;

(d) the maximum weight for which performance data has been established.

6.1.2 **Minimum Weight.** This weight shall be not lower than the highest of the following:—

(a) a weight selected as such by the Applicant;

(b) the minimum weight for which compliance with the structural and engineering requirements has been shown;

(c) the minimum weight for which compliance with the handling requirements has been demonstrated;

(d) the minimum weight for which performance data has been established.

6.2 **C.G. Position**

6.2.1 Limitations on the position of the c.g. shall be established. The limitations shall permit variations of the c.g. position which are not impracticably small and shall be such that they do not exceed:—

(a) the limit selected by the Applicant;

A.B

(b) the limit for which compliance with the structural and engineering requirements has been shown;

(c) the limits for which compliance with all the applicable flight requirements has been demonstrated.

6.2.2 The c.g. limitations established shall be associated with a defined condition of the rotorcraft, shall cover the range of weights between the Maximum Weight and the Minimum Weight, and shall be unique for all operating conditions except that variation of the longitudinal c.g. limitations with forward speed may be accepted subject to the overall requirements of **G8—2,** 5.8 being complied with, subject to the take-off, climb, glide, and landing performance, not being prejudiced, and subject to simple loading instructions being available.

NOTE: For datum point and detail definitions, see **G2—1,** 4.1.

6.3 **Weight Disposition.** If certain weight and c.g. combinations are associated with limits on the disposition of weight which might in practice be exceeded, appropriate limitations shall be established which shall not exceed:—

(a) the limits selected by the Applicant;

(b) the limits for which compliance with the structural and engineering requirements has been shown;

(c) the limits for which compliance with the applicable flight requirements has been demonstrated.

6.4 **Loading Intensity.** Limitations on the maximum intensity of loading shall be established for all flooring likely to be used for the carriage of concentrated loads. These limitations shall not exceed:—

(a) the limits selected by the Applicant;

(b) the limits for which compliance with the structural requirements has been shown.

6.5 **Weight and C.G. Information, Empty.** The empty weight and corresponding c.g. position of the rotorcraft shall be established as prescribed in 6.5.1 to 6.5.4:—

NOTE: The empty weight is the weight of the complete rotorcraft and includes:—
(a) fixed ballast,
(b) unusable fuel supply,
(c) undrained engine oil,
(d) the total quantity of fluid (other than fuel and engine oil) for systems essential for flight, and
(e) the rotor blades (their weights considered as concentrated at the appropriate rotor hub centres).

6.5.1 The weight and the longitudinal and lateral locations of the c.g. position shall be determined either by weighing the complete rotorcraft or by weighing the complete rotorcraft less items weighed in accordance with 6.5.2, and deriving the weight and c.g. of the complete rotorcraft from the combined data.

6.5.2 For each rotor, the weight of the blades (and the minimum number of parts normally detached with them) shall be determined by a separate weighing.

6.5.3 The vertical location of the c.g. of the complete rotorcraft shall be determined by weighing the rotorcraft, less the main rotor blades (and, if necessary, considering the attitude in which the rotorcraft is weighed, the auxiliary rotor

A.B

blades) and less any items such as accumulators which it may be necessary to remove to permit weighing in the attitude chosen. The vertical location of the c.g. shall then be derived from the weight so obtained considered in conjunction with the weights and moment arms of the items removed, which items shall be weighed separately.

6.5.4 The condition of the rotorcraft, to which the empty weight and c.g. so obtained are applicable, shall be recorded and shall be one which can be easily repeated and easily defined, particularly as regards rotorcraft attitude, position of the rotor blades, the contents of the fuel, oil, and coolant tanks, and the items of equipment installed.

SUB-SECTION G1—GENERAL AND DEFINITIONS

CHAPTER G1—2 DEFINITIONS

Revised in part, 1st June, 1976

NOTE: This Chapter gives definitions essential to the accurate interpretation of the requirements of Section G as a whole. Other definitions appropriate to particular Sub-sections or Chapters are given at appropriate places. Definitions of other terms are, in the main, consistent with the Glossary of Aeronautical Terms published by the British Standards Institution as BS 185.

1 GENERAL

1.1 **Applicant.** A person applying for approval of a rotorcraft or any part thereof.

1.2 **Approved.** Accepted by the Authority as suitable for a particular purpose.

1.3 **Atmosphere, International Standard.** An atmosphere defined as follows—

the air is a perfect dry gas;
the temperature at sea-level is 15°C;
the pressure at sea-level is $1{\cdot}013250 \times 10^5$ N/m² (29·92 in Hg) (1013·2 mbar);
the temperature gradient from sea-level to the altitude at which the temperature becomes −56·5°C is 3·25°C per 500 m (1·98°C/1,000 ft);
the density at sea-level, ρ_0, under the above conditions is 1·2250 kg/m³ (0·002378 slugs/ft³); for the density at altitudes up to 15 000 m (50,000 ft) see Table 1 (G1—2).

NOTE: ρ is the density appropriate to the altitude and ρ/ρ_0 the relative density is indicated by σ.

1.4 **Climates, Standard** (see **G1—2** App., **1**)

NOTE: This paragraph defines three Standard Climates—Temperate, Tropical and Arctic—by stating the envelope conditions applicable to each. The conditions thus represented are acceptable as giving suitable design criteria for rotorcraft intended for operation in the United Kingdom and other places in which similar conditions are experienced, Tropical regions and Arctic regions respectively. They are drawn up on the basis of conditions unlikely to be exceeded more often than on one day per year except that they do not cover the extremes of temperature occasionally reached in tropical deserts or in Siberia in winter.

1.4.1 The Temperate, Tropical and Arctic climates are defined by:—

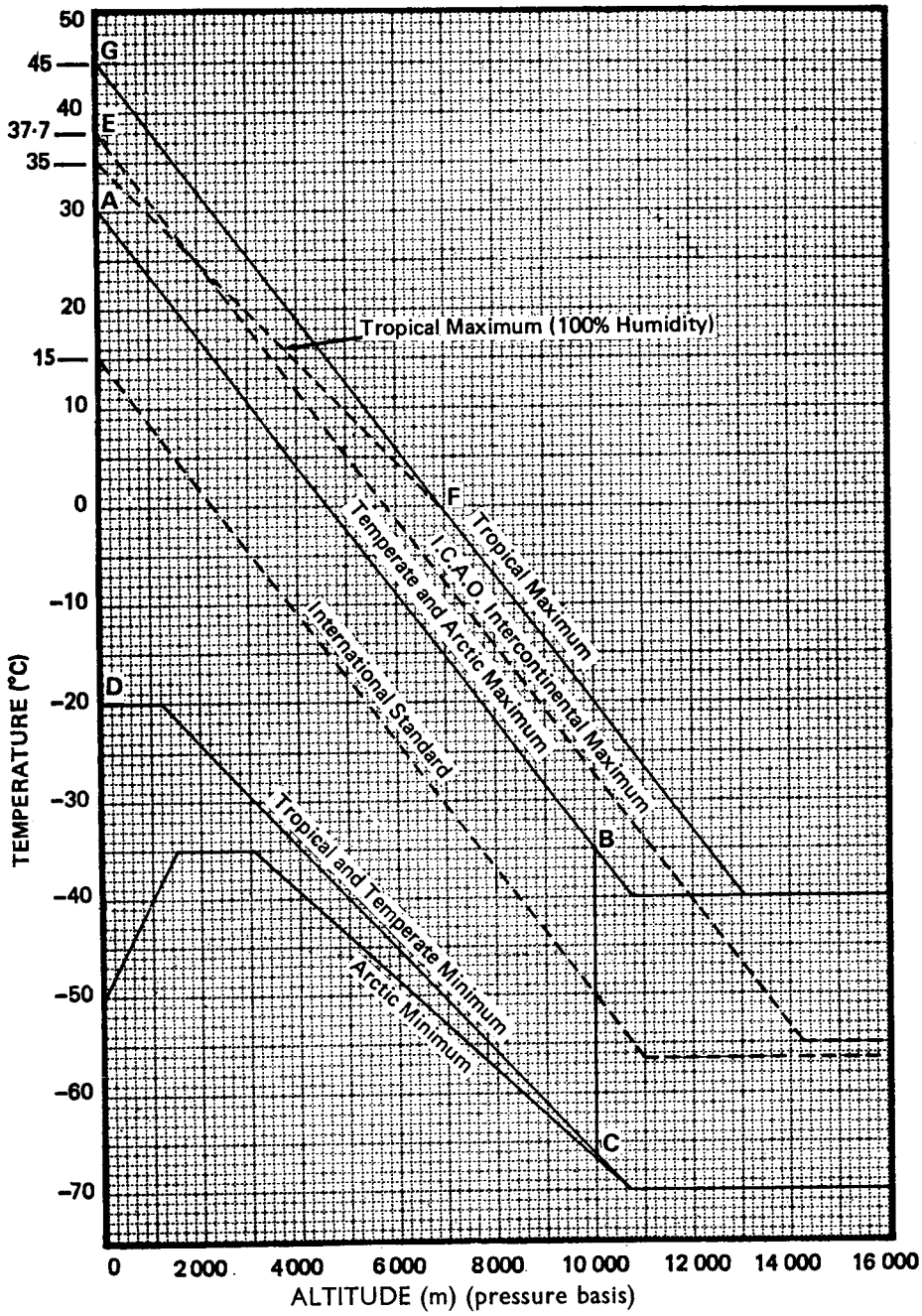
the temperature envelopes enclosed by the appropriate maximum and minimum temperature lines of Fig. 1 (G1—2), from zero metres (feet) to the selected height (e.g. the temperatures appropriate to 0–10 000 m (0–30,000 ft) in the Standard Temperate Climate are those within the envelope A, B, C, D, in Fig. 1 (G1—2));

every point included in these envelopes being associated with a relative humidity range of 20% to 100%; except that in the conditions represented by the area E, F, G in Fig. 1 (G1—2) the relative humidities shall be assumed to vary from 100% maximum and 20% minimum respectively at the line EF to the value appropriate to the height at the line GF. The value of relative humidity on the line GF shall be taken to vary linearly from 100% maximum and 20% minimum at F to some lower values at G (given here as 10% maximum and 2% minimum);

every point included in these envelopes being associated with the International standard pressure (I.C.A.O.) appropriate to the height, as shown in Table 1 (G1—2);

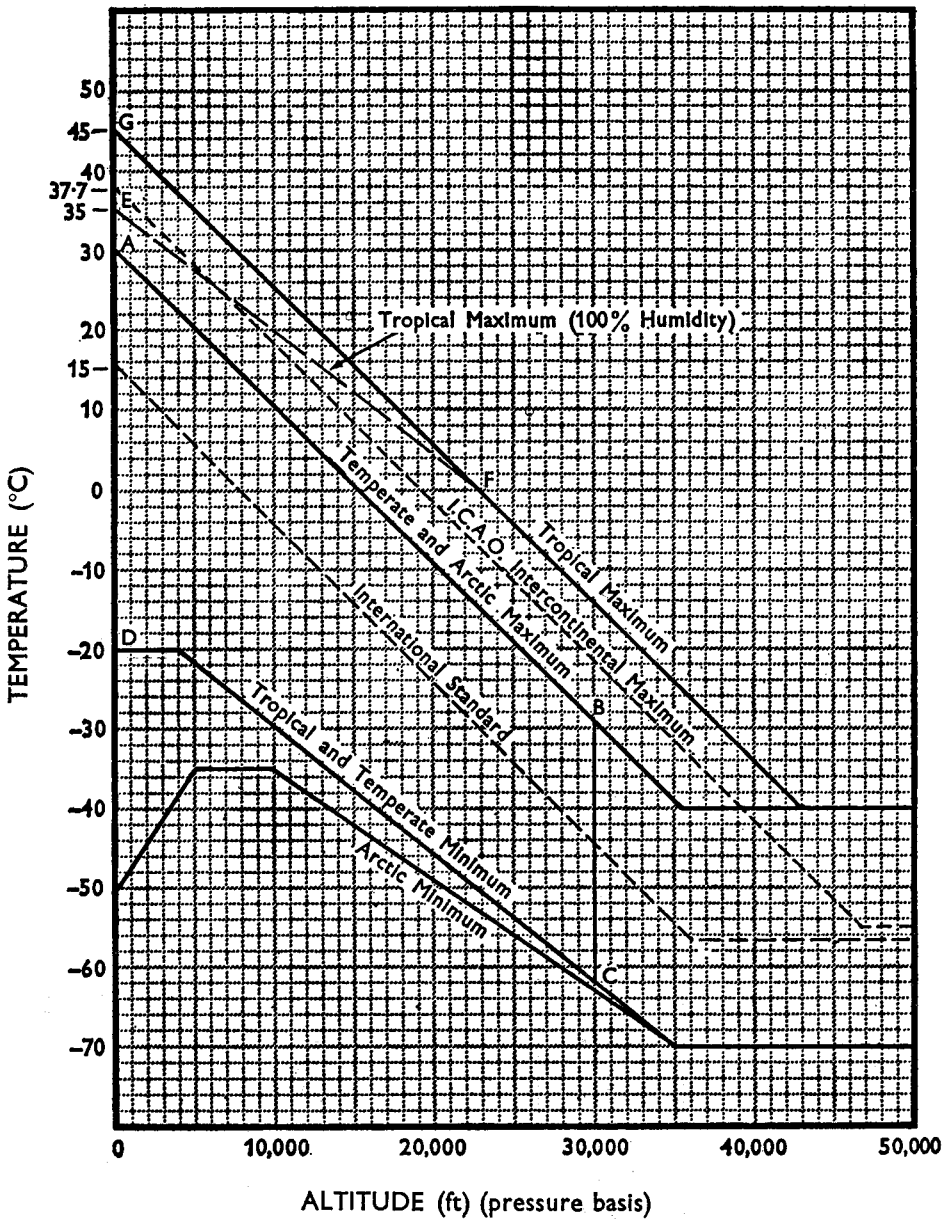
every point included in these envelopes being associated with the density corresponding to the temperature, pressure and humidity; extreme values are given in Table 1 (G1—2).

1.4.2 These conditions do not cover variation of pressure from the International standard. This shall be allowed for by assuming a variation of pressure 5% above and below the International standard pressure (I.C.A.O.) associated with the International standard temperature (I.C.A.O.).



STANDARD CLIMATES—S.I. UNITS
Fig. 1 (GI—2)

NOTES: (1) This diagram gives envelope conditions for design purposes; it does not constitute an accurate representation of any particular climate.
(2) The line BC has no significance other than as illustrating the text.



STANDARD CLIMATES—NON S.I. UNITS

Fig. 1 (GI—2)

NOTES: (1) This diagram gives envelope conditions for design purposes; it does not constitute an accurate representation of any particular climate.

(2) The line BC has no significance other than as illustrating the text.

TABLE 1 (GI—2)

RELATIVE PRESSURES AND DENSITIES—S.I. UNITS

Air density at sea-level (barometer $1{\cdot}013250 \times 10^5$ N/m^2
temp 15°C) is 1·2250 kg/m^3

Altitude (Pressure Basis) m	Relative Pressures (I.C.A.O.)	Relative Densities Associated with Conditions Stated				
		International Standard (I.C.A.O.)	Tropical Maximum	Temperate and Arctic Maximum	Tropical and Temperate Minimum	Arctic Minimum
0	1·000	1·000	0·906	0·951	1·138	1·291
500	0·942	0·953	0·862	0·905	1·072	1·190
1000	0·887	0·907	0·820	0·862	1·010	1·097
1500	0·835	0·864	0·780	0·820	0·955	1·011
2000	0·785	0·822	0·741	0·779	0·908	0·949
2500	0·737	0·781	0·703	0·740	0·862	0·892
3000	0·692	0·742	0·668	0·703	0·818	0·837
3500	0·649	0·705	0·633	0·667	0·776	0·792
4000	0·608	0·669	0·600	0·632	0·735	0·750
4500	0·570	0·634	0·568	0·599	0·696	0·709
5000	0·533	0·601	0·538	0·568	0·659	0·670
5500	0·498	0·569	0·509	0·537	0·623	0·633
6000	0·466	0·539	0·481	0·508	0·589	0·597
6500	0·435	0·509	0·454	0·480	0·556	0·563
7000	0·405	0·481	0·428	0·453	0·525	0·531
7500	0·378	0·454	0·404	0·428	0·495	0·500
8000	0·351	0·429	0·380	0·403	0·466	0·470
8500	0·327	0·404	0·358	0·380	0·439	0·442
9000	0·303	0·381	0·337	0·357	0·412	0·415
9500	0·282	0·358	0·316	0·336	0·388	0·389
10000	0·261	0·337	0·297	0·316	0·364	0·365
10500	0·242	0·317	0·279	0·296	0·341	0·341
11000	0·223	0·297	0·261	0·276	0·317	
11500	0·206	0·275	0·244	0·255	0·293	
12000	0·191	0·254	0·229	0·236	0·271	
12500	0·176	0·235	0·214	0·218	0·250	
13000	0·163	0·217	0·201	0·201	0·231	
13500	0·151	0·200	0·186		0·214	
14000	0·139	0·185	0·172		0·197	
14500	0·129	0·171	0·159		0·182	
15000	0·119	0·158	0·147		0·169	

TABLE 1 (G1—2)

RELATIVE PRESSURES AND DENSITIES—NON-S.I. UNITS

Air density at sea-level (barometer 29·92 in (1013·2 mbar) temp 15°C) is 0·002378 slugs/ft^3

Altitude (Pressure Basis) ft	Relative Pressures (I.C.A.O.)	Relative Densities Associated with Conditions Stated				
		International Standard (I.C.A.O.)	Tropical Maximum	Temperate and Arctic Maximum	Tropical and Temperate Minimum	Arctic Minimum
0	1·000	1·000	0·906	0·951	1·138	1·291
1,000	0·964	0·971	0·879	0·923	1·098	1·229
2,000	0·930	0·943	0·853	0·896	1·058	1·169
3,000	0·896	0·915	0·827	0·869	1·020	1·112
4,000	0·864	0·888	0·802	0·843	0·983	1·058
5,000	0·832	0·862	0·778	0·818	0·953	1·007
6,000	0·801	0·836	0·754	0·793	0·923	0·970
7,000	0·772	0·811	0·731	0·769	0·895	0·934
8,000	0·743	0·786	0·708	0·745	0·868	0·899
10,000	0·688	0·738	0·664	0·699	0·814	0·832
12,000	0·636	0·693	0·623	0·656	0·763	0·779
14,000	0·587	0·650	0·583	0·615	0·714	0·728
16,000	0·542	0·609	0·545	0·575	0·668	0·680
18,000	0·499	0·570	0·509	0·538	0·624	0·634
20,000	0·460	0·533	0·475	0·502	0·583	0·590
22,000	0·422	0·498	0·443	0·469	0·543	0·550
24,000	0·388	0·464	0·413	0·437	0·504	0·511
26,000	0·355	0·432	0·384	0·407	0·470	0·474
28,000	0·325	0·403	0·357	0·378	0·437	0·440
30,000	0·297	0·374	0·331	0·351	0·405	0·407
32,000	0·271	0·347	0·306	0·326	0·375	0·377
33,000	0·259	0·334	0·295	0·313	0·361	0·362
34,000	0·247	0·322	0·283	0·302	0·347	0·348
35,000	0·235	0·310	0·273	0·290	0·334	
36,000	0·224	0·298	0·262	0·277	0·318	
37,000	0·214	0·284	0·252	0·264	0·303	
38,000	0·204	0·271	0·242	0·252	0·289	
39,000	0·194	0·258	0·232	0·240	0·275	
40,000	0·185	0·246	0·223	0·229	0·263	
41,000	0·176	0·235	0·214	0·218	0·250	
42,000	0·168	0·224	0·206	0·208	0·238	
44,000	0·153	0·203	0·189		0·217	
46,000	0·139	0·185	0·171		0·197	
48,000	0·126	0·168	0·156		0·179	
50,000	0·114	0·152	0·141		0·162	

1.5 **Essential Equipment, Services, etc.** A term indicating that the item under consideration is essential to the airworthiness of the rotorcraft or the safety of its occupants.

1.6 **Extended and Retracted.** Except where specifically stated to the contrary, the words "extended" and "retracted" when used in connection with such items as landing gear, mean "fully extended" and "fully retracted" respectively.

1.7 **Resistance to Fire**

1.7.1 **Fireproof.** Capable of withstanding for a period of at least 15 minutes the application of heat by the Standard Flame (see 1.7.3).

1.7.2 **Fire-resistant.** As for Fireproof but the period of application to be 5 minutes instead of 15 minutes.

1.7.3 **Standard Flame.** A flame the characteristics of which are similar to those produced by the sources described in BS 3G.100, Part 2, Section 3, Sub-section 3–13.

1.8 **Operating Control.** That part of the control system which is manipulated by a flight-crew member (e.g. a wheel, lever, push button).

1.9 **Flammable/Inflammable.*** That which will ignite readily or explode.

1.10 **Emergency Landing/Alighting.** A controlled forced landing/alighting made necessary by an occurrence specified in the Requirements, e.g. partial or total power loss.

NOTE: In a descent following partial power loss the rotorcraft retains lift and control in the normal manner, in a descent following total power loss the rotorcraft is in autorotative flight.

1.11 **Crash Landing.** A landing made with the rotorcraft out of control.

1.12 **Critical Power-unit.** The Power-unit, the failure of which gives the most adverse effect in the requirement immediately under consideration.

1.13 **Power-unit Failure Point.†** For the determination of take-off performance, the point at which sudden complete failure of a Power-unit is assumed to occur.

1.14 **Decision Point.†** For the determination of take-off performance, the latest point at which, as a result of Power-unit failure or some other contingency, the pilot is assumed to decide to discontinue a take-off.

1.15 **Rotorcraft.** A heavier-than-air aircraft which derives some or all lift in flight from one or more rotors.

1.16 **Helicopter.** A Rotorcraft which depends principally for its support and motion in flight on power-driven Rotor(s) rotating about substantially vertical axes.

1.17 **Rotor.** A single system of rotating aerofoils.

NOTE: For the purposes of the Requirements the following are also included in the term Rotor: the rotor hub, blade dampers, and those parts of the pitch control mechanism and the de-icing system which rotate with the aerofoils.

1.17.1 **Main Rotor.** A Rotor, the primary function of which is to provide lift or lift and thrust.

1.17.2 **Auxiliary Rotor.** A Rotor, the primary function of which is to counterbalance the torque reaction of the Main Rotor and/or to change the motion of the helicopter about its vertical axis.

1.18 **Rotor System.** The Rotor(s) and those parts of the Transmission System the continued functioning of which is necessary in maintaining lift and control during autorotation.

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*As Chapters are revised "Inflammable" will be replaced by "Flammable".

†By distinguishing between Power-unit Failure Point and Decision Point, account is taken of the delay which occurs before a Power-unit failure can be recognised.

2 POWER-PLANT INSTALLATION

2.1 **Power-plant.** A Power-plant is the system of components installed in a rotorcraft for the purposes of providing power to the Rotor(s) and/or propeller(s).

NOTE: For the purposes of the Requirements the definition includes the Power-unit(s) complete with ancillary parts, the Transmission System where fitted, and any associated protective devices.

2.2 **Power-unit.** A Power-unit is a system of one or more engines and ancillary parts which are together necessary to provide power for lift and/or propulsion independently of continued operation of any other Power-unit.

NOTE: For the purposes of the Requirements the definition excludes separate devices providing power augmentation, and short period lift and thrust producing devices.

2.3 **Transmission System.** The Transmission System consists of all components necessary to transmit power from the engines to the Rotor(s) together with any accessory drive from such components.

NOTE: In the case of a mechanical Transmission System, it includes all gear boxes; clutches; free wheel mechanisms; couplings; shafts and their bearings, together with shafting used for driving, from the transmission, such components as oil cooling fans and rotorcraft service accessories; cooling fans not included in the bare engine; rotor brakes. In the case of a gaseous Transmission System, it includes the pipes and ducts connecting the Power-unit(s) to the Rotor(s).

3 ROTOR SYSTEMS—SPEED AND TORQUE

3.1 Single-engined Helicopters

3.1.1 **Rotor Maximum RPM (Power On).** The maximum rotational speed of the Rotor System permitted* with power applied, under all but transient conditions and approved for use during periods of unrestricted duration.

3.1.2 **Rotor Minimum RPM (Power On).** The minimum rotational speed of the Rotor System permitted* with power applied, under all but transient conditions and approved for use during periods of unrestricted duration.

3.1.3 **Rotor Maximum RPM (Power Off).** The maximum rotational speed of the Rotor System permitted in autorotation under all but transient conditions and approved for use during periods of unrestricted duration.

3.1.4 **Rotor Minimum RPM (Power Off).** The minimum rotational speed of the Rotor System permitted in autorotation under all but transient conditions and approved for use during periods of unrestricted duration.

3.1.5 **Rotor Never Exceed RPM.** The maximum rotational speed of the Rotor System which is not to be exceeded in any condition of operation and which is limited in use to a maximum continuous period of 20 seconds. This speed is to be chosen so that it is at least 3% above the maximum rotor speed likely to occur under transient conditions when operating at the speed of 3.1.1 or 3.1.3.

3.1.6 **Rotor Maximum One-hour Torque.†** The maximum torque approved for the Rotor System and limited in use to a maximum continuous period of one hour.

3.1.7 **Rotor Maximum Continuous Torque.†** The maximum torque approved for the Rotor System for use during periods of unrestricted duration.

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*In general this will be applicable to flight. However, when a different limiting speed is applicable when the helicopter is on the ground, two speeds will be approved.

†See G7—3, 3.1.3.

3.1.8 **Rotor Maximum Over-Torque.*** The maximum torque for the Rotor System that has been determined to have no detrimental effect on the transmission when used for a period of 20 seconds.

NOTES: (1) This torque could occur for example as a result of a defect or mishandling, or as a result of transient changes in normal engine acceleration.
(2) The words "no detrimental effect" need not include fatigue damage of a cumulative nature.

3.2 **Twin-engined Helicopters**

3.2.1 **Rotor Maximum RPM (Power On).** The maximum rotational speed of the Rotor System permitted† with power applied, under all but transient conditions and approved for use during periods of unrestricted duration.

NOTE: This speed is normally associated with twin engine operation. If different speeds are declared for single engine operation, in association with intermediate or maximum contingency torque, they will be defined accordingly, i.e., Rotor Intermediate Contingency RPM (Power On), and Rotor Maximum Contingency RPM (Power On).

3.2.2 **Rotor Minimum RPM (Power On).** The minimum rotational speed of the Rotor System permitted† with power applied, under all but transient conditions and approved for use during periods of unrestricted duration.

3.2.3 **Rotor Maximum RPM (Power Off).** The maximum rotational speed of the Rotor System permitted in autorotation under all but transient conditions and approved for use during periods of unrestricted duration.

3.2.4 **Rotor Minimum RPM (Power Off).** The minimum rotational speed of the Rotor System permitted in autorotation under all but transient conditions and approved for use during periods of unrestricted duration.

3.2.5 **Rotor Never Exceed RPM.** The maximum rotational speed of the Rotor System which is not to be exceeded in any conditions of operation and which is limited in use to a maximum continuous period of 20 seconds. This speed is to be chosen so that it is at least 3% above the maximum rotor speed likely to occur under transient conditions when operating at the speed of 3.2.1 or 3.2.3.

3.2.6 **Rotor Maximum Contingency Torque.‡** The maximum torque approved for the Rotor System for use in the event of the failure of one Power-unit, and limited in use to a maximum continuous period of 2½ minutes. (This torque may be applicable only to certain sections of the Transmission and Rotor System.)

3.2.7 **Rotor Intermediate Contingency Torque.‡** The maximum torque approved for the Rotor System, for use in the event of the failure of one Power-unit during en-route operation. (This torque may be applicable only to certain sections of the Transmission and Rotor System.)

3.2.8 **Rotor Maximum Continuous Torque.‡** The maximum torque approved for the Rotor System for use during periods of unrestricted duration.

3.2.9 **Rotor Maximum Over-Torque.‡** The maximum torque for the Rotor System that has been determined to have no detrimental effect on the transmission when used for a period of 20 seconds.

NOTES: (1) This torque could occur for example as a result of a defect or mishandling, or as a normal acceleration or deceleration transient.
(2) The words "no detrimental effect" need not include fatigue damage of a cumulative nature.

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*See G7—3, 3.1.3.

†In general this will be applicable to flight. However, when a different limiting speed is applicable when the helicopter is on the ground, two speeds will be approved.

‡See G7—4, 3.1.3.

4 WEIGHTS

4.1 **Maximum Weight.** The maximum weight at which the rotorcraft is suitable for operation.

4.2 **Minimum Weight.** The minimum weight at which the rotorcraft is suitable for operation.

4.3 **Design Maximum Weight.** The maximum weight at which compliance is shown with structural loading conditions.

4.4 **Design Minimum Weight.** The minimum weight at which compliance is shown with structural loading conditions.

4.5 **Design Unit Weight.** A unit weight used to show compliance with structural design requirements.

4.6 **Maximum Weight appropriate to the Altitude and Temperature.*** The highest weight, not greater than the Maximum Weight defined in 4.1, at which the relevant airworthiness climb minima are met. The expressions "Altitude" and "Temperature" refer to the assumed pressure altitude and assumed atmospheric temperature for the take-off or landing surface.

NOTES: (1) The weight defined in this paragraph 4.6 will be incorporated in performance information. Correct use of this information will be required by operating rules, when applicable.

(2) In specific operations, rotorcraft weight may be further restricted by considerations such as obstacle clearance.

4.7 **Maximum Landing Weight.** The maximum weight at which landing is normally permitted, by considerations other than available performance.

4.8 **Maximum Take-off Weight.** The maximum weight at which take-off is permitted, by considerations other than available performance.

5 SPEEDS

NOTE: Throughout the Requirements wherever comparative values are prescribed, care will be necessary to ensure that values are corrected to E.A.S.

5.1 **T.A.S.** The true speed of the rotorcraft relative to undisturbed air.

5.2 **E.A.S.** Equivalent air speed. T.A.S. $(\rho/\rho_0)^{\frac{1}{2}}$ or T.A.S. $(\sigma)^{\frac{1}{2}}$.

5.3 **I.A.S.** Indicated air speed. The readings of the pitot-static air-speed indicator as installed in the rotorcraft, corrected only for the instrument error.

5.4 **C.A.S.** Calibrated air speed; the air-speed indicator reading corrected for air-speed indicator system errors. C.A.S. is equal to T.A.S. in the standard atmosphere at sea-level.

5.5 **A.S.I.R.** The uncorrected reading on a specified air-speed indicator.

5.6 **V_D.** The Maximum Design Forward Speed, E.A.S.

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*See G2—2 for definition of WAT curves.

5.7 V_{DF}. The Maximum Demonstrated Flight Speed, E.A.S.

5.8 V_H. The Maximum Speed in Level Flight not exceeding Maximum Continuous Power, E.A.S.

5.9 V_{mp}. The Speed for Minimum Power, E.A.S.

5.10 V_{NE}. The Never Exceed Speed, I.A.S.

5.11 V_{NO}. The Normal Operating Limit Speed, I.A.S.

5.12 V_Y. The Speed for best rate of climb (E.A.S. for flight requirements, I.A.S. for operating information).

5.13 V_2. **The Take-off Safety Speed.** A speed used in the determination of take-off performance (E.A.S. for flight requirements, I.A.S. for operating information). For further details see **G2—3,** 4.1.

5.14 **Maximum and Minimum Air Speeds for Agricultural Operations.** Maximum and minimum air speeds, I.A.S., for rotorcraft operating with agricultural equipment (see **G1—3,** 5.7.6).

5.15 **Landing Gear Operating Speed,** V_{LO}. A maximum speed, I.A.S., at which it is safe to extend or to retract the landing gear.

6 STRUCTURAL

6.1 **Primary Structure.** Those portions of the structure, the failure of which would seriously endanger the rotorcraft.

6.1.1 **Safe Fatigue Life.** The operational period expressed in terms of number of flying hours, number of flights or number of applications of loads during which the possibility of fatigue failure of the part concerned under the action of the repeated loads of variable magnitude in service is estimated to be Extremely Remote.

6.1.2 **Fail-Safe Structure.** A structure which is so designed that after the failure in operation of a part of the Primary Structure, there is sufficient strength and stiffness in the remaining Primary Structure to permit continued operation of the rotorcraft for a limited period.

NOTE: This period will depend upon the nature of the failure and the facilities provided for inspecting such a failure but in no case will the residual strength be less than that which will enable a flight to be completed at a lower but acceptable level of safety.

6.2 **Limit Load.** The maximum load anticipated in normal conditions of operation.

6.3 **Proof Load.** The proof load is the product of the Limit Load and the Proof Factor of safety.

6.4 **Ultimate Load.** The ultimate load is the product of the Limit Load and the Ultimate Factor of safety.

6.5 **Factors of Safety (for static strength)**

6.5.1 **Proof Factor and Ultimate Factor.** Design factors (proof or ultimate) to provide for the possibility of loads greater than those expected in normal conditions of operation, uncertainties in design and variations of structural strength, including variation of strength resulting from deterioration in service.

6.6 **Load Factor.** The ratio of a prescribed load to the total weight of the rotorcraft; the prescribed load may be expressed in terms of any of the following—aerodynamic forces, inertia forces or ground reaction.

7 TERMS ASSOCIATED WITH PROBABILITY

7.1 **Occurrences.** An Occurrence is a condition involving a potential lowering of the level of airworthiness.

7.1.1 **Failure.** An Occurrence in which a part, or parts, of the rotorcraft fail or malfunction, e.g. runaway. A Failure includes:—

(a) a single failure,

(b) independent failures in combination within a system, and

(c) independent failures in combinations involving more than one system,

taking into account:—

(d) any undetected failure that is already present,

(e) such further failures* as would be reasonably expected to follow the Failure under consideration.

7.1.2 **Event.** An Occurrence which has its origin outside the rotorcraft (e.g. atmospheric gusts).

7.1.3 **Error.** An Occurrence arising as a result of incorrect action by the flight crew or maintenance personnel.

7.2 **Probability of Occurrences**

7.2.1 **Frequent.** Likely to occur often during the operational life of each rotorcraft of the type.

7.2.2 **Reasonably Probable.** Unlikely to occur often during the operation of each rotorcraft of the type but which may occur several times during the total operational life of each rotorcraft of the type.

7.2.3 **Recurrent.** A term embracing the total range of Frequent and Reasonably Probable.

7.2.4 **Remote.** Unlikely to occur to each rotorcraft during its total operational life, but which may occur several times when considering the total operational life of a number of rotorcraft of the type.

7.2.5 **Extremely Remote.** Unlikely to occur when considering the total operational life of a number of rotorcraft of the type, but nevertheless has to be considered as being possible.

7.2.6 **Extremely Improbable.** So Extremely Remote that it does not have to be considered as possible to occur.

NOTE: Extremely Improbable has to be sufficiently less than Extremely Remote for the total probability of a catastrophe for the complete rotorcraft to be less than Extremely Remote.

7.3 **Effects.** An Effect is a situation arising as a result of an Occurrence.

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*In assessing the further failures which follow account should be taken of any resulting more severe operating conditions for items that have not up to that time failed.

7.3.1 **Minor Effect.** An Effect which can be readily counteracted by the flight crew; it may involve:—

(a) small increase in flight-crew workload, or

(b) moderate degradation in performance or handling characteristics, or

(c) slight modification of the permissible flight envelope.

7.3.2 **Major Effect.** An Effect which produces:—

(a) significant increase in flight-crew workload, or

(b) significant degradation in performance or handling characteristics, or

(c) significant modification of the permissible flight envelope,

but will not remove the capability to continue a safe flight and landing without demanding more than normal skill on the part of the flight crew.

7.3.3 **Hazardous Effect.** An Effect which produces:—

(a) a dangerous increase in flight-crew workload, or

(b) dangerous degradation of performance or handling characteristics, or

(c) dangerous degradation of the strength of the rotorcraft, or

(d) marginal conditions for, or injury to, occupants.

7.3.4 **Catastrophic Effect.** An Effect which results in the loss of the rotorcraft and/or in fatalities.

APPENDIX TO CHAPTER G1—2

Issued, 1st January, 1954

DEFINITIONS

1 CLIMATIC CONDITIONS (See G1—2, 1.4)

1.1 The standard climatic conditions are intended primarily for use in designing rotorcraft structure and equipment which should remain airworthy when subjected to the appropriate conditions.

1.2 Rotorcraft performance will vary considerably within the defined climates. It is not intended that any one stated performance should be achievable throughout the whole envelope of conditions but rather that sufficient performance data should be scheduled for an operator to determine the performance which will be achieved in particular conditions.

1.3 The climatic conditions given are conditions of the free atmosphere. The temperatures achieved in a rotorcraft in these atmospheric conditions may be considerably higher. In the absence of precise information as to surface finish, ventilation and type of engine, etc., the following maximum ambient temperatures should be assumed :—

	Temperate and Arctic	Tropical
(a) in the interior of a rotorcraft	45°C	60°C
(b) for portions of the outer covering liable to be in the sun and parts attached directly to such covering	55°C	80°C
(c) in an engine compartment for parts not attached directly to the engine	100°C	100°C

NOTE : Parts connected to the engine may attain higher temperatures.

SUB-SECTION G2—FLIGHT

CHAPTER G2—1 GENERAL

Revised, 1st February, 1963

A.B

1 INTRODUCTION

1.1 **General.** The requirements of this Chapter are those of a general nature applicable to the Flight Requirements as a whole.

1.2 **General Principles.** Airworthiness Flight Requirements are of two kinds, namely :—

Requirements defining a minimum acceptable standard of performance or handling.

Requirements prescribing the determination of certain performance and handling characteristics, knowledge of which is essential to safe operation or to the repetition of a declared performance.

1.3 **Arrangement.** The requirements of Sub-section **G2** are those concerning Performance Requirements (Chapters **G2—2** to **G2—5**) and Handling Requirements (Chapters **G2—6** to **G2—10**).

2 PROOF OF COMPLIANCE

2.1 **Test Conditions.** Except as provided by 2.2, compliance with the requirements of this Sub-section shall be established by tests made under conditions approximating, so far as is practical, to those to which the requirement is related.

NOTES : (1) Demonstration of compliance in less complex test conditions than those implied by the form of the requirements, will be acceptable provided that the standard established is in no case lower than the standard prescribed.

(2) Compliance with the requirements will normally be established for prototype rotorcraft by means of comprehensive flight trials, and for series rotorcraft by abbreviated flight trials. The administrative procedures to be followed are given in **Section A.**

2.2 **Indirect Tests**

2.2.1 **Calculations Based on Tests.** In place of direct tests, calculations based on other tests of the rotorcraft type concerned may be acceptable provided that the results obtained by such calculations are shown to be substantially equal in accuracy to the results obtained from direct tests.

2.2.2 **Interpolation.** For various characteristics of the rotorcraft, the requirements are specified in terms of defined ranges of conditions. Tests to prove compliance need, however, only be made at such points in each range as are necessary for reliable inference to be made of the behaviour of the rotorcraft over the remainder of that range.

2.3 **Operating Instructions.** The flight and loading technique used in establishing compliance with this Sub-section will be reflected in the mandatory operating instructions included in the Flight Manual (see **Section A,** Chapter **A6—1**).

A.B 3 STANDARD CONDITIONS

3.1 **Atmospheric Conditions.** Except where otherwise specified, compliance with the requirements of this Sub-section shall be shown for conditions of no appreciable atmospheric turbulence.

3.2 **Technique.** In the absence of specific requirements, controls shall be assumed to be used in all manners likely to be adopted by the pilot when confronted by the operational situation for which the requirement caters.

3.3 **Power-unit Failure (see G2—1 App., 1).** Power-unit failure shall be assumed to result in complete and immediate loss of power from the affected power-unit except for that momentarily supplied by the inertia of moving parts. No further auxiliary power shall be assumed to be supplied from that particular power-unit.

3.4 **Automatic Controls.** The requirements are, in general, written in terms of manually operated controls for such items as rotor pitch, engine cooling, etc. In the case of automatic controls which have a significant effect on flight characteristics, the Board shall be consulted as to the use to be made of such controls in establishing the data prescribed.

4 DEFINITIONS

4.1 **Weight and Centre of Gravity.** These terms refer to the rotorcraft weight and centre of gravity unless otherwise specified, the centre-of-gravity position being quoted in three dimensions, in Cartesian co-ordinates, relative to any convenient set of mutually perpendicular axes intersecting near the centre of gravity.

NOTES : (1) Where there is a fundamental set of reference axes the relationship of these to the axes should be established.

(2) This does not preclude the presentation in the Flight Manual of loading limitations in terms more convenient to the operator, provided that equivalent values in the terms specified above, are also included.

APPENDIX TO CHAPTER G2—1

Issued, 1st February, 1963

FLIGHT—GENERAL

1 MEANS OF SIMULATING POWER-UNIT FAILURE (see G2—1, 3.3) Sudden complete failure of a power-unit may be simulated in accordance with 1.1, 1.2 or 1.3.

1.1 Where the Rotor System is disengaged and remains disengaged from the power-unit when the throttle is in the idling position the appropriate throttle should be moved to the idling position as rapidly as possible without, however, moving the corresponding rotor or propeller control.

1.2 Where the conditions of 1.1 are not obtainable the procedure of 1.2.1 or 1.2.2 as appropriate may be adopted, provided that such action does not result in the operation of any device which would be unaffected by an actual complete failure.

1.2.1 **Piston Engines.** The appropriate throttle should be moved to the closed position as rapidly as possible without, however, moving the corresponding rotor or propeller control. In this case the power-unit should be so adjusted that, when the rotorcraft is stationary on the ground with engine temperatures approximately normal, it is possible readily to stop it solely by moving the appropriate throttle lever or grip to the fully closed position.

1.2.2 **Turbine Engines.** The engine fuel cock should be closed.

1.3 Any other method agreed in consultation with the Board.

SUB-SECTION G2—FLIGHT

CHAPTER G2—2 PERFORMANCE—GENERAL

Revised in part, 7th November,* 1975

A.B 1 INTRODUCTION This Chapter contains general performance requirements, detailed requirements and definitions which are applicable to more than one of the Chapters **G2—3** to **G2—5.** The detailed requirements have been included here for convenience of presentation to avoid the need to repeat them at each appropriate point in the later Chapters. There may be cases where a general requirement given in this Chapter has to be overridden by a detailed requirement in a particular Chapter; the text used in the particular Chapter will make this clear.

2 THE PURPOSE OF PERFORMANCE REQUIREMENTS

2.1 **Operating Regulations.** The level of safety intended by the airworthiness performance requirements will only be achieved by relating the flight characteristics of the rotorcraft to the characteristics of the aerodrome, the aerodrome surroundings and the route. This level of safety will be achieved when rotorcraft certificated in accordance with these requirements are operated using information contained in the Flight Manual in conjunction with the appropriate operational performance rules.

3 CONDITIONS TO BE COVERED IN THE FLIGHT MANUAL (see G2—2 App., 1) The performance shall be determined and scheduled in the Flight Manual for such ranges of weight, altitude, atmospheric temperature and wind as will enable the rotorcraft to be operated in at least one region of the world with only infrequent occasions when the Flight Manual data does not cover the prevailing conditions. In addition to those variable conditions of which direct account is taken in the operational performance rules, the effect of other conditions and the effect of the operation of systems, e.g. anti-icing systems, which may have a significant effect on performance, shall also be scheduled.

4 SPECIAL ITEMS FOR INCLUSION IN THE FLIGHT MANUAL

4.1 **Cruising Speeds**

4.1.1 A representative cruising true air speed† for use in showing compliance with operational performance rules relating to flight over water shall be established and will be included in the Flight Manual.

A 4.1.2 A representative cruising true air speed relating to one-Power-unit-inoperative en-route data shall be established and will be included in the Flight Manual.

NOTE: For rotorcraft with more than two Power-units, it may be necessary to schedule the information with two Power-units inoperative.

A.B 4.2 **Series and Renewal Data.** The Gross Performance (see 6.5.3) agreed with the Authority to be necessary for the evaluation of Series and Renewal Flight Tests (see **Section A,** Chapter **A5—2**) shall be determined and will be included in the Flight Manual.

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*The only change to this Chapter, apart from minor editorial amendments, is the deletion of a sentence in paragraph 5 1.

†This speed is usually related to a representative cruising altitude; only one such speed is to be quoted for a given rotorcraft type.

A.B 5 DETAILED GENERAL CONDITIONS

5.1 **Loading.** Compliance with each performance requirement shall be established for all combinations of weight and c.g. position in the range of weights from the maximum prescribed to the minimum weight associated with a given condition.

5.2 **Compliance with Limitations.** The scheduled performance and the Gross Performance on which it is based, shall be consistent with compliance with all airworthiness limitations established for the rotorcraft.

5.3 **Auxiliary Services**

5.3.1 **General.** In showing compliance with the performance requirements, allowance shall be made for the adverse effects on performance of the use of auxiliary services which may affect performance (e.g. engine air cleaning, electrical loads). The most adverse rational combination, relevant to the particular requirement under consideration, shall be taken into account.

5.3.2 **After Power-unit Failure.** Where the operation of a power operated service (e.g. retractable landing gear) is directly affected by Power-unit failure, allowance shall be made for any unfavourable effect on performance with one or two Power-units inoperative as appropriate. The unfavourable effect shall be taken into account for any operation of the service at or following the earliest point at which Power-unit failure is presumed to occur for a particular performance requirement.

5.4 **Atmospheric Conditions.** The Gross Performance shall be related to conditions of zero free-water content, Reference Humidity (see 6.4.2) and, except where the effect on performance of horizontal component of wind velocity is being scheduled, still air.

5.5 **Handling Techniques**

5.5.1 **Assumed Operational Technique.** The scheduled performance shall be consistent with practical operational techniques covering both normal and emergency conditions, and shall not require undue skill.

5.5.2 **Assumed Handling Information.** The information needed by a qualified crew in order readily to reproduce the assumed operational technique shall be included in the Flight Manual.

5.5.3 **Piloting Technique During Tests.** This shall be readily repeatable and as close as possible to the assumed operational standard; if the technique is superior to the operational standard, suitable allowances shall be made for the differences.

5.5.4 **Use of Devices** (see **G2—2** App., **2**). If credit is to be taken for the use of such devices as variable-pitch propellers in establishing compliance with performance requirements:—

(a) the devices when functioning normally shall not be liable in the manner in which they are used to give inconsistent results in the behaviour of the rotorcraft under operational conditions,

(b) suitable allowance shall be made for the probability of the devices becoming inoperative.

NOTE: For power augmentation devices such as refrigerant injection and rockets see **G2—2** App., 2.2.

5.6 **Cooling.** Engine cooling requirements are related to a standard climate which is chosen by the Applicant in accordance with **G5—4.**

B 5.7 **Landing Gear** (Group B) (see **G2—2** App., 3). If credit for ability to retract the landing gear is to be taken in establishing compliance with the performance requirements, it shall be possible, irrespective of the failure of the Critical Power-unit, to extend the landing gear in not more than 5 seconds, at all speeds up to the speed selected for establishing the en-route gradient of descent or 1·5 times the speed for the best rate of climb, whichever is the greater. If the landing gear is not power-operated the foregoing requirement shall be met without undue exertion or attention from the pilot. If the system is power-operated at least one complete cycle at the maximum permissible rate of operation shall be possible after failure of the Critical Power-unit.

A NOTE: For Group A there is no corresponding maximum time and the performance requirements provide for this in 5.3.2.

A.B 5.8 **Take-off and Landing Surfaces.** Where applicable the type of surface to which the take-off and landing data is related shall be included in the Flight Manual.

6 DEFINITIONS

6.1 Surfaces

6.1.1 **Take-off and Landing Surfaces.** The Take-off and Landing Surfaces are, for the purposes of performance determination, regarded as level planes of infinite extent.

6.2 Altitude and Height

6.2.1 **Altitude.** When not otherwise qualified, pressure altitude, i.e. the expression of atmospheric pressure in terms of altitude, according to the inter-relation of these factors in the International Standard Atmosphere.

NOTE: This would be obtained by setting the sub-scale of an accurate pressure type altimeter to 1013·2 mbar.

6.2.2 **Height.** The true vertical clearance distance between the lowest part of the rotorcraft and the relevant datum.

6.3 Atmospheric Temperature

6.3.1 **Temperature.** Unless otherwise qualified, the temperature of the free air stream, expressed in °C.

6.3.2 **I.S.A.** The temperature of the International Standard Atmosphere appropriate to a particular altitude (see **G1—2**).

6.3.3 **Maximum Temperature.** The maximum atmospheric temperature, appropriate to the altitude, at which all requirements are met.

6.3.4 **Minimum Temperature.** The minimum atmospheric temperature appropriate to the altitude, at which all requirements are met.

6.4 Atmospheric Humidity

6.4.1 **Humidity.** Unless otherwise qualified, the moisture content excluding free water, of the free air stream.

NOTE: It may be expressed as a relative humidity or as an absolute humidity.

6.4.2 **Reference Humidity.** The relationship between altitude, temperature and Reference Humidity is defined as follows:—

—at temperatures at and below ISA, 80% relative humidity,

—at temperatures at and above ISA + 28C°, 34% relative humidity,

—at temperatures between ISA and ISA + 28C°, the relative humidity varies linearly between the humidities specified for those temperatures.

A.B

6.5 **Performance**

6.5.1 **Gradient.** For deriving and applying Flight Manual information, gradient is the tangent of the angle of climb expressed as a percentage.

6.5.2 **Measured Performance.** The average performance of a rotorcraft or group of rotorcraft being tested by an acceptable method in the specified conditions.

6.5.3 **Gross Performance** (see **G2—2** App., **4**). The Gross Performance is such that the performance of any rotorcraft of the type, measured at any time, is at least as likely to exceed the Gross Performance as not.

NOTE: In order to obtain the Gross Performance it is usually necessary to adjust the Measured Performance.

6.5.4 **Net Performance.** The Gross Performance modified in the manner prescribed in the relevant requirement to make appropriate allowance for those variations from the Gross Performance which are not dealt with in the operational performance rules.

6.6 **Miscellaneous**

6.6.1 **WAT Curve.** A diagram giving the variation of Maximum Weight as limited by the appropriate airworthiness climb minima of **G2—4** with take-off and landing surface altitude and temperature. This term is qualified by the words "Take-off" or "Landing" or "Take-off and Landing," as appropriate.

6.6.2 **Starting Point.** A term used in connection with the termination of take-off performance; it is a point from which a stationary rotorcraft commences the take-off manoeuvre.

APPENDIX TO CHAPTER G2—2

Revised in part, 7th November,* 1975

PERFORMANCE—GENERAL

1 CONDITIONS TO BE COVERED IN THE FLIGHT MANUAL (see G2—2, 3)

1.1 **Icing.** When certification for flight in ice forming conditions is sought, the effect of the installation and operation of safeguards against icing on the performance should be determined and scheduled. The effect of the operation should be determined in clear air at the temperatures at which ice formation would be likely to occur.

2 USE OF DEVICES (see G2—2, 5.5.4)

2.1 **Propellers.** Where propellers are used in establishing performance with the Critical Power-unit inoperative, the credit which may be claimed for the use of automatic propeller controls should be agreed with the Authority.

2.2 **Power Augmentation.** The Authority will decide in consultation with the Applicant what performance credit may be taken for power augmentation in meeting requirements, and in doing so will take account of the duration that such power is available and the method of using it.

3 LANDING GEAR (see G2—2, 5.7) For rotorcraft the approach and landing characteristics of which are conventional, the Authority may agree to an air speed lower than that defined in **G2—2,** 5.7 but not lower than 75 knots E.A.S.

4 GROSS PERFORMANCE (see G2—2, 6.5.3)

4.1 It is necessary to make performance measurements in both high and low performance conditions. The extent to which performance measurements are repeated in different conditions of altitude and temperature, and the extrapolation of test data will depend, among other things, on the amount of reliable test data which is available on closely comparable rotorcraft and/or Power-plant installations.

NOTE: Tests in a wide range of atmospheric conditions are necessary in any case to establish the correct functioning of components and to reveal any otherwise unanticipated difficulties of operation of the rotorcraft. (See also **G4—1,** 14).

4.2 When establishing the performance of a rotorcraft type, due allowance should be made for any differences which exist between the condition of the test rotorcraft and that expected in service.

4.2.1 The power or thrust used when correcting the Measured Performance to obtain Gross Performance should be the Engine Fleet Mean Performance or the Minimum Acceptance Power or Thrust.

NOTES: (1) The methods for establishing the installed power to be assumed in establishing the Gross Performance are contained in **Section C**; in Chapter **C2—5** for piston engines, and in Chapters **C4—5** and **C4—7** for turbine engines.

(2) Should the check testing of engine power required by the Authority reveal a reduction in mean engine power below the value used in establishing the Gross Performance a revision of the performance data scheduled in the Flight Manual may have to be made depending upon the actual flight performance of the rotorcraft type(s) concerned.

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*The only changes made to this Appendix are editorial.

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SUB-SECTION G2—FLIGHT

CHAPTER G2—3 PERFORMANCE—TAKE-OFF

Revised, 1st February, 1963

A.B 1 INTRODUCTION This Chapter prescribes the determination of Take-off Space Required, Rejected Take-off Area, Decision Point criteria and the Take-off Flight Path, for the conditions and ranges of conditions selected by the Applicant in accordance with G2—2, 3.

2 GENERAL (see G2—3 App., 1)

2.1 **Techniques.** The Applicant shall select the techniques to be determined and scheduled. In each case the technique used shall be compatible with G2—7 and shall take account of the pilot's field of view and the information presented to the pilot by the rotorcraft instruments.

2.1.1 **Mandatory Technique**

(a) One of the techniques scheduled shall have been demonstrated to provide for a landing within the Rejected Take-off Area (see 5) in the conditions of (i) or (ii), as appropriate.

A (i) **Group A.** In the event of the Critical Power-unit becoming inoperative at any point up to the Decision Point, a landing can be made which does not involve damage to the rotorcraft or hazard to the occupants.

B (ii) **Group B.** In the event of the Critical Power-unit becoming inoperative at any point during the take-off within the Take-off Space Required (see 4.2) a landing can be made which does not involve hazard to the occupants.

A.B (b) The actual technique to be adopted for the landing of (a) shall be decided in consultation with the Board.

2.1.2 **Non-mandatory Techniques.** Corresponding data may, in addition, be determined for techniques other than that of 2.1.1 provided that the extent and implications of the differences in technique are clearly and explicitly stated, and that corresponding landing data are also determined.

2.2 **Conditions to be Covered in the Flight Manual**

2.2.1 **Weight, Altitude and Temperature.** Take-off data for each of the take-off techniques chosen shall be determined and scheduled for the range of temperatures selected in accordance with G2—2, for Take-off Surfaces from 1,000 feet below to 2,000 feet above sea-level, for the appropriate Maximum Take-off and Landing Weight. Take-off data may also be determined and scheduled for such lower weights, lower temperatures and higher altitudes as the Applicant may desire, subject to the maximum weight appropriate to the altitude, temperature, and technique not being exceeded.

2.2.2 **Wind** (see G2—3 App., 1.2). The take-off data shall be scheduled for all wind conditions in which the rotorcraft is permitted to operate.

A.B 2.2.3 **Spaces and Areas** (see G2—3 App., 2)

(a) In each case the scheduled take-off data shall describe the area necessary for movement on the Take-off Surface, as well as the related air space.

(b) The scheduled spaces and areas shall include appropriate allowance for the dimensions of the rotorcraft. A suitable margin, which shall be decided in consultation with the Board, shall also be included.

A 2.2.4 **Track.** When scheduling the Take-off Space Required and the Rejected Take-off Area the rotorcraft shall be assumed to follow a straight track.

A.B 2.3 **Power.** The conditions for power shall be in accordance with this paragraph 2.3.

2.3.1 **Rotorcraft with Piston Engines.** Up to Maximum One-hour Power may be drawn from the operating power-units.

2.3.2 **Rotorcraft with Turbine Engines**

B (a) **Rotorcraft with One Power-unit.** Up to Maximum One-hour Power and/or Thrust may be drawn from the power-unit.

A.B (b) **Rotorcraft with More than One Power-unit.** Up to Maximum Continuous Power and/or Thrust or Maximum Take-off Power and/or Thrust as appropriate to the rating of the engine (see **Section C, Chapter C4—1**) may be drawn during the all power-units-operating condition. In the event of one or more power-units failing during the take-off, up to Maximum Contingency Power and/or Thrust may be drawn from the operating power-units.

2.4 **Landing Gear**

A 2.4.1 **Group A.** Retraction of the landing gear shall not be initiated before either the Decision Point or a height of 50 feet, whichever height is the greater, is reached.

B 2.4.2 **Group B.** The landing gear shall be extended for the determination of the Take-off Space Required and the Rejected Take-off Area.

A 3 DECISION POINT* (see G2—3 App., 3) The Decision Point shall be identified by a suitable Decision Point criterion which shall provide a ready and reliable means of identifying when the applicable Decision Point has been reached.

NOTE : An air-speed indicator reading, possibly combined with a height reading, may provide an acceptable means of identification.

A.B 4 TAKE-OFF SPACE REQUIRED

A 4.1 **Group A** (see G2—3 App., 4). The Take-off Space Required shall be determined using a technique in accordance with the relevant parts of 2.1.1 and shall be the greater of the spaces determined in accordance with either 4.1.1, 4.1.2 or 4.1.3. The Take-off Space Required shall be scheduled in terms of the Decision Point criterion.

4.1.1 The space required, with all power-units operating, to accelerate from the Starting Point to the Decision Point and thereafter continue either up to the point at which the Take-off Safety Speed, V_s, or a height of 50 feet above the Take-off Surface is reached, whichever height is the greater.

4.1.2 The space required to accelerate with all power-units operating from the Starting Point to the Power-unit Failure Point and thereafter with the Critical Power-unit inoperative to continue to the Decision Point and to continue the take-off, reaching the Take-off Safety Speed, V_s (which shall be not less than the speed at which the take-off minimum climb performance of **G2—4**, 3.1, is met), or a height of 50 feet, whichever is the greater.

*It is at the discretion of the Applicant whether the user of the Flight Manual is permitted a choice of Decision Point.

A 4.1.3 The space involved in the determination of 5.1.

4.1.4 For all take-off techniques in which the Decision Point is scheduled at a height greater than 35 feet, the flight path between the Decision Point and V_2 shall not fall below a height of 35 feet.

B 4.2 **Group B**

4.2.1 The Take-off Space Required shall be determined and scheduled and shall be that space required to accelerate from the Starting Point with all power-units operating up to a height of 100 feet above the Take-off Surface, or to a height as required in establishing the Rejected Take-off Area of 5.2, whichever is the greater. The flight path shall be similar to the appropriate part of that used in establishing the Rejected Take-off Area.

NOTE : The Applicant may define the Take-off Space Required up to a height of 100 feet separately

A.B 5 REJECTED TAKE-OFF AREA

A 5.1 **Group A.** The Rejected Take-off Area shall be that area on the Take-off Surface required to accelerate from the Starting Point, with all power-units operating, to the Power-unit Failure Point, to continue to the Decision Point with the Critical Power-unit inoperative, and thereafter to come to a stop from the Decision Point.

B 5.2 **Group B.** The Rejected Take-off Area shall be determined and scheduled, using a technique in accordance with the relevant parts of 2.1.1 and shall be the greater of :—

(a) the area on the Take-off Surface required to accelerate, with all power-units operating, from the Starting Point up to a height of 100 feet above the Take-off Surface ; or

(b) the area on the Take-off Surface required to accelerate from the Starting Point with all power-units operating to a height which is not less than the minimum height from which a landing not involving hazard to the occupants can readily be made in the take-off area in the event of failure of the Critical Power-unit at minimum forward air speed in level flight above a height of 100 feet.

A 6 TAKE-OFF NET FLIGHT PATH (see G2—3 App., 5) The Take-off Net Flight Path shall be determined in accordance with this paragraph 6 and shall be scheduled. The path shall extend from the appropriate maximum height scheduled at the end of the Take-off Space Required to a height of 1,000 feet above the Take-off Surface.

6.1 **Landing Gear**

6.1.1 The effect on performance, if significant, of the power used for the retraction of the landing gear shall be included in the scheduled data.

6.1.2 At the commencement of the path it shall be assumed that the landing gear is in the most adverse position relative to the maximum height(s) scheduled in the take-off data.

6.2 **Air Speed.** The associated air speed(s) selected by the Applicant shall be—

(a) within the range of air speeds from which a controlled landing may be made in the event of the failure of all power-units, and

(b) not less than the Take-off Safety Speed, V_2, and within the range of air speeds at which the associated climb minima are met.

A

6.3 **Derivation.** The Take-off Net Flight Path shall be the gross take-off flight path with one power-unit inoperative, diminished by an amount which shall be agreed in consultation with the Board, and which shall be not less than that used in determining the en-route net data with one power-unit inoperative of **G2—4**, 3.3.2.

6.4 **Significant Turn.** The radius of turn, and the reduction in gradient during a defined rate of turn appropriate to the air speed used in establishing the Take-off Net Flight Path shall be determined and scheduled.

B

7 TAKE-OFF FLIGHT PATH The Take-off Flight Path shall be determined in accordance with this paragraph 7 and shall be scheduled. The path shall extend from the maximum height scheduled in the take-off data to a height of at least 1,000 feet.

7.1 **Landing Gear**

7.1.1 The effect on performance, if significant, of the power used for the retraction of the landing gear shall be included in the scheduled data.

7.1.2 The minimum height from which, in the event of the Critical Power-unit becoming inoperative, extension of the landing gear can be completed before the rotorcraft alights, shall be established and scheduled. The retraction of the landing gear shall not be initiated below this height.

7.2 **Air Speed.** The associated air speed(s) selected by the Applicant shall be within the range of air speeds from which a controlled landing may be made in the event of the failure of the Critical Power-unit.

7.3 **Derivation.** The Take-off Flight Path shall be the gross take-off flight path with all power-units operating.

APPENDIX TO CHAPTER G2—3

Issued, 1st February, 1963

PERFORMANCE—TAKE-OFF

1 GENERAL (see G2—3, 2)

1.1 **Ground Effect.** Account should be taken of ground effect in determining the Gross Performance from which the Take-off Space Required and Rejected Take-off Area are derived. No account should be taken of ground effect in establishing the take-off flight paths.

1.2 **Wind** (see G2—3, 2.2.2)

1.2.1 **General.** Except where otherwise stated, the winds referred to when determining and scheduling the effect of wind on take-off data, are those wind speeds which would be measured at a height of 33 feet above the Take-off Surface ; for the purpose of these requirements they are assumed to be steady.

NOTE : The data and limitations included in the Flight Manual which provide for account to be taken of wind are intended to be used in conjunction with the wind which would be measured at a height of 33 feet above the Take-off Surface.

1.2.2 **Cross Wind.** In determining Gross Performance from which take-off data are derived, the effect of cross wind is usually ignored, and no provision is made for scheduling the effect of cross-wind components. However, should take-off performance prove to be sensitive to cross wind the Board may require that account is taken of cross-wind components.

1.2.3 **Scheduling of Data.** The operational performance rules specify that factors of 50% and 150% should be applied to the head-wind and tail-wind components respectively when assessing the Take-off Space Required and the Rejected Take-off Area. The information scheduled in the Flight Manual should incorporate the effect of these factors so as to enable the direct use of the reported wind.

1.2.4 **Wind Gradient.** The Gross Performance from which the take-off flight paths are derived should be determined in such a way that no effects of wind gradient are present. In scheduling take-off flight path data no provision should be made for taking account of wind gradient.

2 SPACES AND AREAS (see G2—3, 2.2.3) When scheduling the Take-off Space Required in accordance with G2—3, 4.1 or 4.2, and the Rejected Take-off Area in accordance with G2—3, 5.2, the margin to be applied will be decided taking into account the most adverse rational combination of at least the following variables—power, propulsive efficiency, drag, air speed, weight and pilot handling.

3 DECISION POINT (see G2—3, 3) The Decision Point may be chosen by the Applicant except that it should follow the assumed Power-unit Failure Point by a time interval which allows for appreciating that a power-unit failure has occurred. The possible need for varying the Decision Point to suit different operating sites should be considered, and where necessary take-off performance may be scheduled for a range of Decision Points.

4 TAKE-OFF SPACE REQUIRED (see G2—3, 4.1) The Applicant may choose whether to present the all-power-units-operating and one-power-unit-inoperative net spaces separately or as a single space which is based on the more severe case as appropriate. If the former choice is adopted a statement should appear in the Flight Manual stating that the Take-off Space Required is the greater of the two spaces scheduled.

5 TAKE-OFF NET FLIGHT PATH (see G2—3, 6) The amount by which the gross take-off flight path will be diminished will be decided taking into account the most adverse rational combination of at least the following variables—power, propulsive efficiency, drag, air speed, weight and pilot handling.

SUB-SECTION G2—FLIGHT

CHAPTER G2—4 PERFORMANCE—CLIMB

Revised in part, 15th June, 1966

A.B 1 INTRODUCTION This Chapter prescribes the determination of WAT Curve, en-route, and hovering data for the conditions of 2.1.

2 GENERAL

2.1 **Data Required.** The data specified in this Chapter shall be determined and scheduled for the weight range, Minimum to Maximum Weight, for the range of temperature chosen by the Applicant in accordance with G2—2, 3, over ranges of altitude in accordance with the following paragraphs.

2.2 **Power.** The conditions for power shall be in accordance with this paragraph 2.2.

2.2.1 **Rotorcraft with Piston Engines**

(a) **Take-off.** Up to Maximum One-hour Power may be drawn from the operating power-units.

(b) **En Route—All Power-units Operating.** The climb data shall be established using the Maximum Continuous Power rating.*

(c) **Critical Power-unit Inoperative.** In establishing the climb data with the Critical Power-unit inoperative, up to Maximum One-hour Power may be drawn from the operating power-unit(s).

B 2.2.2 **Rotorcraft with One Turbine-engined Power-unit**

(a) **Take-off.** Up to Maximum One-hour Power and/or Thrust may be drawn from the power-unit.

(b) **En Route.** The climb data shall be established using the Maximum Continuous Power and/or Thrust rating.*

A.B 2.2.3 **Rotorcraft with More Than One Turbine-engined Power-unit**

(a) **Take-off.** Up to Maximum Continuous Power and/or Thrust or Maximum Take-off Power and/or Thrust as appropriate to the rating of the engine (see Section C, Chapter C4—1) may be drawn during the all-power-units-operating condition. In the event of one or more power-units failing during the take-off, up to Maximum Contingency Power and/or Thrust may be drawn from the operating power-units.

(b) **En Route—All Power-units Operating.** The climb data shall be established using the Maximum Continuous Power and/or Thrust rating.

(c) **En Route—Power-unit(s) Inoperative.** In the event of one or more power-units failing, up to Intermediate Contingency Power and/or Thrust may be drawn from the operating power-units.

2.3 **Fuselage Attitude.** Where the fuselage angle of pitch and/or yaw has a significant effect upon the performance of the rotorcraft, all climb data shall be related to the most adverse likely condition.

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*See also G2—4 App., 3.

A.B 2.4 **Landing Gear**

2.4.1 **En Route.** When establishing the en-route data the landing gear may be in the retracted position.

2.4.2 **Balked Landing.** When establishing the balked landing data the landing gear shall be fully extended.

NOTE : For the take-off case see G2—3, 2.4.

2.5 **Ground Effect.** Climb performance shall be related to the absence of ground effect except where mention is made otherwise (see G2—3 App., 1.1, and G2—5 App., 1.2).

A 3 WAT CURVE (Group A) (see G2—4 App., 1 and 2) The Maximum Weight appropriate to the Altitude and Temperature shall be determined and scheduled, and for each weight, altitude, temperature condition for which data is established it shall not exceed the Maximum Take-off or Landing Weight, as appropriate, and shall, at each weight, altitude, temperature condition, enable compliance with the climb performance minima of this paragraph 3.

3.1 **Take-off.** Both with all power-units operating, and with the Critical Power-unit inoperative, and the remainder operating in accordance with 2.2, the net rate of climb shall be the gross performance, diminished by a rate of climb which shall be agreed in consultation with the Board and which shall be not less than that used in determining the en-route net data with one power-unit inoperative of 3.3.2. The net rate of climb at the end of the Take-off Space Required shall be not less than 100 ft/min. up to a height of 500 feet above the Take-off Surface, and thereafter shall be not less than 50 ft/min. up to a height of 1,000 feet above the Take-off Surface.

NOTE : The Take-off Safety Speed, V_s, is required to be not lower than the air speed selected to meet this requirement (see G2—3, 4.1.2).

3.2 **Take-off Net Flight Path.** At no stage of the Take-off Net Flight Path, derived in accordance with G2—3, 6, shall the scheduled path of the rotorcraft fall below a profile originating at the 50 feet height point at the end of the Take-off Space Required, and extending at a gradient of 3% up to a height of 500 feet above the Take-off Surface, and thereafter extending at a gradient of 1·5% up to a height of 1,000 feet above the Take-off Surface.

3.3 **En Route**

3.3.1 The net rate and corresponding gradient of climb at an indicated air speed not less than the speed for best rate of climb, with the Critical Power-unit inoperative, and the remainder operating in accordance with 2.2 shall be not less than 50 ft/min. and 0·5% respectively at all altitudes between the altitude of the Take-off Surface and 1,000 feet above it.

3.3.2 The en-route net performance relative to 3.3.1 shall be the gross gradient of climb, diminished by—

(a) **For Rotorcraft with Two Power-units.** A gradient corresponding to a rate of climb of 100 ft/min., or a gradient of 1%, whichever is the greater.

(b) **For Rotorcraft with More than Two Power-units.** A gradient which shall be decided in consultation with the Board.

B 4 WAT CURVE (Group B) The Maximum Weight appropriate to the Altitude and Temperature shall be determined and scheduled, and for each weight, altitude, temperature condition for which data is established, it shall not exceed the Maximum Take-off or Landing Weight, as appropriate, and shall, at each weight, altitude, temperature condition, enable compliance with the climb performance minima of this paragraph 4.

4.1 **Take-off with Ground Run.** For a technique which requires the attainment of a specified forward speed on the surface, before unstick, the sum of the acceleration and gradient of climb at each point in the all-power-units-operating take-off path, shall be at least equivalent to a gradient of climb of 8%.

4.2 **Towering Take-off.** For a technique in which vertical flight is used, but in which vertical flight is confined to heights at which ground effect makes a significant contribution to performance, compliance shall be shown with the gradient of climb requirement of 4.1 and with either (a) or (b) with the power-units operating in accordance with 2.2:—

(a) the rate of climb at zero air speed in free air shall be positive,

(b) the ability to complete a take-off from the hover in ground effect at a height appropriate to the take-off technique shall be demonstrated to the satisfaction of the Board, and a means of checking the required performance level shall be agreed and included in the Flight Manual as a pre-flight hovering drill.

4.3 **Vertical Take-off.** For a technique which involves vertical flight in free air, the rate of climb at zero air speed with all power-units operating in accordance with 2.2 shall be not less than 100 ft/min.

4.4 **En Route—All Power-units Operating.** The rate and corresponding gradient of climb at an indicated air speed not lower than the speed for best rate of climb, with all power-units operating at Maximum Continuous Power Conditions, shall be not less than 200 ft/min. and 4% respectively at all altitudes between the altitude of the Take-off Surface and 1,000 feet above it.

A.B 5 BALKED LANDING

A 5.1 From any point in the landing path determined in accordance with G2—5, 2.2.2, the rotorcraft with all power-units operating shall be capable of achieving the climb minima of 3.1 and 3.2 in the event of a balked landing.

5.2 The one power-unit inoperative balked landing path shall be established and scheduled. It shall extend from the steady approach conditions with the Critical Power-unit inoperative to the flight conditions at which the climb minima of 3.1 and 3.2 at the powers associated with that paragraph are met.

B 5.3 The balked landing path shall be established and scheduled. It shall extend from the steady approach conditions with all power-units operating to the flight conditions at which the appropriate take-off climb minima of 4 are met.

A.B 6 EN-ROUTE DATA (see G2—4 App., 3)

6.1 **En Route—All Power-units Operating.** The gross rate and corresponding gradient of climb with all power-units operating at Maximum Continuous Power, at an indicated air speed selected by the Applicant but not lower than the air speed for best rate of climb, shall be determined and scheduled over the range of altitude from sea-level to the lesser of—

(a) maximum permissible altitude, or

(b) the altitude at which, with Maximum Continuous Power, the rate of climb does not exceed 100 ft/min. at the temperature considered.

A.B 6.2 **En Route—After Power Failure**

B 6.2.1 **Rotorcraft with One Power-unit.** The rate and corresponding gradient of descent, with the power-unit inoperative, shall be determined and scheduled for the range of altitude selected for establishing compliance with 6.1. The air speed with which they are associated may be selected by the Applicant provided it exceeds by a safe margin the minimum air speed (if any) required for the maintenance of control of heading determined in accordance with **G2—8.**

NOTE : It is recommended that, subject to the above, the air speed selected should be that for minimum gradient of descent.

6.2.2 **Rotorcraft with More Than One Power-unit.** The gross rate and corresponding gradient of climb or descent shall be determined and scheduled, for the range of altitude selected for establishing compliance with 6.1, in accordance with either (a) or (b) :—

(a) With all power-units inoperative. The associated air speed may be selected by the Applicant provided it exceeds by a safe margin the minimum air speed (if any) required for the maintenance of control of heading determined in accordance with **G2—8.**

(b) With the Critical Power-unit inoperative, and the remainder operating in accordance with 2.2, at an indicated air speed selected by the Applicant but not lower than the speed for best rate of climb in the condition considered.

A 6.2.3 **One-Power-unit-Inoperative Net Data.** The net gradient of climb with the Critical Power-unit inoperative shall be determined and scheduled and shall be the gross gradient of climb, at an indicated air speed not less than the speed for best rate of climb, diminished by—

(a) **For Rotorcraft with Two Power-units.** A gradient corresponding to a rate of climb of 100 ft/min., or a gradient of 1%, whichever is the greater.

(b) **For Rotorcraft with More than Two Power-units.** A gradient which shall be decided in consultation with the Board.

A.B 7 HOVERING DATA The gross rate of climb or descent in free air at zero air speed in the conditions of 7.1 and 7.2 shall be determined and scheduled for each power rating, other than weak mixture in the case of piston engines, for the range of altitude derived from 6.1 except that such determination may be omitted for those conditions in which the rates of descent give rise to undue vibration or exceed 1,000 ft/min. In those conditions in which a rate of descent exists, the minimum air speed necessary for the rate of descent to be zero shall also be determined.

7.1 **All Rotorcraft.** With all power-units operating.

7.2 **Rotorcraft with More Than One Power-unit.** With the Critical Power-unit inoperative and the remainder operating in accordance with 2.2.1 (c) or 2.2.3 (a) as applicable.

APPENDIX TO CHAPTER G2—4

Issued, 1st February, 1963

PERFORMANCE—CLIMB

1 WIND (see G2—4, 3 and 4) The climb minima are related to conditions of zero wind and zero wind gradient. It is left to the discretion of the Applicant whether or not to schedule the effect of wind on en-route data.

2 CLIMB, TAKE-OFF (see G2—4, 3.1) The amount by which the gross rate of climb will be diminished will be decided taking into account the most adverse rational combination of at least the following variables—power, propulsive efficiency, drag, air speed, weight and pilot handling.

3 CLIMB, EN-ROUTE (All Power-units Operating) (see G2—4, 6.1) In the case of rotorcraft with engines having Maximum One-hour Power ratings, it is at the discretion of the Applicant whether the Flight Manual should include the en-route climb data associated with this power.

SUB-SECTION G2—FLIGHT

CHAPTER G2—5 PERFORMANCE—LANDING

Revised in part, 7th November, 1975

A.B 1 INTRODUCTION

1.1 This Chapter prescribes the determination of the areas and spaces required for normal and emergency landings, for the conditions and ranges of conditions selected by the Applicant in accordance with **G2—2, 3.**

NOTE: The choice of techniques in this Chapter is, in some cases, interrelated with the corresponding choice made in connection with **G2—3.**

1.2 If it is clear that the space required for a take-off case is greater than that required for the corresponding landing case, accurate measurement of the landing space will not be necessary unless it is desired to schedule emergency landing spaces separately.

2 GENERAL CONDITIONS (see G2—5 App., 1)

2.1 **Techniques.** The Applicant shall select the techniques to be determined and scheduled. In each case the technique used shall be compatible with **G2—7** and shall take account of the pilot's field of view and the information presented to the pilot by the rotorcraft instruments.

2.1.1 **Mandatory Technique**

(a) It shall be possible, in the event of failure of the Critical Power-unit at any point of the intended approach path from the maximum height above the Landing Surface to which the landing data are related, to complete the landing in the space prescribed without damage to the rotorcraft or hazard to the occupants.

(b) The requirements of 2.1 shall be met at whatever point the Critical Power-unit may fail.

(c) The flight path shall be controllable at all times.

(d) The rotorcraft heading shall be controllable at all times except that lack of control of heading when airborne at very low horizontal velocities may be accepted provided that there is no inherent tendency to swing and that the rotorcraft is suitable for landing at all angles of yaw likely to be encountered.

NOTE: To achieve compliance with this requirement, it may be necessary to stipulate that the indicated air speed in certain airborne conditions does not fall below a certain value; in such a case, certain additional control requirements given in **G2—8** will have to be met.

2.1.2 **Non-mandatory Techniques.** The extent and implications of the differences in technique shall be clearly and explicitly stated.

A,B 2.2 **Conditions to be Covered in the Flight Manual**

2.2.1 **Wind** (see **G2—5** App., 1.1). The landing data shall be scheduled for all wind conditions in which the rotorcraft is permitted to operate.

2.2.2 **Spaces and Areas** (see **G2—5** App., **2**)

(a) In each case the scheduled landing data shall describe the area necessary for movement on the Landing Surface as well as the related air space.

(b) The scheduled spaces and areas shall include appropriate allowance for the dimensions of the rotorcraft. A suitable margin, which shall be decided in consultation with the Authority, shall also be included.

(c) The Landing Space Required shall extend from whichever is the higher of 100 feet above the Landing Surface or (i) or (ii), as applicable—

A (i) **Group A.** The minimum height from which a balked landing can be made as determined in accordance with **G2—4,** 5.2,

B (ii) **Group B.** The minimum height from which, in the event of failure of the Critical Power-unit at any point when at minimum forward speed, a landing without damage to the rotorcraft or hazard to the occupants can be made in the landing area,

to the point at which the rotorcraft is brought to rest.

A 2.2.3 **Track.** When scheduling landing data the rotorcraft shall be assumed to follow a straight track.

A,B 2.3 **Power.** The conditions for power shall be in accordance with this paragraph 2.3.

2.3.1 **Rotorcraft with Piston Engines.** Up to Maximum One-hour Power may be drawn from the operating Power-units.

2.3.2 **Rotorcraft with Turbine Engines**

B (a) **Rotorcraft with One Power-unit.** Up to Maximum One-hour Power and/or Thrust may be drawn from the Power-unit.

A,B (b) **Rotorcraft with More Than One Power-unit**

(i) Up to Maximum Continuous Power and/or Thrust may be drawn from the Power-units during the all-Power-units-operating condition.

(ii) In the event of one or more Power-units failing during or before the landing, up to Maximum Contingency Power and/or Thrust may be drawn from the operating Power-units.

2.4 **Retardation.** Where credit is claimed for the use of wheel brakes in establishing landing data in which significant forward speeds at touch down are involved, the effect of a wet surface shall be scheduled. The braking coefficients of friction for a wet surface shall be agreed with the Authority (see also **G2—5** App., 1.4).

A.B 3 LANDING DATA REQUIRED

3.1 **Landing Space Required.** Landing data consistent with a technique complying with 2.1.1 shall be determined and scheduled for each weight-altitude-temperature condition for which take-off data are determined and scheduled in accordance with **G2—3,** 2.1.1.

A 3.2 **Landing Space Required with Critical Power-unit Inoperative.** The Landing Space Required with the Critical Power-unit inoperative shall be determined and scheduled and shall extend either from the minimum height from which a balked landing can be made as determined in accordance with **G2—4,** 5.2, or from 100 feet above the Landing Surface, whichever is the higher. The Critical Power-unit shall be assumed inoperative throughout, and the technique chosen shall be such that in the event of the failure of a second Power-unit it shall be possible to comply with 2.1.1 (b), (c) and (d) and to complete the landing in the space prescribed without hazard to the occupants (see also **G2—8, 5**).

NOTE: This data, whilst it has to be scheduled, is not called up in the relevant operational performance rules.

A.B 3.3 **Non-standard Landing Data.** Where the Applicant has elected to establish take-off data in accordance with **G2—3,** 2.1.2, landing data based on corresponding principles, if applicable, shall be determined and scheduled for each weight-altitude-temperature condition for which such take-off data are determined and scheduled.

B 3.3.1 **Emergency Landing Space.** Where the Applicant does not wish the space required for take-off and landing to be scheduled also as the space required for emergency landing, then data for the emergency landing space shall be determined and scheduled in accordance with 2.1.1 and may also be determined for techniques other than those chosen in accordance with 2.1.1 provided that the extent and implications of the differences in technique are clearly and explicitly stated.

APPENDIX TO CHAPTER G2—5

Issued, 1st February, 1963

PERFORMANCE—LANDING

1 GENERAL CONDITIONS (see G2—5, 2)

1.1 **Wind** (see **G2—5,** 2.2.1)

1.1.1 **General.** Except where otherwise stated, the winds referred to when determining and scheduling the effect of wind on landing data, are those wind speeds which would be measured at a height of 33 feet above the Landing Surface; for the purpose of these requirements they are assumed to be steady.

NOTE: The data and limitations included in the Flight Manual which provide for account to be taken of wind are intended to be used in conjunction with the wind which would be measured at a height of 33 feet above the Landing Surface.

1.1.2 **Scheduling of Data.** The operational performance rules specify that factors of 50% and 150% should be applied to the head-wind and tail-wind components respectively when assessing the Landing Space Required. The information scheduled in the Flight Manual should incorporate the effect of these factors so as to enable the direct use of the forecast wind.

1.1.3 **Cross Wind.** In determining Gross Performance from which landing spaces are derived, the effect of cross wind is usually ignored, and no provision is made for scheduling the effect of cross-wind components. However, should landing performance prove to be sensitive to cross wind the Board may require that account be taken of cross-wind components.

1.2 **Ground Effect.** Account should be taken of ground effect in determining the Gross Performance from which the Landing Space Required is derived.

1.3 **Landing Gear.** The landing gear should be fully extended throughout.

1.4 **Retardation**

1.4.1 **Wheel Brakes.** Wheel brakes should not be applied before the rotorcraft has settled on to the ground in its initial ground run attitude. They should not be used in such a manner as to produce a retardation which would necessitate excessive servicing of the brakes and tyres. Emergency braking systems should not be used.

NOTE: This paragraph is not intended to prevent operation in the normal way of automatic braking systems which, for instance, permit brakes to be selected on before touch down.

1.4.2 **Skids.** The technique should not be such as to necessitate excessive servicing of the skids.

2 MARGINS (see G2—5, 2.2.2) The margins to be applied will be decided taking into account the most adverse rational combination of at least the following variables—power, propulsive efficiency, drag, air speed, weight and pilot handling.

SUB-SECTION G2—FLIGHT

CHAPTER G2—6 HANDLING—GENERAL

Revised in part, 16th August, 1982

A.B **1** INTRODUCTION

1.1 This Chapter contains general requirements, detailed requirements and definitions, all of which are applicable to the Handling Requirements as a whole. There may be cases where a general requirement given in this Chapter has to be overridden by a detailed requirement in a particular chapter; the text used in the particular chapter will make this clear.

1.2 The Handling Requirements of Chapters **G2—6** to **G2—10** prescribe both the handling qualities which the rotorcraft shall possess and the determination of limitations (e.g. wind speed) within which the rotorcraft can be safely operated. Compliance with the requirements is established by tests made in conditions selected so as to cover the prescribed ranges of conditions.

2 GENERAL

2.1 **Qualitative Assessments**

2.1.1 **General.** In the course of establishing compliance with the Handling Requirements, a general qualitative assessment of the handling qualities shall be made. If this assessment reveals any unusual characteristics which are not fully investigated during the tests conducted in order to comply with the requirements, then additional tests shall be carried out to establish that the handling qualities in these respects are satisfactory.

2.1.2 **Atmospheric Turbulence.** Although the Handling Requirements are, in general, associated with no appreciable atmospheric turbulence, a qualitative check shall be made to ensure that there is no undue deterioration of the handling characteristics in turbulent air.

2.2 **Loading.** Each handling requirement shall be complied with at each weight between and including the Maximum and Minimum Weight. At each weight compliance shall be established over a range of c.g. positions greater than that for which certification is desired. The extent and direction by which the centre-of-gravity envelope, for which certification is desired, shall be exceeded shall be decided in consultation with the Authority. In showing compliance with each handling requirement, sufficient data shall be obtained to enable the variation in behaviour with centre-of-gravity position to be reliably predicted in the region of the centre-of-gravity limits for which certification is desired.

NOTE: The margin by which the demonstrated c.g. envelope exceeds the envelope for which certification is desired will be not less than 5% of the total range at each end of the range about each of the three axes.

2.3 **Altitude and Temperature.** Each requirement shall be complied with at all altitudes up to the declared maximum operating altitude relevant to the particular requirement, and in all temperature conditions relevant to the altitude in question, for which the rotorcraft is to be certificated.

NOTE: This requirement is intended to cover such effects as freezing of control system lubricants, and differential contraction, as well as aerodynamic effects. Tests at extreme conditions will normally not be required unless there is reason to believe that these conditions are likely to be critical.

A.B 2.4 **Ground Effect.** Compliance with the Handling Requirements shall be established in the absence of ground effect, except in the cases of **G2–7** and where, in particular requirements, specific indication to the contrary is given.

2.5 **Automatic Flight Control and Stability Augmentation Systems.** Each requirement in this Chapter, unless otherwise specified, shall be complied with when the system is not in operation. The requirements do not, however, prohibit modification, at the discretion of the Authority, of the inherent stability characteristics during the time that such a system is actually in use. (See also **G2–8, 8** and **G6–4.**)

2.6 **Control System Characteristics.** In the course of establishing compliance with the Handling Requirements, sufficient observation shall be made of the friction (and other significant rigging characteristics) of the primary flight control systems, to enable such maintenance instructions to be formulated as will ensure that there will be no undue variation between the handling characteristics of the prototype rotorcraft at the time of official trials, and those of series rotorcraft, or of the same rotorcraft during its service life.

2.7 **Power-operated and Power-assisted Controls**

2.7.1 Where the design incorporates power-operated or power-assisted control systems, the Handling Requirements shall be met with the systems in full operation.

2.7.2 The types of failure of these control systems to be considered, the extent and nature of the deterioration in the handling qualities which is acceptable during and after such failures, and the circumstances in which such failures shall be considered, shall be decided in consultation with the Authority, having regard to the characteristics of the rotorcraft and its control systems.

2.8 **Auxiliary Services Affecting Handling Qualities.** When the handling qualities of the rotorcraft are partly or wholly dependent on the operation of an auxiliary service which is in turn dependent on one or more power-units not being stopped, then, for each requirement which is related to conditions which include the failure of one or more power-units, the determination of the Critical Power-unit(s) and the assessment of the handling qualities shall take into account the possibility of such power-unit(s) being stopped.

2.9 **Power Conditions.** These shall be equal for all power-units, except as otherwise prescribed.

2.10 **Structural Implications.** Where proof of compliance with the Handling Requirements might involve structural loads in excess of those provided for in complying with structural requirements, these shall be reported to the Authority.

2.11 **Technique for Flight in Turbulence.** Any special techniques for flight in turbulence shall be established and scheduled. These techniques shall be chosen to give the optimum protection against loss of control and against structural damage either occurring directly as the result of turbulence, or occurring in the recovery from any disturbance of the flight path.

NOTE: The technique should also distinguish where necessary between the procedures to be followed when deliberately entering an area of known turbulence and that to be followed when the encounter is unexpected.

3 DEFINITIONS The definitions of this paragraph are applicable throughout the Handling Requirements.

A.B 3.1 **Trimming and Trimmed Speed.** For the purpose of these requirements "trimming" means "the reduction to zero of the mean control forces needed to maintain straight flight at a given speed without the aid of an automatic-pilot". The words "trimmed speed" are consistent with the foregoing definition, with the proviso that where the effect of friction would render the definition applicable to a band of speeds, the speed intended is that to which the definition would apply in the absence of control friction.

3.2 **Control Force and Control Movement.** Except where otherwise prescribed, these refer to the longitudinal control. The terms "stick-force" and "pedal-force" signify the forces applied to the control specified, longitudinal stick-force being regarded as positive when the force applied by the pilot tends to move the top of the control column forward, such forward movement also being regarded as positive.

3.3 **Excessive Control Forces.** The assessment of whether a control force is excessive, apart from a maximum figure which may be prescribed, may be influenced by the ease of applying it and the general level of control forces for the rotorcraft.

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SUB-SECTION G2—FLIGHT

CHAPTER G2—7 HANDLING—GROUND AND WATER MANOEUVRES

Revised, 1st February, 1963

A.B 1 INTRODUCTION This Chapter prescribes the requirements for handling on the surfaces of ground or water as appropriate. Rotorcraft for which certification as amphibians is sought shall comply with **2, 3** and **4.** On the basis of these requirements certain operating limitations are established which may limit the choice of techniques used in establishing compliance with **G2—3** and **G2—5.**

2 ALL ROTORCRAFT

2.1 **Control Forces.** During a take-off or landing in accordance with the recommended technique, it shall in each case be possible to leave the trimming controls untouched throughout, without excessive forces being encountered, whether or not power-unit failure occurs. Consideration shall be given to any likely error in the initial settings of trimming controls.

2.2 **Directional Control.** Means shall be provided for adequate directional control during taxying ; this means shall be such that at all necessary speeds upon the ground or water there is no uncontrollable tendency to ground loop in the maximum wind speed permitted for taxying.

2.3 **Clutch and Rotor-brake Controls.** The handling qualities of the clutch and rotor brake shall be satisfactory and no exceptional skill shall be necessary for the safe operation of the rotating system. Consideration shall be given to the case of faulty engine starting and reasonable maladjustment of controls having regard to the starting drill laid down. A wind speed up to which it is safe to accelerate the rotor(s) from the stationary condition up to normal operating speed shall be established.

2.4 **Excessive Oscillation.** In all permissible ground or water operating conditions, there shall be no excessive oscillation (including ground resonance) which is not readily controllable.

2.5 **Towing.** All recommended towing techniques shall be demonstrated to be safe in conditions typical of the most adverse likely to be encountered.

3 LAND ROTORCRAFT

The requirements of this paragraph **3** are related primarily to rotorcraft with wheels. The variation of the requirements when they are applied to rotorcraft fitted with skids or skis shall be decided in consultation with the Board.

3.1 **Taxying Limitations.** A wind speed and, if applicable, a ground speed up to which it is safe to taxy in any direction shall be determined. Any limitations on the use of wheel brakes shall also be determined in conjunction with this requirement.

NOTE : If a limitation on the use of wheel brakes is required, the choice of techniques for establishing compliance with **G2—3** and **G2—5** may be limited.

3.2 **Ground Speed Limitations at Unstick and Touch-down.** A horizontal speed up to which it is safe to unstick and touch down shall be demonstrated.

A.B 3.3 **Longitudinal and Lateral Stability.** There shall be no uncontrollable tendency to nose or roll over and no tendency to porpoise in any permissible condition of operation. There shall be no excessive tendency to bounce, pitch or roll when the rotorcraft is landed in any permissible manner.

3.4 **Movement on Rough Ground.** An adequate proportion of the ground handling trials shall be made on ground, the surface of which is representative of the most adverse on which ground operation is recommended. In particular, when the rotorcraft is handled in accordance with any reasonable interpretation of the recommended technique, the characteristics of the landing gear shall be satisfactory and the Rotor System shall not be liable to mechanical damage.

4 SEA ROTORCRAFT

4.1 **Water Conditions.** The worst water conditions in which the rotorcraft has been demonstrated to be safe both for taxying up to the limiting taxying speed in all directions and for achieving the approved take-off and alighting techniques (see **G2—2,** 5.5) shall be entered in the Flight Manual. The water conditions shall be assessed in terms of the Douglas Sea Swell Scale.

4.2 **Wind Conditions.** A wind speed shall be determined at and below which it has been demonstrated that the rotorcraft is safe to taxy up to the limiting taxying speed in all directions, in water conditions up to and including those of 4.1.

4.3 **Take-off and Alighting Limitations.** A limiting rate of descent and a limiting forward speed relative to the water at which a safe alighting may be made shall be established. These conditions shall be related to the technique for alighting with the Critical Power-unit inoperative as prescribed in **G2—5.**

4.4 **Control and Stability**

4.4.1 **Characteristics.** In taxying, taking-off and alighting the rotorcraft shall not possess characteristics which would result in :—

(a) any dangerous uncontrollable porpoising, bouncing, rolling, or swinging tendency,

(b) any immersion of rotor blades, propeller blades or other parts of the rotorcraft which are not designed to withstand water loads,

(c) any spray forming which would dangerously obscure the pilot's view, cause damage to the rotorcraft, or result in the ingress of an undue quantity of water.

4.4.2 **Conditions.** Compliance with 4.4.1 shall be shown for the following conditions:—

(a) all wind and surface conditions in which the rotorcraft is likely to be operated,

(b) all speeds at which the rotorcraft is likely to be operated on the water,

(c) sudden failure of the Critical Power-unit occurring at any moment.

4.5 **Drift.** In the conditions of 4.4.2, the rotorcraft shall be able to drift for five minutes with engines inoperative and controls not operated, aided if necessary by a sea anchor.

SUB-SECTION G2—FLIGHT

CHAPTER G2—8 HANDLING—CONTROLLABILITY

Revised in part, 16th August, 1982

A.B **1** INTRODUCTION This Chapter prescribes minimum standards for controllability and also prescribes the determination of information needed for inclusion in the Flight Manual and for the derivation of performance information. Certain requirements dealing with mechanical characteristics may be complemented by requirements in other Sub-sections.

2 GENERAL The rotorcraft shall be safely controllable and manoeuvrable during take-off and landing and in level flight, ascent, and descent. In all practicable and permissible flight conditions it shall be possible to make safe transitions from one flight condition to another. The execution of such transitions shall not introduce any danger of exceeding the limit load conditions either under any normally expected operating conditions or in the event of sudden failure of any power-unit*.

3 FORCES AND MOVEMENT (see G2—8 App.,1) In respect of the collective pitch, yawing, and cyclic pitch or the equivalent controls, the control forces shall not be excessive and sufficient margin of control movement and blade freedom shall be available to correct for atmospheric turbulence and to permit reasonable control of the attitude of the rotorcraft in flight, during possible combinations of power and collective pitch, in the cases of this paragraph **3.**

3.1 Over an agreed envelope of horizontal velocities exceeding by an agreed amount the envelope of horizontal velocities between which the rotorcraft will be permitted to fly.

3.2 During accelerated manoeuvres including steep turns and straight pull-outs at all points within the forward-positive flight envelope for which strength is provided in accordance with **G3—2,** except that compliance need not be demonstrated in conditions such that the loads occurring in the structure exceed 75% of the design Limit Loads.

3.3 During all changes of engine power including the case of sudden power-unit failure* in all permissible flight conditions.

3.4 During and after changes of collective pitch at the maximum appropriate rate.

3.5 During changes of forward speed at constant power control settings including changes between translational flight and hovering.

3.6 During and after failure of power-operated and power-assisted controls, and such other devices as are used to modify pilots' control forces.

*For the power-unit failure case see also **G2—8** App., **2.**

A.B 4 CHANGES OF FLOW STATE (see G2—8 App.,3) The behaviour of the rotorcraft shall be determined and the rotorcraft shall not exhibit dangerous characteristics when:—

(a) the rotorcraft enters and is in the autorotative state;

(b) pitch on the main rotors is suddenly reduced in vertical flight.

5 LANDINGS FOLLOWING LOSS OF POWER Techniques shall be established for landing the rotorcraft, without hazard to the occupants in the event of—

(a) the failure of all power-units,

B (b) the failure of one power-unit*.

A.B The envelope(s) of forward speed and height from within which, in zero wind, such landings can be made, shall be established.

NOTE: This may include cases where there is a likelihood of damage to the rotorcraft up to, but not exceeding, that assumed in stressing the rotorcraft for the emergency landing case of Sub-section G3, but it is not intended that the technique should be demonstrated for those conditions for which the rotorcraft is liable to be damaged. Sufficient experience is required, however, to enable the behaviour in more adverse conditions to be forecast with reasonable accuracy.

6 CONTROL OF HEADING

6.1 The power conditions in which the rotorcraft heading cannot be changed shall be determined.

NOTE: This will be taken into account in agreeing acceptable mandatory take-off and landing techniques.

6.2 If the mandatory technique chosen for take-off and/or re-landing includes a minimum airborne speed (e.g. for the purpose of avoiding uncontrollable swing), it shall be demonstrated that over a reasonable range of speed above and below this speed, adequate control is available both on the ground and in flight.

6.3 If the mandatory landing technique is associated with a minimum airborne speed a positive indication shall be given to the flight crew when speed is reduced below this minimum in circumstances likely to lead to loss of yawing control. The method of complying with this requirement shall be decided in consultation with the Authority.

NOTE: The reason for this requirement is that an unintentional loss of speed during the last part of a power-off flare-out might lead to the touch down being made during an uncontrollable swing.

7 COLLECTIVE PITCH CONTROL The properties in combination of the controls for the power-plant and rotor shall be such that excessive attention is not required to maintain the desired rotational speed and lift from the main rotor, both normally and in the event of power failure.

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*For the power-unit failure case see also G2—8 App., 2.

A.B

8 CONTROL AFTER FAILURE OF AUTOMATIC FLIGHT CONTROL, OR STABILITY AUGMENTATION SYSTEM OR AFTER AN EVENT AFFECTING THE FLIGHT PATH (see G2—8 App., 4 and G6—4)

A

8.1 General (Group A Rotorcraft)

8.1.1 The controllability of the rotorcraft shall be such that, during and after:

(a) the Failure (active or passive) of any system, or

(b) an Event affecting the flight path,

the situation will not be more severe than a Major Effect.

8.1.2 In showing compliance with 8.1.1 the consequences of any Failure or Event, the probability of occurrence of which, either singly or in combination, is greater than Extremely Remote shall be considered.

8.1.3 No single failure or Event or combination thereof which is not Extremely Improbable shall result in a Catastrophic Effect.

B

8.2 General (Group B Rotorcraft)

8.2.1 The controllability of the rotorcraft shall be such that, during and after:

(a) the Failure (active or passive) of any system, or

(b) an Event affecting the flight path,

the situation will not be more severe than a Major Effect. Nothing arising from such a condition shall preclude the possibility of a safe Emergency Landing.

8.2.2 In showing compliance with 8.2.1, the consequences of any Failure or Event, the probability of occurrence of which, either singly or in combination, is greater than Extremely Remote shall be considered.

8.2.3 No single failure or Event which is not Extremely Improbable shall result in a Catastrophic Effect.

A.B

8.3 Failures and Events

8.3.1 **General**

(a) All Failures and Events shall be considered to begin at all altitudes and at all air speeds and rotor speeds within the relevant declared Flight Envelope. Where appropriate, directions and velocities of flight other than forward shall be taken into account. (See **G6—4, 2** and **G6—4** App., 4.1.)

(b) In each case the rotorcraft shall initially be in trim.

8.3.2 **Nose-down Disturbances.** It shall be demonstrated that, following any nose-down disturbance which results from the Failures and Events prescribed in 8.1 or 8.2, it is possible, using the assumed recovery technique, to recover to steady level flight without exceeding the Maximum Demonstrated Flight Speed, V_{DF}, and without encountering dangerous characteristics such as excessive changes of control force, normal acceleration or height.

A.B

8.3.3 **Nose-up Disturbances.** It shall be demonstrated that, following any nose-up disturbance which results from the Failures and Events prescribed in 8.1 or 8.2, it is possible, using the assumed recovery technique, to recover to steady level flight without encountering dangerous characteristics such as excessive changes of control forces, normal acceleration or airspeed.

8.3.4 **Roll and Yaw Disturbances.** It shall be demonstrated that, following any roll or yaw disturbance which results from the Failures and Events prescribed in 8.1 or 8.2, it is possible, using the assumed recovery technique, to recover to steady level flight without encountering dangerous characteristics such as excessive changes of control force.

APPENDIX TO CHAPTER G2—8

Revised in part, 16th August, 1982

HANDLING—CONTROLLABILITY

1 FORCES AND MOVEMENT (see G2—8, 3)

1.1 The control force required over the range of control movement should neither vary excessively nor exhibit any undesirable discontinuities.

1.2 From trimmed initial conditions, the control forces required for executing normal operational manoeuvres should not exceed—

(a) a stick force of—
  (i) 27 N (6 lbf) for light rotorcraft*,
  (ii) 45 N (10 lbf) for other rotorcraft, and

(b) a pedal force of—
  (i) 90 N (20 lbf) for light rotorcraft*,
  (ii) 225 N (50 lbf) for other rotorcraft.

1.3 The force required for operation of the collective pitch control should be—

(a) not less than 9 N (2 lbf) and not more than 45 N (10 lbf) for light rotorcraft*, and

(b) not less than 9 N (2 lbf) and not more than 70 N (15 lbf) for other rotorcraft.

1.4 **Interaction of Controls**

1.4.1 There should be the minimum of coupling between the longitudinal and other control planes. The lateral travel of the control stick with speed change in straight steady flight should be not more than 20% of the longitudinal movement at any part of the range, and corresponding lateral stick forces should not exceed 20% of the longitudinal forces. Induced rudder pedal forces should not exceed 75% of the longitudinal stick forces.

1.4.2 Lateral control displacement should not produce longitudinal stick forces greater than 40% of the lateral stick forces or rudder pedal forces in excess of 100% of the lateral stick force. Directional control displacements should not produce longitudinal stick forces in excess of 8% of the rudder pedal forces or lateral control forces in excess of 6% of the rudder pedal force.

1.4.3 Movement of the collective pitch control should not produce any objectionable forces in the cyclic control.

1.5 **Powered Controls.** In the event of a failure in the power-control system it should be possible to continue steady flight and execute a normal landing without exceeding the following control forces:—

(a) for longitudinal controls . .	111 N (25 lbf)
(b) for lateral controls	70 N (15 lbf)
(c) for directional controls . .	360 N (80 lbf)
(d) for collective controls	160 N (35 lbf)

*For the purposes of this Appendix, a rotorcraft, the Maximum Weight of which is less than 1150 kg, is considered as a light rotorcraft.

2 POWER-UNIT FAILURE (see G2—8, 2, 3 and 5) The transition between normal powered flight and that existing after a failure of the Critical Power-unit should be accomplished safely allowing for a pilot reaction time compatible with the characteristics of the rotorcraft. In no case should the delay period be less than 2 seconds when the rotorcraft is under manual control or less than 5 seconds when the rotorcraft is under automatic-pilot control. The rotor speed should not fall below the safe minimum auto-rotative speed during this manoeuvre, nor should it exceed the safe maximum within 2 seconds after the pilot has applied the minimum likely pitch.

3 CHANGES OF FLOW STATE (see G2—8, 4) Sufficient information should be provided to enable the pilot to avoid any combination of forward speed and rate of descent likely to result in a condition of flight where control response is inadequate.

4 CONTROL AFTER FAILURE OF AUTOMATIC FLIGHT CONTROL, OR STABILITY AUGMENTATION SYSTEM OR AFTER AN EVENT AFFECTING THE FLIGHT PATH (see G2—8, 8)

4.1 The Failures and Events to be considered for Groups A and B should include those which can be caused by:—

(a) A Failure of the trimming control system.

(b) A Failure of an automatic flight control or stability augmentation system. (See also **G6—4**.)

(c) Saturation of limited authority automatic flight control of stability augmentation systems. (See also **G6—4**.)

4.2 The control and manoeuvrability requirements of **G2—8** should be met after a Failure of a stability augmentation device within a practical flight envelope, which must be specified, but may be reduced from the original declared flight envelope. The trim and stability characteristics should not be reduced below a level which would permit either:—

(a) for Group A continued safe flight and landing, or

(b) for Group B an Emergency Alighting to be safely accomplished without demanding more than normal skill on the part of the flight crew.

4.3 **Disturbances Resulting from Failures**

4.3.1 Action to arrest a condition resulting from Failure, or to retrim should be assumed to be initiated after a reasonable time, dependent on the simplicity and lack of ambiguity of the required action.

NOTE: See **G6—4** regarding pilot intervention times.

4.3.2 Account should be taken of any changes in the sequence of operation and use of controls which, although not part of the recommended recovery technique, might be instinctively used (e.g. collective pitch). Such changes should not decrease significantly the manoeuvrability and ability to recover a level flight attitude.

4.3.3 While no specific values are given for changes in normal acceleration which may be considered excessive, changes greater than $\pm 0{\cdot}5g$ would be so considered.

SUB-SECTION G2—FLIGHT

CHAPTER G2—9 HANDLING—ABILITY TO TRIM

Revised in part, 16th August, 1982

A.B **1 INTRODUCTION** This Chapter prescribes the ability to trim. It may be found that in order to meet these requirements limitations have to be imposed on the choice of air speeds used in establishing compliance with the performance requirements.

2 GENERAL

2.1 The ability to trim, or the extent to which it is not possible to trim, shall be established for all likely operational conditions.

NOTE: This information will be used for the assessment of compliance with 2.2 to 2.4.

2.2 Both in normal operations, and in those conditions associated with Power-unit failure for which performance characteristics are to be scheduled, it shall be possible to trim the rotorcraft in such conditions of loading, speed and power (particularly those conditions applicable to instrument flight when certification for such a purpose is required) as will ensure that the pilot will not be unduly fatigued or distracted by the effort which would otherwise be required for safe handling of the rotorcraft.

A 2.3 In straight flight it shall be possible, at all engine powers (including the case of one Power-unit inoperative), to reduce the mean control loads to zero at all speeds between the Normal Operating Limit Speed, V_{NO}, and the speed for best rate of climb, V_Y, or (in the case of rotorcraft seeking certification for instrument flight) the minimum permissible air speed for instrument flight, whichever is the lower, and to less than 25 N (5 lbf) at all lower speeds, including hovering.

B 2.4 In straight flight it shall be possible, at all engine powers (including the case of one Power-unit inoperative) to reduce the mean control loads to zero at all speeds between the Normal Operating Limit Speed, V_{NO}, and the speed for best rate of climb, V_Y, and to less than 25 N (5 lbf) at all lower speeds, including hovering.

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SUB-SECTION G2—FLIGHT

CHAPTER G2—10 HANDLING—STABILITY

Revised in part, 16th August, 1982

A.B **1** GENERAL (see G2—10 App., 1 and 2)

1.1 The rotorcraft shall have such stability in relation to its other flight characteristics, performance, structural strength, equipment, operating limitations, and most probable operating conditions, as to ensure that the demands made on the pilot's energy and powers of concentration are not excessive when the stage of the flight at which these demands occur and their duration are taken into account. The characteristics of the rotorcraft shall not, however, be such that excessive demands are made on the pilot's strength or that the safety of the rotorcraft is prejudiced by lack of manoeuvrability in emergency conditions.

1.2 No excessive skill shall be needed for the co-ordination of the controls.

1.3 Measurements of stick-fixed and stick-free static and dynamic stability shall be made for all likely operating conditions.

2 STABILITY IN TURNS There shall be no serious tendency for the rotorcraft to tighten up in the turn of its own accord during a turn at normal accelerations up to 1·5g, at all engine powers.

3 STABILITY WITH ALL CONTROLS FREE The rotorcraft under smooth air conditions shall exhibit no dangerous behaviour if, in straight steady trimmed level flight at any speed between the speed for best rate of climb and the Normal Operating Limit Speed, V_{NO}, all controls are abandoned for a period of five seconds.

A **4** ROTORCRAFT SEEKING CERTIFICATION FOR INSTRUMENT FLIGHT

4.1 The rotorcraft shall exhibit positive static and dynamic stability in all axes at all forward air speeds between the minimum speed for instrument flight and the Never Exceed Speed, V_{NE}.

4.2 When the stability required by 4.1 is provided by means of automatic flight control or stability augmentation systems, it shall be demonstrated that in the event of any Failure, the rotorcraft can continue to be flown without exceptional pilot skill for a length of time appropriate to the range of the rotorcraft. (See **G6—4**, 2.3.) Test techniques shall be agreed with the Authority.

A.B **5** LONGITUDINAL, LATERAL AND DIRECTIONAL OSCILLATION CHARACTERISTICS (See **G2—10** App., **3**). There shall be no short period* oscillation of the rotorcraft, and no unsafe short period oscillation of any rotorblades which is not heavily damped under any permissible flight condition, both with controls fixed and controls free.

*"Short period" here means "not analogous to phugoid oscillation".

A.B **6** FLUTTER, VIBRATION AND BUFFETING

6.1 **General.** All parts of the rotorcraft shall be free from flutter and excessive vibration, and from buffeting of such severity as to interfere with control of the rotorcraft, or to cause structural damage to the rotorcraft or excessive fatigue to the crew.

6.2 **Associated Conditions.** The requirements of 6.1 shall be met, whether the primary flight controls are moved or not, in all conditions specified in **G2—8, 3**.

7 ROTOR BLADE CLEARANCE Compliance with **G4—9,** 4.1 shall be demonstrated.

8 CONTROL BALANCE There shall be no noticeable over-balance of the yawing, rolling, and pitching controls.

APPENDIX TO CHAPTER G2—10

Revised in part, 16th August, 1982

HANDLING—STABILITY

1 CONDITIONS OF FLIGHT (see G2—10, 1)

1.1 Stability characteristics should be investigated throughout the range of speeds and conditions used in establishing performance in accordance with **G2—2** to **G2—5**.

1.2 For a helicopter a typical interpretation of 1.1 is given in Table 1 (G2—10 App.).

TABLE 1 (G2—10 App.)

Initial Trim and Power Condition	Speed Range
(a) Hovering	—37 to +56 km/h (—20 to +30 knots)
(b) Level flight at V_{mp}	V_{mp} ± 37 km/h (±20 knots)
(c) Level flight at 80% V_H	60% V_{NO} to V_{NO}
(d) Level flight at V_H	80% V_{NO} to V_{DF}
(e) Climb at best rate of climb	V_Y ± 28 km/h (±15 knots)
(f) Autorotation with trim as in (c)	60% V_{NO} to maximum speed in autorotation
(g) Autorotation, speed for minimum rate of descent	Speed for minimum rate of descent— ±37 km/h (±20 knots)

NOTE: Where V_H is less than V_{NO}, V_H may be used in place of V_{NO}.

1.3 For rotorcraft approved for instrument flight, minimum air speeds for climb, level flight, and descent should be established, which are appropriate to those normally used for instrument flight, including approaches.

2 STABILITY (see G2—10, 1)

2.1 **Longitudinal**

2.1.1 In steady trimmed flight the controls should possess a self-centring force gradient of at least 175 N/m (1 lbf/in) for the first inch of travel from trim. There should be no undesirable discontinuities in the stick force/displacement curves and their gradients should be positive at all times; failing this a rotorcraft may be considered satisfactory for contact flight if it is not noticeably unstable in a qualitative test and the general flying qualities of the rotorcraft are otherwise satisfactory.

2.1.2 For rotorcraft certificated for instrument flight the relationship of control force with air speed throughout the range of air speeds for instrument flight should be such that preceptible change in control force is required to change air speed.

2.2 **Directional**

2.2.1 Assuming the yawing controls to be left free* and other controls held fixed,

(a) in trimmed flight the rotorcraft should tend to correct automatically moderate disturbances in yaw,

(b) for rotorcraft able to hover at zero air speed (even if only under favourable conditions) any angular velocity in yaw imparted to the rotorcraft when it is initially trimmed for zero air speed, constant height, and constant heading should tend to diminish.

NOTE: If the standard trimming device is inadequate, other means of trimming may be used in establishing compliance with this recommendation.

2.2.2 The directional stability should be sufficient to prevent objectionable or dangerous flight conditions following abrupt pedal displacements.

2.2.3 In steady trimmed flight the controls should possess a self-centring force gradient of approximately 1·75 kN/m (10 lbf/in) for the first 12·5 mm (0·5 in) of travel from trim. There should be no undesirable discontinuities in the control force/displacement curves, and their gradients should be positive at all times.

2.3 **Lateral**

2.3.1 Moderate disturbances in bank should tend to be corrected automatically without the pilot applying* force to the lateral control, the other controls being fixed.

2.3.2 In steady trimmed flight the lateral controls should possess a self-centring force gradient of at least 88 N/m (0·5 lbf/in) for the first 25 mm (1·0 in) of travel from trim. There should be no undesirable discontinuities in the control force/displacement curves, and their gradients should be positive at all times.

3 OSCILLATION CHARACTERISTICS (see G2—10, 5) When certification is required for instrument flight, longitudinal, lateral or directional oscillations with controls fixed and following a single disturbance in smooth air, it should be demonstrated that at least the following criteria are met:—

(a) Any oscillation having a period of less than 5 seconds should damp to one-half amplitude in not more than one cycle. There should be no tendency for undamped small amplitude oscillations to persist.

(b) Any oscillation having a period between 5 and 10 seconds should damp to one-half amplitude in not more than two cycles. There should be no tendency for undamped small oscillations to persist.

(c) Any oscillation having a period between 10 and 20 seconds should be at least lightly damped, and in no circumstances should an oscillation having a period greater than 20 seconds achieve more than double amplitude in less than 20 seconds.

(d) The probability of encountering pilot induced oscillations which might prove hazardous should be Extremely Remote.

The disturbance should be introduced, with the rotorcraft in trimmed steady flight and with the other primary flight controls fixed, by moving one primary flight control sharply to an out-of-trim position and immediately returning it to its original trim position at which it then held fixed.

*For test purposes, it would probably be necessary to disturb the control, return it to its original position and then effectively free it.

SUB-SECTION G3—STRUCTURES

CHAPTER G3—1 GENERAL

Revised in part, 20th January, 1975

A.B 1 INTRODUCTION Sub-section G3—Structures prescribes the strength which shall be provided in the rotorcraft as a whole and in its component parts. The requirements are directly applicable to the Primary Structure of the rotorcraft.

1.1 In the case of rotorcraft used for agricultural purposes, the requirements of this Sub-section G3 shall be met taking into account the effect of any agricultural equipment included in the design of the rotorcraft.

2 PROOF OF COMPLIANCE Compliance with the requirements of this Sub-section G3 shall be established in conformity with the general principles prescribed in this chapter except in so far as any particular requirement contains over-riding clauses.

3 WEIGHT AND WEIGHT DISTRIBUTION

3.1 Unless otherwise stated, each structural requirement shall be complied with:—

(a) at all practicable weights from the Design Minimum Weight to the Design Maximum Weight (the Design Maximum Weight shall be not less than the Design Take-off Weight);

(b) when the c.g. of the rotorcraft is in the most adverse positions compatible with the weight assumed, within the c.g. range for which certification is sought;

(c) when the weight is distributed in the most adverse manner, within the operating limitations for which certification is sought.

3.2 **Design Unit Weights.** The following weights shall be used to show compliance with the structural requirements:—

petrol	0·72 kg/litre (7·2 lb/Imp. gal)
kerosene	0·81 kg/litre (8·1 lb/Imp. gal)
lubricating oil..	0·90 kg/litre (9·0 lb/Imp. gal)
crew and passengers	77 kg (170 lb) per person.

4 STATIC STRENGTH REQUIREMENTS—GENERAL

4.1 Strength requirements are, as far as possible, prescribed in terms of flight and ground manoeuvres, and of atmospheric gusts. The external loads arising in such conditions shall be placed in equilibrium with appropriate inertia loads. The air and inertia loads resulting from the prescribed manoeuvres and gusts shall be distributed so that actual conditions are closely approximated or conservatively represented.

4.2 **Limit Loads.** The prescribed loads, except where otherwise stated, are Limit Loads.

A.B 4.3 **Factors of Safety (Strength).** The ultimate factor shall be at least 1·5 and the proof factor at least 1·0 unless otherwise prescribed. Where there is uncertainty about the absolute strength of parts of the structure or about their variability or where inspection in service is difficult, such parts shall be designed with additional factors of safety which can reasonably be expected to make them as reliable as the rest of the structure.

NOTE: Main causes of uncertainty may be the absence of tests, variability of strength and possible deterioration in service.

4.4 **Strength and Deformation**

4.4.1 Under all critical loading conditions:—

(a) The Primary Structure as a whole shall be capable of supporting all loads up to and including the Ultimate Load.

(b) Such elastic and permanent deformation as occurs during application of loads up to and including the Proof Load shall not interfere with the safe operation of the rotorcraft. Such permanent deformation as remains after removal of such loads shall not significantly reduce the airworthiness of the rotorcraft.

(c) Unless otherwise allowed, moving parts essential to the safe operation of the rotorcraft shall function satisfactorily at all loads up to and including the Proof Loads.

4.4.2 Any change in the distribution and magnitude of external or internal loads as a result of deformation of structure under load shall be taken into account.

4.4.3 The Authority shall be satisfied that adequate allowance has been made for the effect of dynamic loading.

4.5 **Calculations and Test Procedures**

4.5.1 Proof of compliance with strength and deformation requirements of 4.4 shall be shown for all critical loading conditions by structural analysis and substantiating strength tests unless the designer has evidence to satisfy the Authority that structural analysis alone gives sufficient assurance.

NOTE: For structures having more than one critical design case, it will usually be acceptable for tests to be made up to a proportion of Ultimate Load to be agreed with the Authority, provided that structural analysis supported by experimental data obtained in these tests indicates that the strength is sufficient for the Ultimate Load, and that the structure is tested to full Ultimate Load for one critical design case, which is chosen in consultation with the Authority.

4.5.2 Evidence to satisfy the Authority that structural analysis alone gives sufficient assurance in the case of rotorcraft which are developments of certificated rotorcraft types shall take into account:—

(a) the overall increases in load compared with the previous structure,

(b) the changes in stress and stress distribution compared with the previous structure,

(c) the scope and type of test work carried out on the previous structure.

4.5.3 The use of simplified design criteria will be acceptable where there are supporting data to justify them and provided that they will ensure a level of safety not less than that obtainable by a rational investigation of the prescribed conditions.

4.5.4 In making tests to establish compliance with proof load conditions, the Proof Load shall be supported until static equilibrium is reached.

4.5.5 In making tests to establish compliance with ultimate load conditions, the Ultimate Load shall be applied for a period sufficient to demonstrate that the structure is capable of supporting the Ultimate Load.

A.B 4.6 The mechanical properties and the dimensions of the structural elements, which are assumed in design calculations, shall be so chosen in relation to the specification values and in relation to the dimensions shown on drawings that it is extremely unlikely that, as a result of this choice, the completed structure will have a lesser strength than the design value.

4.7 **Correction of Test Results.*** The results obtained from strength tests shall be corrected for departures from the mechanical properties and dimensions assumed in the design calculations.

5 FATIGUE STRENGTH

5.1 The strength and fabrication of the rotorcraft shall be such as to ensure that the possibility of disastrous fatigue failure of the Primary Structure and other Class 1 Parts under the action of the repeated loads of variable magnitude expected in service, is Extremely Remote throughout its operational life.

5.2 The method of proving compliance with 5.1 shall be agreed with the Authority.

5.3 Parts of the Primary Structure and other Class 1 Parts, which may be critical from fatigue aspects, shall be subjected to such analysis and substantiating load tests as to demonstrate, either:—

(a) a safe Fatigue Life,† or

(b) that such parts of the Primary Structure exhibit the characteristics of a Fail-Safe Structure.‡

NOTES: (1) Where there are two parts in a rotorcraft, the double failure of which could affect the rotorcraft in the same way as the failure of a Class 1 Part, their Safe Fatigue Lives shall be established as being sufficient to ensure that the possibility of a double failure is acceptably remote. In assessing the possibility of a double failure the ease with which a part can be inspected and the frequency of inspection should be considered.

(2) In demonstrating Safe Fatigue Life the Authority will expect that, at the time of initial certification, the Safe Fatigue Life which can be substantiated will be such as to give reasonable assurance as to the soundness of the structure (see G3—1 App. No. 2, 6.5).

(3) In demonstrating Fail-Safe characteristics, information should be provided in the relevant manual as to the frequency and extent of the repeated inspection of the structure necessary to ensure that any failure will be found within a reasonable period.

(4) In order that vibratory stresses can be kept low, great care should be given to the detailed design of:—
(a) the main and auxiliary rotors including retaining hubs and controls;
(b) the transmission system;
(c) certain parts of the main control system;
particularly with a view to reducing stress concentrations.

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*See also G3—1 App. No. 1.

†See also G3—1 App. No. 2.

‡See also G3—1 App. No. 3.

APPENDIX NO. I TO CHAPTER G3—I

Issued, 15th June, 1966

STATIC STRENGTH

I CORRECTION OF STATIC TEST RESULTS (see G3—I, 4.7). The Board will accept corrections to test results when based on the methods of this paragraph 1.

1.1 For simple elements the dimensions and material properties of the test specimen should be measured and the test results adjusted to give the load corresponding to the minimum strength permitted by the material specification and the drawing limits.

1.2 For other structures in which failure of a particular element results in a redistribution of the load through alternative structural paths, either,

(a) the dimensions and material properties of the test structure should be measured and the test results adjusted to correspond to the use of materials of average dimensions and with the minimum strength properties permitted by the material specification, or

(b) the correction should be determined by the designer in consultation with the Board.

APPENDIX NO. 2 TO CHAPTER G3—1

Revised in part, 20th January,* 1975

SAFE FATIGUE LIFE

1 EVALUATION OF SAFE FATIGUE LIFE (see G3—1, 5) Safe Fatigue Life may be evaluated in accordance with this Appendix No. 2.

NOTE: Although it would be desirable to standardise on a method of resolving fatigue problems, it is realised that new design features and differing methods of fabrication may require variations and deviations from the recommendations contained in this Appendix.

2 GENERAL

2.1 The evaluation of Safe Fatigue Life should be carried out on the lines summarised in (a) to (d).

(a) The determination of the components considered to be critical from fatigue aspects. (See **3**)

(b) The determination of the magnitude and frequency of the stress variations in the critical components under ground and flight conditions, together with the determination of the relative time spent in the ground and flight conditions. (See **4**)

(c) The determination of the fatigue strength characteristics of the components. (See **5**)

(d) The establishment of Safe Fatigue Life by a method acceptable to the Authority. (See **6**)

2.2 As minor discrepancies in manufacture may result in large variations in fatigue life, assemblies and parts used in testing should be of the same quality and made to the same drawings as the components used in the rotorcraft.

3 DETERMINATION OF COMPONENTS CRITICAL FROM FATIGUE ASPECTS

3.1 In assessing the possibility of fatigue failure (see 5.1.2) for a new rotorcraft type, use should be made of the structural analysis and those parts which are considered to need investigation should be checked by strain gauging under critical alternating stress conditions. (See **4**)

3.2 Prior to conducting ground and flight strain-gauge tests it may be possible to determine approximately the critical stress areas, and this will assist in determining the appropriate distribution of the strain gauges. A qualitative study for this purpose could be made by means of brittle coatings. Photo-elastic methods may be used for assisting in determining points of high stress concentration.

3.3 The strain gauging and measurement should be conducted in a manner compatible with the system to be used in laboratory testing in order that the loads and critical vibratory stresses can be accurately reproduced in those parts or sections of parts where measurement of actual stresses is difficult or impossible.

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*In addition to the marginally lined amendment, a few minor editorial changes have also been incorporated.

4 DETERMINATION OF THE PATTERN OF ALTERNATING STRESS AND THE RELATIVE TIME SPENT IN THE GROUND AND FLIGHT CONDITIONS The method for determining the pattern of alternating stress expected in service is detailed in this paragraph **4.** Alternating stresses of a relatively high frequency of occurrence (e.g. associated with rotating parts) are dealt with in 4.1; those of a relatively low frequency of occurrence (e.g. fixed aerodynamic surfaces, landing gear) are dealt with in 4.2.

4.1 **Parts Subjected to Alternating Stress of a Relatively High Frequency of Occurrence.** The parts subjected to alternating stress of a relatively high frequency of occurrence and requiring investigation in accordance with this paragraph 4.1 should be agreed with the Authority and will normally include such parts as main rotor blades, rotor head, auxiliary rotors, primary control systems (both rotating and static) together with such other components, e.g. rotor pylons, transmission, engine mountings, the failure of which could be catastrophic.

4.1.1 **Strain Gauging**

(a) In view of the approximations used in the stress analysis of rotor and transmission systems, it is not possible to determine analytically, with the necessary accuracy, the stresses throughout the systems. Rotor and transmission stress levels should therefore be determined by means of carefully controlled instrumented ground and flight strain-gauge testing. These tests should determine the magnitude of the mean (see 5.1.5 (c)) and alternating stresses associated with the likely operation of the rotorcraft and in particular should determine the critical alternating stresses associated with specific manoeuvres or operating conditions. In some cases the information might lead to limitations of operating conditions or manoeuvres, but in other cases the critical data obtained can be used as a basis for a test programme required to determine the fatigue life of the various individual assemblies.

(b) When conducting flight strain-gauge measurements, in addition to obtaining alternating stress data on the hubs, blades, control members, pylons and certain parts of the transmission, it may be advisable to record the control movements of the rotor blades and the accelerations of the rotorcraft, at its centre of gravity, during manoeuvres. This record should provide the data on which to estimate safe control movements and manoeuvres encountered during normal service operation.

(c) Corresponding flight parameters (air speed, rotor speeds, c.g., rotorcraft weight, etc.) should also be recorded simultaneously by suitable methods.

4.1.2 **Conditions to be Investigated.** The parts agreed should be investigated in accordance with this paragraph 4.1.2, for all practical combinations of the conditions prescribed in (c); where the combination of extreme conditions is incompatible, agreement with the Authority on limitations is necessary. For the purposes of fatigue assessment those flight and ground parameters of weight, c.g., rotor speed and altitude producing the most critical stresses should be used.

(a) The severity and rapidity of control movement used in reversing the controls and the extent of blade stall investigated during the investigation should be at least as severe as that which is likely to occur in service, consideration being given to inadvertent overshoot and pilot training as well as normal operation.

(b) When the Primary Structure is used to carry hot compressed air internally the effect of both this internal pressure occurring on every flight in addition to variations during flight and the temperature effects of the hot gases should also be assessed.

(c) **Range of Conditions**

(i) Rotorcraft Weight: Minimum Design Weight to Maximum Design Weight.

(ii) c.g.: the most adverse position appropriate to each weight.

(iii) Rotorcraft speed: all speeds between declared maximum backward speed and 1·11 VNE and between declared maximum sideways speed in each direction.

(iv) Rotor rotational speeds: all speeds between Rotor Minimum RPM (Power On) or Rotor Minimum RPM (Power Off), whichever is the lesser and the Rotor Never Exceed RPM.

(v) Altitude: sea-level to declared maximum altitude.

(vi) Engine power: full range of engine power covering the speeds from Ground Idling to Maximum Engine Overspeed.

(vii) Engine failure: each engine-out condition for multi-engined rotorcraft.

4.1.3 **Frequency of Different Manoeuvres**

(a) A factor of importance in determining the Safe Fatigue Life of the various components is the assessment of the percentage of total operating time associated with each manoeuvre. This evaluation will be largely a statistical one and will vary according to the purpose for which a particular helicopter is used.

(b) Table 1 (G3—1 App. No. 2) is a typical distribution of the different manoeuvres for a single-engined single-main-rotor helicopter and also represents a typical range for a strain-gauge survey. If any particular manoeuvre or combination of operating conditions (e.g. a condition producing resonance) has critical effects on fatigue life it will be necessary either to impose restrictions to ensure that the effects on fatigue life are within acceptable limits or to prohibit the manoeuvre or particular combinations of operating conditions. The Table is only a guide and the distribution of the particular manoeuvres should be declared by the Applicant for consideration by the Authority and, if necessary, for inclusion in the Flight Manual.

(c) For those manoeuvres which occur infrequently it is permissible to consider them on a number of manoeuvres per flight basis, e.g. one flare out per flight. For overall operation an average of two flights per hour may be assumed.

NOTE: For specific operations where there is reason to assume that this figure is too low then a higher figure should be declared by the Applicant and agreed by the Authority.

(d) In assessing the life of a component due allowance should be made for the effect of the ground-flight-ground cycle of stresses on the fatigue life.

(e) For multi-engined helicopters Table 1 (G3—1 App. No. 2) will require modification. There is some evidence to suggest that Autorotation (Part 4) should be considerably decreased and the appropriate parts of the powered flight spectrum increased accordingly. Further it is necessary to add a Power-unit inoperative section. The distribution of powers for this condition of flight should be declared by the Applicant and agreed by the Authority.

4.1.4 **Factors.** In determining the fatigue strength characteristics of components subjected to alternating stress, it is necessary to introduce a factor to cover variations in stress from one rotorcraft to another, therefore all measured alternating stresses of this nature should be factored by 1·2.

NOTE: This factor is for general use. Where in a particular application there is evidence to show that this factor is too high or too low such evidence should be made available to the Authority and any consequent change will have to be agreed with the Authority.

TABLE 1 (G3—1 App. No. 2)

Condition	Occurrence (%)	Condition	Occurrence (%)
PART 1 GROUND CONDITIONS			
(a) Rapid increase of rpm on ground to quickly engage clutch	0·5	(c) Take-off	0·5
(b) Taxying with full cyclic control	0·5		
PART 2 VERY LOW SPEED FLIGHT			
(a) Steady hovering	0·5	(d) Longitudinal reversal	1·0
(b) Lateral reversal	0·5	(e) Backward flight	0·5
(c) Sideways flight	0·5	(f) Directional reversal	1·0
PART 3 FORWARD FLIGHT—POWER ON			
(a) Level flight at 20% VNE	5·0	(l) Cyclic and collective pull-ups from level flight	0·5
(b) Level flight at 40% VNE	10·0	(m) Change to autorotation from power-on flight	0·5
(c) Level flight at 60% VNE	18·0	(n) Partial power descent (including zero flow through rotor)	2·0
(d) Level flight at 80% VNE	18·0	(o) Landing, including approach	3·0
(e) Maximum level flight (but not greater than VNE)	10·0	(p) Lateral reversals at VNE	0·5
(f) VNE	3·0	(q) Longitudinal reversals at VNE	0·5
(g) 111% VNE	0·5	(r) Directional reversals at VNE	0·5
(h) Right turns	3·0	(s) Climb (Maximum One-hour Power)	2·0
(j) Left turns	3·0		
(k) Climb (Maximum Continuous Power)	4·0		
PART 4 AUTOROTATION—POWER OFF			
(a) Steady forward flight	2·5	(e) Longitudinal reversals	0·5
(b) Right turns	1·0	(f) Directional reversals	0·5
(c) Left turns	1·0	(g) Cyclic and collective pull-ups	2·0
(d) Lateral reversals	0·5	(h) Landings (including flares)	2·5

4.2 Parts Subjected to Alternating Stresses of a Relatively Low Frequency of Occurrence

4.2.1 The investigation of the wing, tail plane and fin should take into account the provisions of (a) to (f).

(a) The effect of the rotor aerodynamic and forced vibratory loads on the auxiliary surfaces.

(b) The general average gust frequency and magnitude and the variation of these with terrain and geographical location appropriate to the route over which the rotorcraft is to be operated, as obtained from data on this and other aircraft types.

(c) A scatter factor of 1·5 on gust frequency to cover the possibility of one rotorcraft in the fleet experiencing a greater frequency of these loads than the average rotorcraft in the fleet.

NOTE: To avoid the necessity of assumptions which overestimate the gust intensities it is desirable to fit a sufficient number of rotorcraft with load recording instruments, approved by the Authority, in order to provide adequate comparative data if varying types of operation are carried out especially in different parts of the world. The Authority will consider the reduction of the scatter factor of 1·5 if this is justified by the records obtained.

(d) The best possible assessment of the comparative effects of gust loading and forced vibration from the rotors on auxiliary surfaces.

(e) The expected average flight plan involving climb, cruise, descent, flight times, speeds and altitudes.

(f) Any additional loads such as the effect of the repeated change from the condition of zero-lift to steady flight on take-off and return to the zero-lift condition on landing and the possible effect of ground loads in ground handling, taxying, take-off and landing.

4.2.2 The investigation of such parts as landing gear, hydraulic and control system components, fuel systems, etc., should be carried out.

NOTE: In many cases it will be necessary to check the frequency and corresponding magnitude of the loads in the components by appropriate means, e.g. during ground steering for hydraulic components and during flight (under automatic-pilot conditions if appropriate) for servo-controlled mechanisms.

5 FATIGUE STRENGTH CHARACTERISTICS The determination of the fatigue strength characteristics of those parts indicated by the investigations of **3**, should be carried out in accordance with this paragraph **5** which is written in terms of rotorcraft the expected service life of which is of the order of 10,000 hours or more.

5.1 **General**

5.1.1 The Authority will require tests on a complete rotorcraft airframe under the critical alternating stress conditions, unless, as a result of the structural analysis and strain gauging, the indicated alternating stresses both at critical regions and in the general structure are of such a low order that past experience indicates the possibility of fatigue failure to be Extremely Remote during the anticipated operational lifetime of the rotorcraft type. In any event, sufficient testing of the most critical details of the rotorcraft will be necessary.

5.1.2 The main purpose of the complete rotorcraft airframe tests is to establish for the first and subsequent failures, the components involved and their corresponding fatigue lives. It is intended that, if possible, the component be repaired after each failure until a stage is reached when further repair is impracticable or it is agreed not to continue the testing. In addition, laboratory testing of a number of components, similar to those which failed in the complete rotorcraft tests, should be made at the corresponding critical conditions of alternating stress both to obtain an estimate of the scatter of fatigue life and to establish the average fatigue life.

5.1.3 Experience has shown that data on the fatigue characteristics of simple material specimens cannot be directly applied to built-up structures. Although material data modified by appropriate stress concentration factors can be used as a guide in design, experience indicates that the fatigue strength of a built-up structure is below that of material specimens for which allowance has been made for estimated stress concentration. It is therefore necessary that endurance tests of an adequate number of specimens of the critical parts be conducted by applying steady and alternating loads, in a manner simulating the loading actually encountered in service.

5.1.4 Parts that may be subject to high temperature, e.g. hot air ducts in rotor blades and parts subject to turbine exhaust impingement, should have the effect of such high temperatures on the fatigue strength of the structure evaluated by a method to be agreed with the Authority.

5.1.5 **Definitions.** The definitions of this paragraph 5.1.5 are applicable throughout this Appendix.

(a) **S/N Curve.** A mean curve constructed from the results of those tests carried out to determine the relationship between the magnitude of alternating stress and the number of cycles of such stress required to cause the failure of a part.

(b) **Fatigue Limit.** The alternating stress at or below which a part sustains no fatigue damage.

NOTES: (1) The Fatigue Limit is associated with a steady (mean) stress level.
(2) Acceptable assumptions on Fatigue Limit are prescribed in 6.2.

(c) **Mean Stress.** The steady stress in a part when the part is in a state of dynamic equilibrium.

5.1.6 **Methods of Endurance Testing**

(a) Since neither of the two current methods of fatigue endurance testing is completely adequate by itself, it is essential to make the methods complementary to each other.

(i) **Testing of Complete Assemblies.** This method consists of either the testing on the ground of the complete rotorcraft, or the testing of complete assemblies on a suitable rig.

(ii) **Testing of Components.** This method consists of the testing of components, or critical sections of components, using fatigue testing machines.

(b) Both the methods described in (a) suffer from the disadvantage that it is not practical to simulate all the atmospheric conditions (temperature and humidity) which will be encountered in service and in addition the effects of corrosion, which appreciably reduce the fatigue life cannot be simulated. A further disadvantage associated with the method of (a)(ii) is that it is not possible to simulate, with existing fatigue testing machines, the pattern of the alternating stress that is estimated to occur during the service life of the rotorcraft, both in regard to the sequence of occurrence and the rate at which the stresses are applied. In view of the deficiencies of these testing methods, it may be necessary to take steps to ensure that the effects of these deficiencies are kept to a minimum. (See 6.6)

5.2 **Establishment of Mean Fatigue Limit**

5.2.1 The establishment of the mean Fatigue Limit of a component will usually necessitate the production of an S/N Curve for the component. The critical range of stress cycles for the component (probably 10^5 to 10^8) should be determined and an S/N Curve should be obtained by testing a sufficient number of identical specimens at different magnitudes of alternating stress within the envelope of stress expected in service determined in accordance with **4.**

5.2.2 The curve obtained by the method of 5.2.1 should be adequate to give an assurance that a mean Fatigue Limit obtained by extrapolation or comparison with S/N Curves for similar materials will be valid.

5.2.3 Where there are a number of Mean Stress levels for any one part it will not normally be necessary to investigate more than two of them and, accordingly, the results from two S/N Curves may be suitably modified for the other Mean Stress levels without further testing. Alternatively, it can be assumed that all the alternating stress variations occur about the higher Mean Stress level unless this assumption is known to be optimistic. Such assumptions should be agreed with the Authority as the testing proceeds.

6 ESTABLISHMENT OF SAFE FATIGUE LIFE Having established the pattern and frequency of stress levels by the method of **4** and the mean Fatigue Limit by the method of 5.2 the Safe Fatigue Life should be established in accordance with one or more of the methods described in this paragraph **6.**

6.1 **Use of the Pattern of Alternating Stress to Establish Safe Fatigue Life**

6.1.1 The loads can be directly applied in units representative of the pattern of alternating stress. The units should represent a convenient time period, say 50 or 100 hours each, during which time the number of alternating stress cycles corresponding to each critical alternating stress level should be applied in a regular sequence; should the Mean Stress for any particular alternating stress level vary, this may be fed into the pattern.

6.1.2 Suppose that two flight or ground conditions (Condition 1 and Condition 2) are critical from a fatigue standpoint to the exclusion of all other conditions, and that the following parameters apply,

	Condition 1	Condition 2
Mean Stress	X_1	X_2
Alternating Stress about Mean Stress	Y_1	Y_2
Cycles of Stress Y per minute	n_1	n_2
Percentage of life spent in this condition (from Table 1 G3—1 App. No. 2)	l_1	l_2

together with a load unit time of 100 hrs. then the following total mean and alternating stress cycles would be applied during each load unit,

$$60\ n_1\ l_1 \text{ at } X_1 \pm F.Y_1^*$$

$$\text{plus } 60\ n_2\ l_2 \text{ at } X_2 \pm F.Y_2$$

and repeated in this sequence until failure occurred. The estimated safe life in hours would then normally be assumed to be the geometric mean of the numbers of load units completed on the specimens multiplied by 100.

NOTE: Where the scatter of experimental results is unusually large for the number of specimens tested it may be necessary to reconsider whether the mean value gives an adequate margin of safety.

6.1.3 The value of the factor F will depend on the number of specimens tested in accordance with this paragraph 6.1 and should be applied to the alternating stress as follows:—

1 specimen	3·0
2 specimens	2·5
3 specimens	2·25
4 or more specimens	2·0

the factor on the Mean Stress, X, being 1·0 in all cases.

NOTES: (1) For a single specimen all those cases giving rise to stresses higher than the mean Fatigue Limit divided by 3·0 will need to be considered. For two specimens only those cases giving rise to stress higher than the mean Fatigue Limit divided by 2·5 need be considered and so on. If initially it is decided to test more than three specimens then only those cases giving rise to stresses greater than the mean Fatigue Limit divided by 2·0 need be considered.

(2) Where there is sufficient evidence to justify the use of factors other than those quoted in 6.1.3 then such evidence should be made available to the Authority and such factors as are used will have to be agreed with the Authority.

(3) Where there is sufficient evidence to suggest that the factor required under 4.1.4 can be combined with the factors of this paragraph as amended by Note (2), then the resultant factors will have to be agreed with the Authority.

6.2 Unlimited Fatigue Life and Reduced Testing Time

6.2.1 In establishing unlimited fatigue life it is necessary to demonstrate that the alternating stresses anticipated in service lie below the working Fatigue Limit of the material of the component in its assembled condition.

NOTE: By working Fatigue Limit is meant the mean Fatigue Limit divided by a similar factor to that required in 6.1.3.

6.2.2 In the absence of better information the following assumptions may be made:—

(a) for aluminium alloys, that the Fatigue Limit is the maximum alternating stress that the material can sustain for 10^8 cycles,

(b) for alloy steels, free from attrition and corrosion, that the Fatigue Limit is the maximum alternating stress that the material can sustain in accordance with Table 3 (G3—1 App. No. 2).

*For values of F see 6.1.3.

TABLE 3 (G3—1 App. No. 2)

Ultimate Tensile Strength (tons/sq. in.)	Cycles (10^6)
up to 50	5
51— 60	20
61— 80	40
81—110	100

6.2.3 In order to reduce testing time to establish the mean Fatigue Limit, it will be permissible to test to less than the number of cycles prescribed in 6.2.2, and to extrapolate the results using suitable factors. The extrapolation factor to be used, which should be agreed with the Authority, will depend on the material and it is permissible to use factors appropriate to established S/N Curves for the material.

6.3 **Use of Life Factors only to Establish Finite Fatigue Life.** The provisions of this paragraph 6.3 are applicable to those parts subjected to alternating cycles of stress which are not likely to occur more than 10^5 times during the life of the rotorcraft; for parts subjected to a greater number of cycles of stress, the provisions of 6.1 or 6.2 should be applied.

6.3.1 If no alternating stress factor other than that of 4.1.4 is used it will be necessary to use the Life Factors of Table 4 (G3—1 App. No. 2) which are applicable to light alloys. Life Factors for steel and other materials should be agreed with the Authority.

6.3.2 If, in any case where more than one specimen is tested, the result obtained for any one specimen is less than 1·5 times the Safe Fatigue Life which would be obtained by using the factors of Table 4 (G3—1 App. No. 2), the assessment of the Safe Fatigue Life will have to be agreed in consultation with the Authority.

TABLE 4 (G3—1 App. No. 2)

Life Factors for Light Alloy Components

No. of Specimens	Life Factor
1	6·0 on the result
3	4·5 on the average of the results
6	3·5 on the average of the results

NOTE: These factors may be used in conjunction with results of repeated load tests in which a single level of alternating stress is applied, this level of stress is usually chosen to correspond with the level of maximum fatigue damage; the level of maximum fatigue damage being determined by superimposing the pattern of alternating stress on the best estimate of the shape of the S/N Curve for the particular component. If tests are carried out to cover the repeated application of more than one level of alternating stress, then the Authority may review the magnitude of the factors.

6.4 **Acceptance of Calculations.** In special circumstances the Authority may, in consultation with the Applicant, accept calculations based on measured stresses obtained as in 4 in place of fatigue tests on certain components. A condition of acceptance of such calculations is that a safety factor on fatigue stresses, high enough to satisfy the Authority, be used for design purposes. Normally a fatigue safety factor of 3·0 will be acceptable after agreed stress concentration factors have been applied. Stress concentration factors should be obtained from the best available information or derived from tests.

6.5 **Safe Fatigue Life at Initial Certification**

6.5.1 The factors specified in this Appendix for the determination of Safe Fatigue Life are based on certain assumptions as to the absolute value of the average result of tests and as to the scatter. Where there is sufficient evidence to suggest that the factors assumed in this Appendix are too high or too low then such evidence should be made available to the Authority and any consequent change in factors will have to be agreed with the Authority.

6.5.2 If the results available when certification is required have established a relatively low value of fatigue life or if the testing has only been carried to a relatively low number of cycles, there would be doubt as to the adequacy of the specified factors and there would, therefore, be doubt as to whether a value of Safe Fatigue Life could be quoted at all. For those parts where the major alternating stresses are predominantly:—

(a) of engine order frequency, the established Safe Fatigue Life should be appreciably greater than the anticipated life of the rotorcraft,

(b) of rotor order frequency, the established Safe Fatigue Life at the time of initial certification will depend on the type, rotor speed and normal duration of the rotorcraft concerned; for a conventional transport type rotorcraft a minimum figure of 1,000 hours should be established.

6.6 **Overhaul and Re-testing of Components.** As mentioned in 5.1.6 (b) the deficiencies in the methods of testing require special procedures to ensure that the fatigue properties of the components are adequately maintained throughout the life of the rotorcraft. It will therefore be necessary for the Applicant to declare and institute methods to achieve this purpose. Such methods will usually take the form of:—

(a) adequate inspection (including overhaul),

(b) specimen fatigue testing of components or parts at periodic intervals, and

(c) limiting lives of components or parts for reasons other than fatigue where these reasons are likely to affect the fatigue properties.

6.7 **Type Development.** For new variants of rotorcraft types, the necessity for additional testing on the complete rotorcraft and/or details of the rotorcraft will be assessed on the basis of comparing the results of:—

(a) analysis of the estimated stresses in the critical parts of the re-designed rotorcraft, and

(b) a check of the analysis by suitable means (e.g. stress lacquer technique and strain gauging of the critical re-designed parts of the rotorcraft),

with the results of the original tests of the rotorcraft covering the measured stresses and correspondingly achieved fatigue life.

6.8 **Repairs.** Where a repair has been carried out as a result of damage in service, the possible effect of the repair on the fatigue strength of the structure should be considered. Further tests may be necessary to substantiate the fatigue strength of the repair.

6.9 **Change of Operation.** If the type of operation of the rotorcraft is altered, the Authority reserves the right to check whether the scope of the proposed new operation is satisfactorily covered by the tests for the original operation.

APPENDIX NO. 3 TO CHAPTER G3—I

Issued, 15th June, 1966

FAIL-SAFE STRUCTURES

I EVALUATION OF FAIL-SAFE STRUCTURE CHARACTERISTICS (see G3—I, 5)

1.1 After failure of a part or parts of the Primary Structure (as in the definition of a Fail-Safe Structure in G1—2), the remaining Primary Structure should have sufficient strength and stiffness to withstand the loads which are reasonably expected to occur after the failure during the maximum period which may elapse before the failure can be assumed to have been found by inspection. The loads which should be assumed in cases where the failure can be assumed to be found by inspection within a very short period, are those specified in 1.1.1. In cases where longer periods may elapse before the part is inspected, more severe load conditions should be provided for in the remaining structure; the conditions to be assumed should be agreed with the Board.

NOTES : (1) It is recommended in Fail-Safe Structures to avoid the use of parts which are difficult to inspect or which it is only convenient to inspect at infrequent intervals.
(2) It is recommended that the Primary Structure in addition to having fail-safe characteristics should be such as to provide long fatigue life of its constituent parts.

1.1.1 **Load Conditions to be Applied after Failure of the Parts.** Subsequent to the failure of a part which can be assumed to be found by inspection within a very short period of time, the remainder of the structure should be capable of supporting the Limit Loads with an Ultimate Factor of 1·0.

1.1.2 In addition to meeting the requirements of G3—1, 4.5, load tests should be carried out to substantiate the fail-safe characteristics. The nature and extent of such tests will depend upon previous experience on similar types of structure both as regards tests of this nature and characteristics in operation.

1.1.3 In cases where a repair has been carried out on parts damaged in service, the possible effect of the repair on the fail-safe characteristics previously established should be considered. Further tests may be necessary to substantiate the repair.

SUB-SECTION G3—STRUCTURES

CHAPTER G3—2 FLIGHT LOADS

Revised in part, 20th January, 1975

A.B 1 SYMMETRICAL FLIGHT LOADS

1.1 General

1.1.1 The structure shall have proof and ultimate factors of not less than the values specified below under the loads arising during balanced flight at all points on or within the flight envelope:—

Rotor Blades	Proof 1·2	Ultimate 1·5
Other Primary Structure	Proof 1·0	Ultimate 1·5

1.1.2 The specified flight load factors apply to the main rotors only. The corresponding load factors acting at the c.g. of the rotorcraft shall be obtained by balancing out under the appropriate flight condition and configuration.

1.1.3 The loads due to the specified manoeuvres shall be balanced by inertia forces on the whole rotorcraft.

1.2 Flight Envelope

1.2.1 The flight envelope which is based on the estimated performance of the rotorcraft shall be declared by the designer and submitted to the Authority at an early stage in the design of the rotorcraft.

1.2.2 The flight envelope shall cover the limiting design conditions of flight speed and rotor rotational speed at which the rotorcraft will be permitted to fly at the Design Maximum Weight including the emergency condition after engine failure.

1.2.3 If during the progress of the design, the estimated performance of the rotorcraft is changed, then the flight envelope shall be correspondingly altered and the design cases reconsidered.

1.2.4 The finalised limiting conditions of speed and rotor rotational speed will be stated on the Certificate of Airworthiness or in the Flight Manual and a restriction of flying to this envelope will be specified by a placard in the cockpit.

1.2.5 A sufficient number of points on the envelope shall be investigated to ensure that the critical load for each component of the structure has been obtained.

1.3 Manoeuvring Loads

1.3.1 The rotorcraft shall withstand the maximum loads which arise from the most severe movements of the controls which it is anticipated will occur during operational flight including the emergency condition after engine failure. The most adverse combinations of flight speed, rotor rotational speed and control movements shall be included.

1.3.2 The values of the load factors to be assumed for design purposes, at all forward speeds from hovering to Maximum Demonstrated Flight Speed, V_{DF} need not exceed—

(a) Limit Positive Factor 3·0 times the Design Maximum Weight,

(b) Limit Negative Factor −0·5 times the Design Maximum Weight.

A.B

1.3.3 A value of the limit positive factor below 3·0 (but not less than 2·0) may be used for design purposes if it can be demonstrated to the satisfaction of the Authority that such a lower value cannot be exceeded within the limitations of the flight envelope.

1.3.4 The resultant force shall be assumed to act at the centre of the rotor hub and in such directions as to cover all critical loading conditions.

1.3.5 The manoeuvres shall be assumed to occur at all heights between sea-level and the maximum operating height of the rotorcraft.

GUST CASES*

2.1 General

2.1.1 The structure shall have proof and ultimate factors of not less than the values specified below under the loads arising from the following gust conditions:—

Rotor Blades	Proof 1·2	Ultimate 1·5
Other Primary Structure	Proof 1·0	Ultimate 1·5

2.1.2 The calculated flight load factors will apply to the main rotors only. The corresponding load factors acting at the c.g. of the rotorcraft shall be obtained by balancing out under the appropriate flight condition and configuration.

2.2 Design Assumptions

2.2.1 The induced loads on the rotorcraft due to the application of the gust shall be balanced by inertia forces on the whole rotorcraft.

2.2.2 The gust loads shall be considered in the category of sudden or momentary loads and fatigue effects can be ignored.

2.2.3 During the application of the gust there will be no change in the trimmed condition of the rotorcraft.

2.3 Symmetrical Gust Loads

2.3.1 The rotorcraft is assumed to be flying in a trimmed unaccelerated flight condition corresponding to any point on or within the symmetric flight envelope.

2.3.2 In this condition the rotorcraft encounters a gust of velocity 35 f.p.s. from any direction, upwards, downwards, sideways or intermediate.

2.3.3 This gust intensity shall be considered as sharp-edged, i.e., the air velocity is suddenly and uniformly increased over the rotor in the direction of the gust. (The assumption is thus made of unit alleviating factor for this gust velocity.)

2.3.4 Both the power-on and power-off states shall be considered.

2.4 Gust Gradient Distance

2.4.1 For individual blade stressing it shall be assumed that a vertical gust intensity of 50 f.p.s. increases linearly from zero to the maximum value while the rotorcraft travels a distance of 100 feet.

2.4.2 For design purposes the worst combination of rotor speed and forward speed shall be considered, in conjunction with this gust gradient.

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*The gust requirements of this paragraph **2** are only intended to cater for flight in clear air (see **G1—1, 5** (b)).

A.B | 3 ASYMMETRICAL FLIGHT LOADS AND CONTROL MOVEMENT LOADS

3.1 General

3.1.1 The structure, and in particular the auxiliary rotor and its drive and mounting, shall have proof and ultimate factors of safety not less than the values specified below under the loads corresponding to the conditions prescribed in this paragraph 3:—

Rotor Blades	Proof 1·2	Ultimate 1·5
Other Primary Structure	Proof 1·0	Ultimate 1·5

3.1.2 The loads due to the specified manoeuvres shall be balanced by inertia forces on the whole rotorcraft.

3.2 Steady Unaccelerated Loads

3.2.1 Under the conditions of trimmed unaccelerated flight at all forward speeds the lower sideways velocity defined by (a) or (b) shall be superimposed.

(a) The rotorcraft is considered to be flying at the maximum sideways velocity in either direction for which it can be trimmed.

(b) A sideways velocity of 50 f.p.s. in either direction.

3.2.2 Both the power-on and power-off states shall be considered.

3.3 **Yawed Flight.** At the Rotor Maximum RPM (Power On), and at all forward speeds between a speed numerically equal to the sideways velocity as defined in 3.2.1 and whichever is the lesser of the Never Exceed Speed, V_{NE}, or the Maximum Speed in Level Flight, V_H, it shall be assumed that:—

(a) With the rotorcraft in unaccelerated flight at zero yaw, the pilots' directional control is suddenly displaced to the maximum deflections, as limited by the control stops or by maximum pilot effort.

(b) With the directional control deflected as in (a), the rotorcraft yaws to a resulting sideslip angle.

(c) With the rotorcraft yawed to the resulting sideslip angle of (b), the directional control is suddenly moved to return the control to the initial stabilized flight condition.

APPENDIX TO CHAPTER G3—2

Issued, 1st January, 1954

FLIGHT LOADS

1 STRENGTH UNDER SYMMETRICAL FLIGHT LOADS

1.1 **General.** The requirements for strength under symmetrical flight loads will in the main be a criterion for the airframe and not for the rotor blades.

1.2 **Flight Envelope.** At this juncture it is not possible to envisage the appropriate form of the design flight envelope for rotorcraft. The envelope will involve the parameters of forward speed, vertical speed, rotor rotational speed and the acceleration initiated by control movements.

1.3 **Manoeuvring Loads**

1.3.1 It is recommended that the calculations used for design purposes should be checked by tests on the prototype rotorcraft carried out near the ground. By fitting accelerometers the accelerations initiated by control movements can be measured.

1.3.2 It is also recommended that statistical accelerometers be fitted for the type tests of G7. The magnitude and frequency of the accelerations experienced during these tests will provide information to build up the flight envelope for the rotorcraft.

1.4 **Gyroscopic Loads.** The gyroscopic loads induced by pitching velocities should be considered, if appreciable.

SUB-SECTION G3—STRUCTURES

CHAPTER G3—4 ENGINE AND TRANSMISSION SYSTEM

Revised in part, 15th June, 1966*

A.B 1 TORQUE LOADS

1.1 The whole structure and in particular the structural components not covered by the engine and transmission type tests shall have an ultimate factor of 1·5 under the combination of loads (a) and (b) below :—

(a) 4 × mean torque for 2-cylinder engines
2 × mean torque for 4-cylinder engines
1·5 × mean torque for engines with more than 4 cylinders
} firing 1 cylinder at a time

(b) Loads due to acceleration in flight.

1.2 For engines with more than 4 cylinders the torque value to be used for design purposes shall be decided in consultation with the Board.

1.3 If a torsiograph is fitted, then the maximum indicated torque values may be used for design purposes.

1.4 In accelerated flight at cruising rotational speed, loads shall be considered from the fatigue aspect.

2 STARTING TORQUE LOADS

2.1 The rotor head system and in particular the rotor blades shall have an ultimate factor of 1·5 when the maximum starting torque is applied.

2.2 The design value of the starting torque used shall be the maximum which can be applied under the system provided and at the rate at which it can be applied by the system.

2.3 Unless it can be demonstrated to the contrary, each blade of a particular rotor shall be designed to withstand the full value of the proportionate design maximum starting torque transmitted to the rotor.

2.4 The blades shall be considered initially as being stationary before the starting torque is applied.

2.5 On the prototype rotorcraft, starting tests shall be carried out to check the resulting stresses in the blades.

3 FATIGUE TESTS Those parts of the Transmission and Rotor System which by the fault analysis of G4—9, 3 are shown to require an established Safe Fatigue Life shall be fatigue tested to the satisfaction of the Board.

NOTE: Fatigue testing of gear boxes is dealt with in G3—4 App., 1. General fatigue testing is dealt with in G3—1 App. No. 2.

*Requirements applicable to clutches, free wheels and rotor brakes are now contained in G4—9.

APPENDIX TO CHAPTER G3—4

Issued, 15th June, 1966

ENGINE AND TRANSMISSION SYSTEM

1 FATIGUE TESTING OF GEAR BOXES (see G3—4, 3)

1.1 In considering general fatigue testing, **G3—1** App. No. 2 calls for a fatigue limit stress factor of not less than 2·0 times the maximum loading that is likely to occur in service, unless evidence justifying a different factor is available.

1.2 From evidence in relation to the strength of steel gears of conventional design, the Board is prepared to accept that adequate fatigue strength of such gears can be demonstrated by the use of a stress factor of 1·4 for a single test, or 1·3 for four or more tests. In the latter case the specimens tested should be selected so that the gears do not have common batch origins, or heat treatments, and are not tested in the same gear box.

1.3 In carrying out the test, the maximum loading should be adjusted to compensate for the differences in vibratory loading experienced in the rotorcraft (as measured in the vibration survey of **G7—3,** 2.2 or **G7—4,** 2.2 as appropriate) and on the rig.

SUB-SECTION G3—STRUCTURES

CHAPTER G3—5 GROUND AND WATER LOADS

Revised, 17th December, 1980

A.B **1** APPLICABILITY The requirements of this Chapter **G3—5** apply to rotorcraft equipped with landing gear of the following types:—

(a) one main-wheeled unit on each side of the plane of symmetry with either a nose or tail-wheel unit, and

(b) skids.

For requirements for other types of landing gear the Authority shall be consulted at an early stage in the design.

2 GENERAL

2.1 The rotorcraft structure shall have Proof and Ultimate Factors of Safety of not less than 1·0 and 1·5 respectively under the Limit Loads specified in the appropriate paragraphs of this Chapter **G3—5.**

2.2 In determining the loads on each of the units the full range of the rotorcraft c.g. shall be considered.

2.3 The externally applied loads shall be balanced by the inertia of the rotorcraft in a rational and conservative manner.

2.4 Each landing gear unit shall be subjected to the vertical loads arising from the vertical velocity of descent at touch-down prescribed in **G4—5, 3.**

3 WHEELED LANDING GEAR

3.1 **Normal Landing Case Design Loads**

3.1.1 **Run-On Landing.** The rotorcraft structure shall be designed to withstand the following Limit Loads applied simultaneously:—

(a) The vertical loads determined in accordance with **G4—5,** 3.1, in each of the landing gear units.

(b) A drag load varying from 0 to 0·25 times the vertical load of (a) on each of the units applied at the hub.

(c) Lift on the rotor equal to not more than two-thirds of the weight of the rotorcraft.

3.1.2 **Landing with Lateral Drift.** The rotorcraft structure shall be designed to withstand the following Limit Loads applied simultaneously:—

(a) 0·5 times the vertical loads determined in accordance with **G4—5,** 3.1 in each of the landing gear units.

(b) A drag load varying from 0 to 0·25 times the vertical load determined in accordance with **G4—5,** 3.1 in each of the units applied at the hub.

(c) A side load, applied at the ground, varying from 0 to 0·4 times the vertical load determined in accordance with **G4—5,** 3.1 on one main unit acting inwards, and 0·3 times the same vertical load on the other main unit acting outwards.

A.B

(d) For the attitude of 3.1.3(a)(i) or 3.1.3(b)(i), a side load, applied at the ground, varying from 0 to 0·4 times the vertical load determined in accordance with **G4—5,** 3.1 on either the nose or tail wheel in the same direction as (c).

NOTE: For fully castoring wheels, the side load may be applied at the centre of the axle.

(e) Lift on the rotor equal to not more than two-thirds of the weight of the rotorcraft.

3.1.3 **Attitude.** In showing compliance with 3.1.1 and 3.1.2, the following limiting attitudes shall be considered:—

(a) for tail-wheeled rotorcraft:—

(i) all wheels in simultaneous contact with the ground,

(ii) the main wheels in contact with the ground and the tail wheel just clear of the ground.

(b) for nose-wheeled rotorcraft:—

(i) all wheels in simultaneous contact with the ground,

(ii) the main wheels in contact with the ground and the tail of the rotorcraft just clear of the ground,

(iii) the main wheels in contact with the ground and the nose wheel just clear of the ground.

3.1.4 **One-Wheel Landing.** The requirements of 3.1.1 and 3.1.2 shall apply with the rotorcraft in a level attitude with only one main wheel unit in contact with the ground.

3.2 **Emergency Alighting Case.** The landing gear units and their attachments shall achieve an Ultimate Factor of 1·0 on the vertical loads determined in accordance with **G4—5,** 3.2.

4 BRAKED ROLL CONDITIONS Each main wheel fitted with brakes, and its supporting structure, shall be designed to withstand at ground contact a combination of the following loads:—

(a) 1·33 times the static reaction on the particular main unit with the rotorcraft in the most critical attitude (W_M) at Maximum Design Weight.

(b) Drag loads at each wheel up to the maximum brake torque limit, but need not exceed 0·8 times the vertical reaction, acting both backwards and forwards.

5 MULTI-WHEEL UNIT LANDING GEAR

5.1 Multi-wheel unit landing gear shall comply with the requirements of **3** and **4.** In addition, the requirements of **3** and **4** shall be met under the following conditions.

5.1.1 **Twin-wheeled Units**

(a) 60% of the total ground load shall be applied to each wheel in turn and 40% to the other wheel.

(b) With each tyre deflated in turn, 60% of the maximum load shall be applied to the other wheel, except that the vertical load shall not be less than the maximum static load.

A.B

6 SKID LANDING GEAR*

6.1 Normal Landing Case Design Loads

6.1.1 **Run-On Landing.** The rotorcraft structure shall be designed to withstand the following Limit Loads applied simultaneously:—

(a) Vertical loads determined in accordance with **G4—5,** 3.1, divided equally between the skids.

(b) Drag loads between 0 and 0·5 times the vertical load of (a) applied at ground level to each skid.

(c) Lift on the rotor equal to not more than two-thirds of the weight of the rotorcraft.

6.1.2 **Landing with Lateral Drift.** The rotorcraft structure shall be designed to withstand the following Limit Loads applied simultaneously:—

(a) The vertical loads determined in accordance with **G4—5,** 3.1 divided equally between the skids.

(b) A side load between 0 and 0·25 times the vertical load on both skids determined in accordance with **G4—5,** 3.1 distributed evenly along the length of each skid, acting either inboard or outboard.

(c) Lift on the rotor equal to not more than two-thirds of the weight of the rotorcraft.

6.1.3 **One Skid Landing.** With the rotorcraft level and one skid contacting the ground, the vertical load on that skid shall be the same as would apply to that skid in accordance with 6.1.1(a).

6.1.4 **Distribution of Ground Loads.** With the rotorcraft level and in contact with the ground along the bottom of the skids, the ground loads of 6.1.1, 6.1.2 or 6.1.3 shall be distributed along the bottom of the skids in a reasonable manner.

6.2 **Additional Cases.** The rotorcraft structure shall be designed to withstand the Limit Loads resulting from the application of:—

(a) A load equal to 1·33 times the Maximum Design Weight assumed to act upwards and rearwards at an angle of 45° to the longitudinal axis of the rotorcraft, and distributed as follows:—

(i) equally between the skids,

(ii) applied to the forward end of the straight section of the skids, and

(iii) reacted at the attachments to the rotorcraft.

(b) With the rotorcraft in the level landing attitude, a vertical load equal to 0·5 times the maximum vertical load of 6.1.1(a) applied as follows:—

(i) only to the skid and its attachment to the rotorcraft, and

(ii) concentrated at a point midway between the skid attachment points.

6.3 **Emergency Alighting Case.** The skid landing gear and attachments shall achieve an Ultimate Factor of 1·0 on the vertical loads determined in accordance with **G4—5,** 3.2.

*Structural yielding of elastic spring members under Limit Loads is acceptable provided adequate inspection procedures are included in the Maintenance Manual.

A.B

7 ADDITIONAL CASES APPLICABLE TO ALL TYPES OF LANDING GEAR

7.1 **Rotors Turning with Rotorcraft on the Ground.** The rotorcraft structure shall be designed to withstand Limit Loads arising when:—

(a) the rotorcraft is stationary on the ground,

(b) the Rotor System is not supporting any of the rotorcraft weight,

(c) the landing gear is prevented from moving by chocks or other means, and

(d) with the Main Rotor at Rotor Maximum RPM (Power On) the directional control is applied as quickly as is practicable to give the maximum horizontal thrust.

7.2 **Towing Case.** With the rotors stationary the rotorcraft structure and in particular the rotor blades and their supporting structure shall be designed to withstand the Limit Loads resulting from the application, on each landing gear unit, of:—

(a) a vertical load equal to 1·67 times the maximum static reaction, and

(b) any combination of drag and side loads equal to from 0 to 0·25 times the vertical load.

NOTES: (1) This case is straightforward but important in that it may provide a criterion for the rotor blades, since inertia loads are superimposed on hinged blades which rest against droop stops when stationary.

(2) For skid landing gear, the rotorcraft is assumed to be standing on ground handling wheels.

7.3 **Emergency Alighting on Water*.** The rotorcraft, together with any equipment fitted for emergency alighting on water shall achieve an Ultimate Factor of Safety of 1·0 on the loads arising from impact with the water at a vertical velocity of 1·5 m/s (5 ft/sec), and a forward speed equal to two-thirds of the best autorotational descent speed (V_Y) and with angles of yaw up to 15°.

NOTE: This requirement is intended to cover the strength of any emergency flotation gear and its attachment to the aircraft structure. However, where no such gear is required it may be assumed that rotor lift is equal to rotorcraft weight.

*See also **G6—12.**

SUB-SECTION G3—STRUCTURES

CHAPTER G3—6 CONTROL SYSTEM LOADS

Revised, 20th January, 1975

A.B

1 GENERAL The flight control system and supporting structure shall have proof and ultimate factors of safety of not less than 1·0 and 1·5 respectively under the loads specified in the appropriate paragraphs of this Chapter.

NOTE: See 5 for additional factors for control chains and cables.

2 MANUALLY OPERATED PRIMARY FLIGHT CONTROLS

2.1 Maximum pilot effort loads shall be considered for manually operated primary flight controls as follows:—

(a) 580 N (130 lbf) applied to foot operated controls, and

(b) 450 N (100 lbf) normal to the cyclic pitch control and to the collective pitch control in the fore and aft vertical plane, and 300 N (67 lbf) laterally, applied to hand operated controls.

2.2 Where it can be shown that the system design, or the normal operating loads, are such that the system cannot be subjected to the loads corresponding to the specified pilot-applied loads in 2.1, then the system shall be designed to have the same factors on the maximum loads which can be obtained in normal operation of the rotorcraft, or on the loads resulting from 60% of the specified pilot-applied forces, whichever is the greater.

NOTE: The loads assumed should, in any case, be sufficient to ensure a robust system to provide for excess loading arising as a result of jarring, taxying and parking in a wind, control inertia, friction, and gusts encountered by the rotorcraft while on the ground.

2.3 The loads resulting from pilot effort shall be assumed to act at the appropriate control grips in a manner simulating operating conditions, and shall be placed in equilibrium by an appropriate force, with the rotor blade or control surface being taken to be in the most critical position, at the attachment of the control system to the rotor blades (or control surface), at the control stops, or at any irreversible mechanism.

2.4 In the cases where the simultaneous application of loads in more than one system (e.g. cyclic and collective pitch systems) could result in critical loads, the system shall have the factors of safety prescribed in 1 under combinations of loads of 50% of the magnitude of the loads prescribed in 2.1 acting together.

2.5 In determining the distribution of loading in the elements of the control system, the most critical angular setting of the rotor blades or control surfaces shall be assumed.

2.6 **Dual Controls.** Dual control systems shall have the factors of safety prescribed in 1 when loads are applied by the pilots acting together and in opposition to each other. For these cases individual pilot effort equal to 75% of the pilot effort to which the individual system is designed in accordance with 2.1 or 2.2, shall be assumed, provided that the individual pilot effort shall be not less than 60% of the loads prescribed in 2.1.

A.B

3 POWER-OPERATED, POWER-ASSISTED PRIMARY FLIGHT CONTROL SYSTEMS AND AUTOMATIC-PILOT SYSTEMS*

3.1 Power-operated and power-assisted primary flight control systems shall comply with the strength requirements of **1** and **2** as far as they are applicable. In addition, power operated systems shall have the factors of safety prescribed in **1** under the maximum load which can be developed in the systems under all expected operating conditions (e.g. the loads corresponding to automatic-pilot effort if they alone can produce higher loads than the human pilot).

NOTE: Requirements for automatic-pilot systems are prescribed in **G6—4.**

3.2 Where a power-assisted control system is installed, the system shall have the factors of safety prescribed in **1** under the manually applied loads which are likely to occur in the event of failure of the power source of the system.

3.3 Where a power-assisted control system, the failure of which would necessitate the use of high manual forces, is installed, consideration shall also be given to the case of the pilots acting together. The loads assumed to be applied individually shall be those of 2.6 (i.e. 0·75 times the loads of 2.1 or 1·0 times the loads of 2.2 whichever are the greater).

4 OTHER CONTROL SYSTEMS

4.1 Each system shall have the factors of safety prescribed in **1** under the maximum loads likely to be experienced under all expected operating conditions.

4.2 Where a power-assisted control system is installed, the system shall have the factors of safety prescribed in **1** under the manually applied loads which are likely to occur in the event of failure of the power source of the system.

5 CONTROL CHAINS AND CABLES Irrespective of the factors prescribed in **1**, control chains and cables shall achieve the following when subjected to the maximum (unfactored) design loads:—

(a) **Control Chains.** An ultimate factor of 3·0.

(b) **Control Cables.** A nominal strength giving a factor of 2·0.

6 FATIGUE AND VIBRATION A complete vibration survey of the primary flight control system shall be carried out to a schedule agreed with the Authority as part of the determination of components critical from fatigue aspects (see **G3—1** App. No. 2, 3).

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*For hydraulic systems see also the general requirements of **G6—2.**

SUB-SECTION G3—STRUCTURES

CHAPTER G3—8 CRASH LANDING CONDITIONS

Revised in part, 7th November, 1975

A.B 1 GENERAL The requirements of this Chapter are intended to ensure that in the event of the rotorcraft making a Crash Landing then the safety of the occupants has been fully considered. Such consideration extends to the avoidance of injury to the occupants due to the damage which the rotorcraft is likely to suffer under the prescribed conditions.

2 ACCELERATIONS All combinations of inertia forces, in the following ranges (expressed in terms of accelerations) up to a maximum resultant of 6*g*, shall be considered, taking the direction of the forces in each case as relative to the rotorcraft:—

6*g* downwards to 3*g* upwards

Zero to 4*g* forwards

Zero to 3*g* backwards

Zero to 3*g* sideways.

3 EQUIPMENT (see G3—8 App., 1) Items of equipment shall, as far as is practicable, be so positioned that if they break loose they are unlikely to cause injury to the occupants or to nullify any of the escape facilities provided. When such positioning is not practical the attachments and surrounding structure shall be designed to withstand inertia forces equal to those prescribed in 2.

APPENDIX TO CHAPTER G3—8

Issued, 1st February, 1963

CRASH LANDING CONDITIONS

1 EQUIPMENT AND SEAT ATTACHMENT (see G3—8, 3) It is recommended that inertia forces corresponding to higher accelerations than those prescribed should be used for the design of seat and equipment attachments, etc., since, in the event of a crash involving such higher accelerations, it is desirable to protect occupants from injury by detached equipment and seats.

SUB-SECTION G3—STRUCTURES

CHAPTER G3—9 FLUTTER PREVENTION AND STIFFNESS

Revised in part, 7th November, 1975

A.B 1 GENERAL Structural distortion in flight shall be reduced to a minimum to ensure that the control and stability of the rotorcraft shall not be seriously impaired and that flutter and other vibration effects shall be prevented.

2 DEFORMATION The design of the main rotor blades and their articulation shall be such that under all possible conditions of loading their functioning will be satisfactory. In particular the rotor blades shall possess such torsional stiffness qualities as to prevent any serious changes of aerodynamic contour and characteristics under all possible flight conditions.

3 RESONANT FREQUENCIES It shall be demonstrated that the natural frequency of any part of the rotorcraft, which may be excited by Rotor vibration, shall be remote from the fundamental Rotor frequency and its higher harmonics. In particular the Rotor mounting shall be so checked.

4 FLUTTER It shall be demonstrated that all rotor blades are free of any dangerous characteristics, including flutter and resonance:—

(a) by flight test, at rotorcraft speeds of up to 1·1 times the Never Exceed Speed, V_{NE}, and

(b) by ground test, at Rotor speeds up to 1·05 times the Rotor Never Exceed RPM, account being taken of any engine conditions likely to be critical during power-on operation.

APPENDIX TO CHAPTER G3—9

Issued, 1st January, 1954

FLUTTER PREVENTION AND STIFFNESS

1 GENERAL

1.1 At this juncture it is not possible to specify stiffness criteria for rotor blades and it is left to the designer with his experience to ensure as far as is possible in the design stage, that the blades possess such stiffness qualities as will prevent the onset of flutter up to the maximum permissible speed and rotor rotational speed.

1.2 The tests carried out on the prototype rotorcraft will provide the positive proof of freedom from flutter characteristics within the permissible range of speeds and rotor rotational speed.

2 DESIGN ASSUMPTIONS

2.1 It is recommended that in the design of the blades, sufficient mass balance shall be provided uniformly along the blade to bring the aerodynamic and inertia axes as nearly coincident as possible. The flexural axis should be as nearly coincident as other considerations will permit.

2.2 The displacement of the inertia axis due to the effect of humidity on the blade should be considered.

3 CONTROL SYSTEM STIFFNESS The percentage stretch of the control systems should be as low as possible having regard to—

(a) allowance for full control movement.

(b) avoidance of resonance with the rotor.

SUB-SECTION G3—STRUCTURES

CHAPTER G3—13 ADDITIONAL DESIGN CASES

Revised in part, 7th November, 1975

A.B 1 GENERAL The following design cases cover contingencies which might arise on or near the ground and apart from landing gear cases.

2 BLADE STRIPPING

2.1 The Primary Structure, and in particular the structure which in the event of failure might endanger the occupants, shall have an Ultimate Factor of 1·5 under the load condition when the rotorcraft is assumed to be hovering in ground effect at the Rotor Never Exceed RPM and any likely part of the secondary structure if one blade is lost. The resulting out-of-balance aerodynamic loads shall be reacted by inertia loads on the rotorcraft.

3 LOADS AT BLADE TIP

3.1 The rotor blades shall have Proof and Ultimate Factors of 1·2 and 1·5 respectively under the following vertical and horizontal loads applied separately.

3.2 **Vertical load.** A vertically applied load at the tip of one blade of either 225 N (50 lbf) or the load which produces 305 mm (12 in) vertical deflection at the tip, whichever is the lesser of the two loads.

3.3 **Horizontal Load**

3.3.1 For blades not fitted with friction dampers, a horizontally applied load at the tip of one blade of 225 N (50 lbf) minimum, or such higher load as the Authority may prescribe in individual cases.

3.3.2 For blades fitted with friction dampers, either a horizontally applied load at the tip of one blade of 225 N (50 lbf) or 1·5 times the load applied at the tip required to overcome the friction damper, whichever is the greater of the two loads.

4 FLUTTER, VIBRATION AND BUFFETING

4.1 **Mechanical Characteristics.** There shall be no possibility of the occurrence of dangerous mechanical characteristics, such as unintentional bending loads being imposed upon the blades, in any permissible operating condition.

SUB-SECTION G4—DESIGN AND CONSTRUCTION

CHAPTER G4—1 GENERAL

Revised, 20th January, 1975

A.B

1 INTRODUCTION

1.1 The requirements of this Chapter are of a general nature and are applicable to Section G as a whole. There may be cases where a general requirement given in this Chapter has to be overridden by a detailed requirement in a particular Chapter; the text used in the particular Chapter will make this clear.

1.2 Sub-section G4 prescribes requirements relating to the design and construction of the rotorcraft and its component parts other than engines, propellers and equipment. Engines, propellers and equipment shall be of types which have been Approved by the Authority in accordance with the appropriate Sections of the Requirements.

1.3 The loads to which the various items are subjected and strength aspects generally are dealt with in Sub-section G3—Structures, except in some cases (e.g. seats, seat harnesses, retractable landing gear).

NOTE: See **G4—9,** Rotor and Transmission Systems.

2 FAILURES

NOTE: Failure of Primary Structure and other high integrity parts is dealt with in **G3—1, 5.** Failures in the Rotor and Transmission Systems are dealt with in **G4—9, 3.**

2.1 The design of rotorcraft shall be such that the probability of a Failure resulting in a Catastrophic Effect is Extremely Remote.

A1

2.2 The design of rotorcraft to be certificated in Group A1 shall be such that:—

(a) the probability of a Failure resulting in an immediate Emergency Landing is not greater than Extremely Remote, and

(b) the probability of a Failure resulting in an Emergency Landing within a specified period* subsequent to the initial failure is not greater than Remote.

A2

2.3 The design of rotorcraft to be certificated in Group A2 shall be such that the probability of a Failure resulting in an immediate Emergency Landing is at least one order of magnitude less likely than the accepted engine failure rate.†

A.B

3 OPERATION OF ESSENTIAL SERVICES

3.1 **Power-unit Failure**

B

3.1.1 **Rotorcraft with One Power-unit** (see **G4—1** App. No. 1, **2**). Following Power-unit failure, Essential Services shall be available for the maximum time likely to be required to enable an Emergency Landing to be completed.

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*The minimum specified period shall be 10 minutes. Where the manufacturer demonstrates a longer period, this period may be declared.

†The present accepted engine failure rate lies in the order of probability 10^{-3} to 10^{-4} per hour.

A.B

3.1.2 **Rotorcraft with Two Power-units**

A (a) Following the failure of one Power-unit, all Essential Services shall continue to function and perform adequately (see **G4—1** App. No. 1, **1**).

B (b) Following the failure of one Power-unit, Essential Services shall be available for the maximum time likely to be required to enable an Emergency Landing to be completed (see **G4—1** App. No. 1, **2**).

A.B 3.1.3 **Rotorcraft with more than Two Power-units** (see **G4—1** App. No. 1, **2**). Following the failure of more than one Power-unit, Essential Services shall be available for the maximum time likely to be required to enable an Emergency Landing to be completed.

NOTE: This requirement is intended to cover, for example, the case of a double Power-unit failure in a rotorcraft having three Power-units.

3.1.4 **Failure of all Power-units** (see **G4—1** App. No. 1, **2**). Following the failure of all Power-units, Essential Services shall be available for the maximum time likely to be required to enable an Emergency Landing to be completed.

3.2 **Accessory Drive Failure.** Where the failure of a part driven by the Transmission System will affect the power supply for Essential Services then (a) and (b) shall apply (see also **G4—9, 8**).

A (a) **Group A.** The requirements of 3.1.2 to 3.1.4, as appropriate.

B (b) **Group B.** The requirements of 3.1.1 to 3.1.4, as appropriate.

A.B NOTE: It is not intended that this requirement should be applied in combination with any Power-unit failure.

4 MATERIALS AND FABRICATION PROCESSES

4.1 Materials used in parts affected by airworthiness requirements shall conform to Approved material specifications.

4.2 The methods of fabrication employed in the Primary Structure shall be such as to produce a consistently sound structure. This structure shall also be reliable with respect to maintenance of the required strength* under all conditions anticipated in operation. Where a fabrication process requires close control to attain these objectives, the process shall be performed in accordance with an Approved process specification.

4.3 For the purposes of 4.1 and 4.2, in addition to specifications specifically Approved by the Authority†, British Standard Specifications‡ in the Aircraft Series and DTD Specifications are accepted as Approved. Other specifications accepted by an Approved Design Organisation (with the necessary technical capabilities for this purpose) for a material or fabrication process to be used in a part designed within the terms of their approval, are accepted as Approved (unless the Authority has notified non-approval) provided that:—

(a) the specification is such that materials or fabrication processes accepted as complying with it will have the essential properties assumed in the design,

(b) the Approved Design Organisation maintains a record of each specification accepted in this way, together with its means of identification (date, title and/or number) and of any amendments thereto, this record being available for inspection by the Authority at any reasonable time.

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*See also **G3—1.**
†See **Section A,** Chapter **A6—6.**
‡Obtainable from the British Standards Institution.

A.B

5 FLAW DETECTION The need for a flaw detection test on each part shall be considered and the drawings endorsed accordingly. The technique to be employed in conducting such tests shall be agreed, where necessary, between the designer and the manufacturer.

6 REDUCTION OF NORMAL ACCELERATION Essential Services and Equipment, the failure to function of which could result in a Catastrophic Effect shall function satisfactorily when subjected to a reduction of normal acceleration. The magnitude and associated duration of the reduction of normal acceleration shall be agreed with the Authority.

NOTE: This does not prohibit those temporary malfunctions or failures to function under reduction of normal acceleration which would not hazard the safety of the rotorcraft.

7 INSPECTION AND MAINTENANCE PROVISIONS (see G4—1 App. No. 2) Adequate means shall be provided to permit the inspection and maintenance of such parts of the rotorcraft as are required to be inspected and maintained in accordance with the Maintenance Manual (see **Section A,** Chapter **A6—2** App., **1**). Regions where normal means of access cannot be provided shall be defined in the Overhaul Manual. Methods of access to, and inspection of, such regions shall be described in the Overhaul Manual (see **Section A,** Chapter **A6—2** App., **2**).

NOTES: (1) This information should include any provisions made to enable inspections such as radiographic and ultrasonic examination to be undertaken.
(2) **G4—1** App. No. 2, 2.5 will have to be complied with, unless otherwise agreed by the Authority for a particular case.

8 PROTECTION IN SERVICE (see G4—1 App. No. 2) All parts of the rotorcraft, both inside and outside, shall be so designed, protected, drained and vented that, when the rotorcraft is maintained in accordance with the Maintenance Manual, there will be no unacceptable loss of airworthiness as a result of weathering, corrosion, abrasion, unavoidable mechanical damage to protective treatment during normal maintenance or other causes.

9 IDENTIFICATION OF PIPE LINES

9.1 Marking of pipe lines for the purpose of distinguishing their functions shall, when employed, be to the satisfaction of the Authority.

NOTE: It is recommended that a system of identification conforming to that contained in British Standards Specification M23* should be used.

9.2 The markings shall be such that risk of confusion by servicing or maintenance personnel will be minimized.

NOTE: Markings incorporating names or descriptions should be in the language most suitable for ensuring compliance with 9.2.

9.3 Distinction by means of colour marking alone is not acceptable. The use of alphabetical or numerical symbols may be acceptable if recognition depends upon reference to a Master Key and any relation between symbol and function is carefully avoided.

10 BIRD STRIKES (see G4—1 App. No. 3) The probability of a Catastrophic Effect as a result of the rotorcraft striking a bird shall be Extremely Remote.

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*Obtainable from the British Standards Institution.

A.B **11** LOCKING OF FASTENERS

11.1 An Approved means of locking shall be provided on all connecting elements in the Primary Structure, fluid systems, control and other mechanical systems essential to the safe operation of the rotorcraft.

11.2 Any removable fastening device (e.g. bolt, screw, nut, pin) the loss of which could hazard the safe operation of the rotorcraft shall incorporate two independent locking devices. The fastener and its locking devices shall not be affected adversely by the environmental conditions (e.g. vibration) associated with the particular installation. No self-locking nut shall be used on any bolt subject to rotation in operation unless a non-friction locking device is used in addition.

12 INCIDENTAL LOADS All items of equipment and parts of systems shall be installed and supported so as to withstand loads arising from vibration, rough landing conditions and handling during maintenance operations together with loads from fluid pressures where appropriate.

13 EQUIPMENT HAVING HIGH ENERGY ROTORS Unless there is reliable assurance that such rotors will not fail, the equipment shall either be demonstrated as being capable of containing a failed rotor, or be so located that such a Failure will not result in a Catastrophic Effect (see also **G4—9, 7** for cooling fans).

14 TESTS

14.1 Additional confirmatory tests to those prescribed throughout Section G shall be made where there is doubt as to the suitability or reliability of any detail of design or construction.

14.2 All moving parts essential to the safe operation of the rotorcraft shall be demonstrated to function correctly under all foreseeable operating conditions.

APPENDIX NO. 1 TO CHAPTER G4—1

Issued, 20th January, 1975

OPERATION OF ESSENTIAL SERVICES FOLLOWING POWER-UNIT FAILURE

1 ONE POWER-UNIT INOPERATIVE (see G4—1, 3.1.2) It is intended that in the one-Power-unit-inoperative condition the rotorcraft should not suffer the loss, or unacceptable reduction, of performance of any Essential Service. The following are examples of Essential Services which, if installed, should provide an acceptable level of performance in the one-Power-unit-inoperative condition:—

(a) main flying controls and trimmers,
(b) landing gear lowering system,
(c) transmission lubrication,
(d) essential instruments as required by G6—1,
(e) communication and emergency equipment,
(f) de-icing equipment,
(g) landing lamps.

In cases where the one-Power-unit-inoperative performance of any particular Essential Service is lower than that provided in the all Power-units-operating condition, the lower value will be used for the purpose of scheduling the appropriate performance of the rotorcraft.

2 POWER-UNIT FAILURE NECESSITATING AN EMERGENCY LANDING (see G4—1, 3.1.1, 3.1.3 and 3.1.4) The intention of the requirements of G4—1, 3.1.1 to 3.1.4 is to ensure the provision of sufficient facilities to enable an Emergency Landing to be made. The following Essential Services should be provided as a minimum; others may have to be included for particular rotorcraft:—

(a) main flying controls and trimmers,
(b) landing gear lowering system,
(c) transmission lubrication,
(d) essential instruments for a limited period of time, the instruments and the period to be agreed with the Authority,
(e) communication and emergency equipment appropriate to the rotorcraft situation,
(f) landing lamps.

APPENDIX NO. 2 TO CHAPTER G4—1

Issued, 20th January, 1975

PROTECTION AGAINST CORROSION AND OTHER EFFECTS OF THE PRESENCE OF FLUIDS

1 INTRODUCTION It is intended that this Appendix should be used for guidance purposes in meeting the requirements of **G4—1, 7** and **8.**

2 GENERAL In assessing the design for inspection and maintenance provisions and protection, particular attention should be given to:—

(a) the effects of leaks from systems containing fluids (e.g. hydraulic, water);

(b) the effects of rain, sleet, snow, ice, hail, slush, sea-spray etc.;

(c) the effects of liquids spilt in cargo compartments, galleys, toilets and from batteries;

NOTE: The liquids assumed to be spilt should be appropriate to the intended use of the rotorcraft, e.g. carriage of special liquids.

(d) the effects of condensation especially where it may drip (e.g. on to the top side of roof panels) and where it may collect in underfloor regions and belly;

(e) the effects of gassing from batteries and condensation contaminated by such gassing;

(f) the effects of cleaning of, or ground or airborne de-icing of, the outside of the rotorcraft (the liquids for which could gain access to the inside of the rotorcraft); cleaning of the inside of the rotorcraft;

(g) the effects of changes of rotorcraft attitude in operation;

(h) those parts of the rotorcraft in which liquids and vapours could collect:—

(i) in the normal course of events,

(ii) as a result of a drain, or drain hole becoming blocked, and

(iii) as a result of a system leaking.

NOTES: (1) It should be borne in mind that as time passes a liquid could bring down with it certain solids such as swarf (which cannot always be entirely removed from the structure during manufacture) dirt, dust, sand, mud, flakes of paint, sealant, grease, as well as chemicals from lagging, etc.

(2) Specification No. 8, Issue 2, available on application to the CAA, Airworthiness Division, Brabazon House, Redhill, Surrey RH1 1SQ, contains an advisory Appendix dealing with testing for corrosive impurities in textiles.

2.1 **Fluids.** The design of the rotorcraft should be such as to minimize the possibility that any fluid which may leak from a system or may be spilled in the accommodation (e.g. in galleys and toilets) will result in:—

(a) a direct or indirect danger to the rotorcraft or its occupants,

(b) an immediate or eventual loss of airworthiness to a serious extent.

NOTE: The effects of corrosion as a result of spilled fluids should be given particular consideration.

2.1.1 Particular attention should be given to the design of those compartments where the spilling of liquids is likely to occur. Sealed floors with suitable drainage should be provided for galleys and toilets.

2.1.2 Particular attention should be given to the location of pipes, tanks and apparatus containing fluids which are installed in or near compartments containing critical electrical equipment, or critical mechanical parts, the operating temperature of which is likely to be below the freezing points of the particular fluids.

NOTES: (1) Care should be taken to avoid pockets where liquids could freeze and so jam mechanisms.

(2) It is recommended that joints and unions in pipe lines should not be located in closed portions of the structure.

(3) See **G4—3, 8** and **9** for requirements for water systems and location of pipes and tanks for other considerations.

2.2 **Rain.** The effects of rain on the rotorcraft should be considered. Where sealing is not practical, precautions should be taken to ensure that any rain that does gain access to the interior of the rotorcraft does not constitute a direct or indirect danger. Particular attention should be given to the results of the wetting of equipment, the possibility of jamming by freezing (especially if water can collect in pockets) of mechanisms (especially control systems), exits, emergency exits and latches.

NOTE: See also **Section J, Chapter J1—3, 5** for protection of electrical equipment.

2.3 **Drainage.** All compartments in the structure, including those in control surfaces, should be adequately drained both on the ground and in flight.

2.3.1 Each drainage system should be considered separately and drains and drain holes should be so located that the blockage of any one drain or drain hole in any one drainage system will not prevent compliance with 2.3.

NOTE: Particular attention should be given to the location of internal drain holes so as to minimize the possibility of fluids being trapped in the structure and being prevented from running to a drain.

2.4 **Vents.** All compartments in the structure should be adequately vented.

2.4.1 Vents should be located, constructed and (if necessary) drained so as to preclude the possibility of their becoming obstructed:—

(a) by fluid or other foreign matter when the rotorcraft is in the ground attitude and when it is in any steady flight attitude,

(b) by ice, when the rotorcraft is in any ground or flight attitude.

2.5 **Closed Sections.** Where closed sections (e.g. tubes) are employed as load carrying members the design organisation should be satisfied that adequate inspection schemes have been established for checking on the presence and extent of any corrosion that may occur in these regions and that corrosion will be detected before an unacceptable loss of airworthiness has taken place.

NOTES: (1) Particular attention should be given to those closed sections which constitute tension members.
(2) See also **G3—1**, 4.3 for additional factors of safety.

2.6 **Corrosion**

2.6.1 Contact between fluids and materials likely to result in detrimental corrosive action should be kept to a minimum and, so far as is practical, the juxtaposition of dissimilar metals should be avoided.

NOTE: With regard to electrolytic action in cases where juxtaposition is unavoidable, the best available data should be used; where no such data are available then the Authority should be consulted.

2.6.2 Where contact between fluids and materials likely to result in detrimental corrosive action cannot otherwise be avoided, adequate protection should be given to parts (particularly those made up of dissimilar metals) likely to come into contact with such fluids. In particular closed sections which are employed in structural members, especially tension members (e.g. tubes), should as far as practical be protected on assembly.

(a) The fluids (i.e. liquids and vapours) to be taken into account should include:—

(i) water, cleaning fluids, ground and airborne de-icing fluids, fuel, oil, hydraulic fluid, fluids associated with galleys and toilets;

(ii) slush (including grit, salt and other ground surface de-icing chemicals) which will impinge on, and possibly get inside parts of, the rotorcraft during taxying, take-off or landing on precipitation-covered ground surfaces.

(b) Adequate protection should also be given against microbiological attack resulting from use of such liquids as kerosene and water.

APPENDIX NO. 3 TO CHAPTER G4—I

Issued, 20th January, 1975

BIRD STRIKES

I BIRD STRIKES (see G4—I, 10) In the absence of better information the maximum weight of the bird assumed to be struck by a rotorcraft the Maximum Weight of which is greater than 5700 kg (12,500 lb) should be 1·81 kg (4 lb) and for rotorcraft the Maximum Weight of which is greater than 2730 kg (6,000 lb) and less than 5700 kg (12,500 lb) the weight should be 0·91 kg (2 lb). The associated rotorcraft speeds should be all speeds up to the maximum true air speed which is likely to be achieved in operational service at altitudes up to 2440 m (8,000 ft).

SUB-SECTION G4—DESIGN AND CONSTRUCTION

CHAPTER G4—2 FLIGHT-CREW COMPARTMENT DESIGN

Revised in part, 17th December, 1980

A.B 1 GENERAL This Chapter prescribes requirements relating to the design and construction of flight-crew compartments and to the safety of flight-crew members in normal and emergency conditions. Flight-crew compartments shall also comply with the relevant requirements of **G4—3.**

2 FLIGHT-CREW COMPARTMENT

2.1 **Suitability** (see **G4—2** App., **1**). The arrangement of the flight-crew compartment shall be such as to minimize the likelihood of injury to the flight-crew members, both in normal operation and during an Emergency Landing, and to ensure that they will be able to perform all their duties and operate the controls in the correct manner without unreasonable difficulty, fatigue or concentration. The temperature in the flight-crew compartment shall be suitable for safe control of the rotorcraft.

2.2 **Communication with Passengers.** Where the flight-crew compartment is separated from the passenger compartment by a partition, a means of aural communication shall be provided between the flight crew and passengers.

2.3 **Signal Pistol and Discharger.** Where a signal pistol is carried:—

(a) it shall be demonstrated that the pistol can readily be used, discharging clear of the rotorcraft;

(b) a mounting shall be provided such that the pistol can be loaded, fired, and unloaded, in the firing position;

(c) provision shall be made for the stowage of the signal pistol and cartridges.

NOTE: Paragraph 2.3 does not prohibit the use of the mounting as a stowage for the pistol nor does it prohibit the firing of the pistol by hand.

3 PILOTS' STATION

3.1 **View**

3.1.1 The arrangement of the flight-crew compartment shall be such as to afford a sufficiently extensive, clear and undistorted field of view for the safe operation of the rotorcraft, and to prevent interference with this field of view from glare and reflections. Compliance with these requirements shall be demonstrated in flight, including night flight tests on rotorcraft for which certification for flight by night is sought.

3.1.2 On rotorcraft the flight-crew compartment of which is enclosed there shall be one readily accessible window which can be easily opened by the pilot, even in icing conditions, to afford him an adequate view during take-off, level flight, approach, and landing. When this window is opened and in normal use, the draught on the pilot's face shall not be excessive.

A.B

3.1.3 During flight in precipitation conditions it shall be demonstrated that an adequate portion of the windscreen and windows serving each pilot's station can be maintained in a clear condition. The cleared portion of each such windscreen or window shall be such as to give the pilot(s) an adequate field of view for normal flight, approach and landing under conditions of heavy rain at all air speeds up to V_H or V_{NO} whichever is the lesser. On rotorcraft intended for flight in icing conditions, this requirement shall also be met in icing conditions up to the severity in which the rotorcraft as a whole has been shown to be satisfactory.

3.1.4 On rotorcraft where two pilots' stations are provided, and where, for compliance with 3.1.3, means are provided for maintaining the windscreen and windows in a clear condition, the means shall be so arranged that no Reasonably Probable Failure of such means can result in a reduction of the cleared field of view such as seriously to interfere with the ability of the flight crew to continue the operation and land safely.

NOTE: The requirements of 3.1.4 can be met by arranging that such failures affect only one pilot's windscreen or windows; it is not intended that duplication of systems on both pilots' windscreens or windows should be provided.

3.2 **Windscreens and Windows** (see **G4—1, 10**)

3.2.1 Means shall be provided for preventing the pilot(s) essential view windscreen and windows from being obscured by misting.

3.2.2 Windscreens and windows shall be made of material which will not break into dangerous fragments. Windscreens shall be designed so that either:—

(a) they are made of material which will not cause a serious reduction in the field of view by becoming suddenly opaque, or

(b) any one panel becoming opaque will not cause a serious reduction in the field of view.

3.2.3 In the event of any Reasonably Probable Failure, a transparency heating system shall be incapable of raising the temperature of any windscreen or window to a point where there would be a danger of fire or structural failure.

4 CONTROLS

4.1 **General.** In addition to complying with the relevant requirements of **G4—8**, controls in the flight-crew compartment shall comply with 4.2.

4.2 **Control Movement and Seat Position**

4.2.1 The design and arrangement of the flight-crew compartment, and in particular the relative positions of controls and seats, shall be such that each flight-crew member, with his seat and any adjustable controls suitably adjusted, can:—

(a) without interference produce full and unrestricted movement of each control which he is responsible for operating, both separately and with all practical combinations of movements of other controls,

(b) at all control positions exert adequate control forces for the operation to be performed.

NOTE: It is recommended that controls should be located so that they can be operated by pilots from 157 cm (62 in) to 183 cm (72 in) in height.

A.B

4.2.2 In showing compliance with 4.2.1, when a seat at a station from which the rotorcraft may be piloted has been adjusted so as to suit the occupant, subsequent change of seat position to operate any controls needed for piloting is not acceptable.

4.2.3 It shall be possible for the flight crew, with their safety harness correctly worn, to comply with 4.2.1, except in respect of controls which it can be shown will only be required on very rare occasions dissociated from the need for safety restraint.

5 EMERGENCY EXITS Emergency exits shall be provided in the flight-crew compartment and shall be such as to afford the flight crew means of rapidly leaving the rotorcraft in emergency conditions. Two such exits shall be provided, and shall be either:—

(a) located one on each side of the rotorcraft, or

(b) one on the side of the rotorcraft and the other in the roof or floor.

NOTES: (1) For this purpose the normal entrance door to the flight-crew compartment may be considered an emergency exit, provided it meets the relevant requirements of Chapter G4—3.

(2) This requirement may be waived where the Authority is satisfied that the proximity of passenger emergency exits to the flight-crew compartment renders them convenient and readily accessible to the flight crew.

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APPENDIX TO CHAPTER G4–2

Issued, 17th December, 1980

FLIGHT-CREW COMPARTMENT DESIGN

1 ENVIRONMENTAL TEMPERATURE (see G4—2, 2.1)

1.1 This paragraph contains information on the temperatures considered acceptable in flight-crew compartments.

1.2 Where necessary, temperatures are given as globe temperature. Globe temperature depends on the effective mean radiation temperature of the environment, the air temperature, solar radiation, and on convective heat transfer. Globe temperatures should be measured at the position of each seated flight crew member.

1.3 It is recommended that in normal flight it should be possible for the flight crew to maintain globe recorded temperatures at their seat positions within the range + 15°C to + 30°C.

NOTES: (1) Where flight-crew compartment ambient temperatures are likely to stabilise at more than +30°C, consideration should be given to the provision of air-conditioning equipment.

(2) It is recommended that the temperature of those areas of floor where flight-crew members are likely to place their feet should not be less than +5°C.

1.4 No surface which can be touched by the flight crew should exceed a surface temperature of +60°C or fall below −15°C in normal cruise conditions.

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SUB-SECTION G4—DESIGN AND CONSTRUCTION

CHAPTER G4—3 COMPARTMENT DESIGN AND SAFETY PROVISIONS

Revised in part, 17th December, 1980

A.B 1 INTRODUCTION This Chapter prescribes detailed requirements related to the design and construction of passenger, cargo and baggage compartments and to the safety of occupants in normal and emergency conditions (see **G4—4** for the design of seats, safety belts and harnesses). Certain requirements apply equally to the design and construction of flight-crew compartments, or need to be considered in relation to the accommodation as a whole. Variations to the requirements for rotorcraft with pressurization systems shall be agreed with the Authority.

2 GENERAL The design of all compartments (occupied or likely to be occupied in flight) shall be such that the possibility of danger or injury to the occupants in both normal and emergency conditions is reduced to a minimum.

3 CARGO AND BAGGAGE COMPARTMENTS The requirements of this paragraph 3 are applicable to all cargo and baggage compartments. The variation of the requirements when they are applied to installations which do not constitute a separate compartment shall be decided in consultation with the Authority.

NOTE: Attention is drawn to the fact that the strength prescribed in this paragraph 3 only caters for airworthiness and thus caters for flight and ground and, in some instances, Crash Landing cases. In meeting such cases, sufficient robustness for general usage will not necessarily be provided. It is recommended that consideration should be given to providing sufficient robustness wherever possible.

3.1 Provision shall be made for restraining cargo and baggage.

NOTE: This requirement does not apply to hand baggage which a passenger is normally permitted to retain at his seat.

3.2 **Ground and Flight Conditions.** With the maximum authorised weight of cargo or baggage in the compartment, and with the critical load distribution of the cargo or baggage, the compartment and the means provided for restraining the cargo or baggage shall have sufficient strength to withstand the critical factored loads corresponding to the flight and ground conditions of Chapters **G3—2** and **G3—5**, prescribed for the rotorcraft as a whole.

3.3 **Crash Landing Conditions.** The cargo and baggage compartments shall comply with either 3.3.1 or 3.3.2.

NOTE: Account should be taken of any possible dynamic loading resulting from movement of the cargo or baggage; possible variations in the geometry of the means of restraint and wear and tear of the means of restraint and local attachments.

3.3.1 The cargo and baggage compartments shall be positioned so that if the cargo or baggage breaks loose during a Crash Landing it is unlikely to cause injury to the occupants or to nullify any of the escape facilities provided for use after a Crash Landing.

A.B 3.3.2 The cargo and baggage compartments, together with the means of restraining the cargo and baggage and their attachments, shall, when containing the maximum authorised weight of cargo or baggage and with the critical load distribution of that cargo or baggage, have sufficient strength to withstand loads equal to those resulting from the inertia forces of **G3—8, 2,** taking account of any conditions which might otherwise be expected to reduce the ability of the attachments and means of restraint from developing their intended design capacity.

3.4 Controls, wiring, pipe lines, equipment, or accessories, the damage, failure or jamming of which would affect the safe operation of the rotorcraft, shall not be installed in cargo or baggage compartments unless they are adequately shielded, isolated, or otherwise protected.

4 WINDOWS

4.1 Windows, the breakage of which might injure any of the crew or passengers, shall be made of material which will not break into dangerous fragments if fractured.

4.2 **Aerodynamic Loads.** All windows and their fixings shall comply with the strength requirements in flight prescribed for the rotorcraft in Sub-section G3.

5 EXITS

5.1 **Normal Exits.** Rotorcraft having closed passenger compartments shall be provided with at least one normal exit in the form of a main door.

NOTE: On rotorcraft having a Maximum Weight not exceeding 2730 kg (6,000 lb) the Authority may accept an alternative form of exit if it provides equivalent facilities.

5.1.1 The normal means of exit shall be adequate and shall comply with the access requirements of 5.2.5.

5.1.2 Means shall be provided to open normal exits from both inside and outside, even though persons may be crowded against the door on the inside of the rotorcraft. The means of opening shall be rapid and obvious and shall be so arranged that they can be readily located and operated, even in darkness.

5.1.3 Means shall be provided to secure each external door against opening in flight (either inadvertently by persons, or as a result of mechanical failure).

5.1.4 Means shall be provided for direct visual inspection of the locking mechanism to ascertain whether external doors (including doors for passengers, crew, service and cargo) for which the initial opening movement is outward, are fully locked. In addition, for such doors and for any other external doors (excluding emergency exits) for which the position of both the locking handle and the closure cannot be checked by a crew member from his station, a visual indicator shall be provided to indicate to the appropriate crew member(s) that doors which are normally used are closed and fully locked.

5.1.5 Reasonable provision shall be made to prevent the jamming of normal exits as a result of fuselage deformation in a minor crash (but see 5.2.6 when the normal exit is to be declared as an emergency exit).

5.1.6 Each external exit shall be located where persons using it will not be endangered by rotors, propellers, or engine intakes and effluxes when appropriate operating procedures are used.

A.B 5.2 **Emergency Exits.** Emergency exits shall be provided to facilitate the rapid evacuation of all occupants in the event of a Crash Landing. To this end emergency exits of the number and minimum size prescribed in this paragraph 5.2 shall be provided.

5.2.1 **Passengers', Type of Exits.** Passenger emergency exits are classified as to type as indicated in (a) to (e):—

(a) **Type I.** A rectangular opening of not less than 610 mm (24 in) wide by 1219 mm (48 in) high, with the sill at floor level. Corner radii shall be not greater than $\frac{1}{3}$ of the width of the exit.

(b) **Type II.** The same as Type I, except that the opening is not less than 508 mm (20 in) wide and 1118 mm (44 in) high and, if located over a wing or sponson, a step up inside the rotorcraft of not more than 254 mm (10 in) and a step down outside the rotorcraft of not more than 432 mm (17 in) is permitted.

(c) **Type III.** A rectangular opening of not less than 508 mm (20 in) wide by 914 mm (36 in) high with a step up inside the rotorcraft of not more than 508 mm (20 in) and, if located over a wing or sponson, a step down outside the rotorcraft of not more than 686 mm (27 in). Corner radii shall be not greater than $\frac{1}{3}$ of the width of the exit.

(d) **Type IV.** A rectangular opening of not less than 483 mm (19 in) wide by 660 mm (26 in) high, with a step up inside the rotorcraft of not more than 737 mm (29 in) and, if located over a wing or sponson, with a step down outside the rotorcraft of not more than 914 mm (36 in). Corner radii shall be not greater than $\frac{1}{3}$ of the width of the opening.

NOTE: Larger openings than those specified will be acceptable, whether or not of rectangular shape, provided the prescribed openings can be inscribed therein, and further provided that the base of the openings affords a flat surface not less than the width specified.

(e) For rotorcraft having a Maximum Weight not exceeding 2730 kg (6,000 lb) the emergency exit shall consist of an opening that will admit an ellipse not less than 483 mm × 660 mm (19 in × 26 in).

5.2.2 **Passengers', Location of Exits**

(a) The optimum fore and aft location of emergency exits shall be decided on each rotorcraft bearing in mind the relevant considerations which will include but not necessarily be confined to:—

(i) the disposition of passengers in the fuselage and the ease with which they can reach the exits;

(ii) the probability of occurrence of damage to different parts of the fuselage in Emergency Landing conditions;

(iii) the need to avoid passengers leaving the rotorcraft in areas where dangerous conditions (e.g. spilt liquids, hot engine parts, rotors, propellers) can be encountered;

(iv) the need to avoid areas that might become potential fire hazards in an Emergency Landing or Crash Landing.

(b) Sufficient additional exits shall be provided to allow evacuation should the rotorcraft come to rest on its side after an Emergency Landing, unless the probability of this situation can be shown to be Extremely Remote.

5.2.3 **Passengers', Number of Exits.** Emergency exits shall be provided on each side of the fuselage in accordance with the following:—

(a) The number and size of emergency exits shall be related to the seating capacity as shown in Table 1 (G4—3).

A.B

TABLE 1 (G4–3)

Passenger Seating Capacity (Inclusive)	Emergency Exits each side of the fuselage			
	Type I	Type II	Type III	Type IV
1 – 19	–	–	1	–
20 – 39	–	1	–	1
40 – 59	1	–	-	1
60 – 79	1	–	1	–
80 – 109	1	–	1	1

NOTES: (1) It is not the intention to require that exits necessarily be at locations diametrically opposed to each other.

(2) It is acceptable to provide two Type IV exits instead of each Type III exit required.

(3) Where compensating factors exist which justify an increase in seating capacity beyond those specified in Table 1 (G4—3), such an increase up to a maximum of ten extra passengers is permissible with the agreement of the Authority.

(b) For rotorcraft having a Maximum Weight not exceeding 2730 kg (6,000 lb) there shall be one emergency exit as defined in 5.2.1 (e) on each side of the fuselage.

5.2.4 Where the passenger accommodation is divided into two or more compartments, each compartment shall be provided with exits, unless the passage ways connecting compartments are such that they would not become blocked or retard passenger movement in the event of a Crash Landing.

5.2.5 **Access.** Easy means of access to the exits shall be provided to facilitate use even in darkness; exceptional agility shall not be required of persons using the exits. To this end the following shall be complied with:—

(a) Passage ways between individual passenger compartments and passage ways leading to normal exits and Type I and Type II exits and any exits where an escape chute is required shall be unobstructed and not less than 508 mm (20 in) wide.

(b) The main aisle at any point between the seats shall be not less than:—

(i) for rotorcraft having a maximum passenger seating capacity of more than 19 persons, 381 mm (15 in) wide up to a height above the floor of 635 mm (25 in) and 508 mm (20 in) wide above that height.

(ii) for rotorcraft having a maximum passenger seating capacity of 19 or less persons, 305 mm (12 in) wide up to a height above the floor of 635 mm (25 in) and 508 mm (20 in) wide above that height.

(iii) for rotorcraft having a maximum passenger seating capacity of 10 or less persons, 305 mm (12 in) wide up to a height above the floor of 635 mm (25 in) and 457 mm (18 in) wide above that height.

(c) Adjacent to each exit where an escape chute or similar means of escape needs to be used there shall be sufficient space to allow a crew member to assist in the evacuation of passengers without reduction in the unobstructed width of the passage way to such an exit. Access shall be provided from the main aisle to all Type III and IV exits and such exits shall not be obstructed by seats or other protrusions to an extent which would significantly interfere with their use.

(d) Where footholds, ladders, etc., are provided giving access to exits in order to meet the requirements of 5.2.5, they shall be of rigid construction, and shall be permanently fixed in position, except that they may fold if they can be brought into use immediately, and are unlikely to jam as a result of structural distortions during a Crash Landing.

A.B

5.2.6 **Means of Opening.** The means of opening of emergency exits shall be rapid and obvious. The securing devices shall be self-contained without removable handles or keys and, in the case of exits for which the initial opening movement is outwards, a means of direct visual inspection shall be provided to ascertain that the exit is fully locked. The exits shall be openable both from inside and outside the rotorcraft even though the occupants may be crowding to the maximum extent likely against the door. Emergency exits shall not be liable to jamming as a result of structural distortions arising during a Crash Landing.

5.2.7 **Marking.** Emergency exits, together with their means of access and means of opening, shall be adequately marked for the guidance of occupants using the exits in light and in darkness (e.g. by the use of luminous paint or emergency lighting). Adequate marking shall also be provided for the guidance of rescue personnel outside the rotorcraft.

5.2.8 **Dual Purpose Exits.** Any door, panel, window, etc., including the normal exit, may be counted as an emergency exit, provided that it complies with the requirements prescribed for emergency exits.

5.2.9 **Ditching Emergency Exits.** With the rotorcraft in the configuration appropriate to a planned ditching, the most adverse static water level shall be established. At least one exit per side, of Type III or larger shall be located above the water level so established. For passenger seating capacities greater than 59, additional exits shall be provided such that there is at least one Type III emergency exit located above the water level for each additional 35 passenger seats or part of 35.

5.2.10 Cargo and service doors not suitable for use as emergency exits need only comply with 5.1.3 and 5.1.4.

5.2.11 **Tests.** The proper functioning of all exits shall be demonstrated.

5.3 **Means of Escape.** Where a rotorcraft may be required to carry escape apparatus, suitable provision shall be made for its stowage and attachment.

6 HEATING SYSTEMS

Heating systems shall comply with the appropriate requirements covering fuel burning heater installations, fuel systems, and exhaust systems, where applicable.

7 VENTILATION

7.1 All enclosed passenger and crew compartments shall be suitably ventilated. It shall not be possible for the rate of supply of fresh air to fall below 0·0038 kg/s (0·5 lb/min) per person in any foreseeable conditions of normal and emergency conditions.

7.2 The fresh air supply to compartments normally occupied by passengers or crew shall not, unless suitably ducted, pass through any compartment inaccessible in flight.

7.3 In rotorcraft employing a recirculating air-conditioning system it shall be possible to stop the system and still maintain the fresh air supply in compliance with 7.1 and 7.2.

A.B 7.4 Precautions shall be taken to preclude contamination of cabin air.

7.4.1 Carbon monoxide concentration shall not exceed one part in 20,000 parts of air in any flight or ground conditions or rotorcraft configuration which is likely to be maintained for more than 5 minutes.

7.4.2 Fuel vapour shall not be present in dangerous concentrations.

7.4.3 Harmful concentrations of fire extinguishing agent shall not be liable to occur either as a result of intentional use of any fire extinguishing systems, or extinguishers provided, or due to any failure which might lead to unintentional discharge of the extinguishing fluid.

7.4.4 Systems employing fluids liable to give off noxious vapour (e.g. some hydraulic fluids) shall not be installed in such a manner as to risk harmful contamination of the cabin air either by leakage or by use.

7.5 Where internal doors or partitions between compartments are equipped with louvres or other ventilating means, provision convenient to the crew shall be made for the prevention of flow of air through these means.

8 WATER SYSTEMS (see G4—3 App., 1 and 2)

8.1 Where water is provided in the rotorcraft for consumption or use by the occupants (excluding water supplies for water closets), the associated system shall be designed so as to ensure that no contamination of the water supply is possible as a result of storage in or passage through the system.

NOTE: Account should be taken of all foreseeable conditions of operation of the rotorcraft and all practicable conditions of operation of the water system.

8.2 Water systems in which waste water can be discharged from the rotorcraft in flight shall be designed so that water cannot leave the rotorcraft in the form of lumps of ice.

9 FIRE PRECAUTIONS

9.1 Wherever lagging is used care shall be taken to ensure that it does not promote a fire hazard.

9.1.1 All lagging used shall be sufficiently Fireproof as not to propagate combustion, except that where complete combustion would not constitute an increased hazard, this requirement may be waived.

9.1.2 Whenever lagging is used in compartments in which pipes, tanks or apparatus containing Flammable fluids are installed, it shall not be possible for wetting of the lagging to take place as a result of:—

(a) the normal operation of apparatus,

(b) the failure of apparatus,

(c) leakage from joints or unions.

9.2 The requirements of this paragraph 9.2 apply to all passenger, crew, cargo and baggage compartments through which re-circulating cabin air passes, except that relaxation may be given in particular cases to open cockpits or small compartments which provide similar escape facilities in which smoking is prohibited.

A.B

9.2.1 Pipes, tank and apparatus containing fuel, oil and other Flammable liquids shall not be installed in such compartments unless adequately shielded or otherwise protected against damage, and isolated so that any breakage or failure of such an item would not create a hazard (see also **G5—2,** 2.2.1 and 5.1.2 for requirements covering portions of fuel systems in compartments).

9.2.2 In all compartments (smoking and non-smoking alike) no material shall be used in a form in which it burns readily, and the materials of all fittings and furnishings, the covering of all upholstery, the wall, floor and ceiling linings and any lagging, shall be such as not to propagate fire beyond the immediate neighbourhood of ignition.

NOTES: (1) It is strongly recommended that the material used should be such that it will not propagate combustion even when subjected to a major fuel fire.

(2) Suitable methods of flame-resistance testing are available on application to the Authority.

9.2.3 Receptacles for used towels, papers and waste shall be constructed of materials resistant to fire. The receptacles shall incorporate covers or other provisions for containing a fire in the receptacle.

9.2.4 Removable ash containers shall be provided to give adequate service in compartments where smoking is permitted.

9.2.5 Indicators, operable by the crew and visible from each passenger seat, shall be provided in all compartments where smoking is permitted to indicate when smoking is prohibited.

9.2.6 Placards shall be placed in all compartments where smoking is not permitted, including all baggage and cargo compartments, stating that smoking is prohibited.

9.3 Compartments in which a potential fire hazard exists which are inaccessible or unoccupied in flight, including all cargo and baggage compartments, shall either:—

(a) be constructed of, and contain, only such materials and equipment as will not propagate combustion when subject to a minor fire, or

(b) be equipped with fire detecting, indicating and extinguishing apparatus.

NOTE: Where it can be demonstrated that the presence of fire will be made known immediately, then fire detecting and indicating devices may be omitted.

9.3.1 Instructions for the use of extinguishing apparatus fitted in compliance with this requirement shall be placarded at the appropriate crew-member's station.

10 PRESSURIZATION SYSTEMS The requirements for pressurization systems shall be agreed with the Authority.

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APPENDIX TO CHAPTER G4—3

Issued, 20th January, 1975

WATER SYSTEMS

1 CONTAMINATION (see G4—3, 8.1)

1.1 There should be no distinction between water supplies for drinking and ablutions.

1.2 The tanks should be accessible for the purposes of inspection, cleansing and the introduction of additives in solid or liquid form.

1.3 The tanks should have a removable plate so that the interior surfaces can be seen and cleansed.

1.4 Each tank should have a service draining point through which it can be flushed and completely emptied.

1.5 Filters should not be fitted in any interior water system.

1.6 The filling point should be so situated and designed that foreign matter cannot enter during the process of refilling.

1.7 Tanks should be lagged to prevent the water temperature rising to such an extent as to favour the growth of organisms.

2 DISCHARGE (see G4—3, 8.2) Where there is otherwise any possibility of the water freezing as lumps or icicles on the outside of the rotorcraft, water should be discharged clear of the rotorcraft.

SUB-SECTION G4—DESIGN AND CONSTRUCTION

CHAPTER G4—4 SEATS, SAFETY BELTS AND HARNESSES

Revised, 7th November, 1975

A.B 1 INTRODUCTION This Chapter prescribes detailed requirements related to seats, to safety belts and harnesses, and to the restraint of occupants in normal and emergency conditions.

NOTE: Suitable methods of testing seats to establish compliance with the strength requirements of this Chapter are contained in CAA Airworthiness Division Specification No. 3, 'Tests for Seats with Safety Belts Attached', which is obtainable on request from the CAA, Airworthiness Division, Brabazon House, Redhill, Surrey, RH1 1SQ.

2 SEATS AND ADJACENT ACCOMMODATION

2.1 Types

2.1.1 This paragraph **2** applies to seats, and, so far as its provisions are applicable, to all parts of the rotorcraft forming the passenger accommodation adjacent to the seat.

2.1.2 Seats shall be of Approved types.

NOTE: An Approved seat is one of a type individually approved by the Authority or is one certified as suitable for a particular rotorcraft type by an Approved Design Organisation (Aircraft). In the former case "an Approved Organisation" supervising the installation is responsible for selecting seats the forms and certified strengths of which are appropriate to the particular installation.

2.2 **Design** (see **G4—4** App., **1**)

2.2.1 Seats shall be of a form such as to fulfil the duty for which they are installed, and to provide, as far as possible, the maximum safety in emergency conditions for the occupants and other persons thrown against the seats. In particular, there shall be no hard edges or excrescences in a position likely to cause head injuries to the occupants of the rotorcraft in emergency conditions. The design of seats shall be such that in emergency conditions they are unlikely to trap or injure the legs of the occupants or other persons (e.g. a seat of unsuitable design might cause unnecessary risk of injury to the legs of a person seated behind).

NOTE: On rotorcraft where two pilots' stations are provided, and where inertia-reel harnesses with locking mechanisms are installed, it is recommended that the means of operating both harness locking and seat adjusting mechanisms are fitted on the inboard side of each pilot seat.

A.B 2.2.2 Seats facing aft shall have suitable backs and head-rests to assist in the safe restraint of the occupants in emergency conditions. (See **G4—4** App., 1.2).

2.2.3 Side-facing seats shall be arranged so that not more than two occupants can lean against any third in Crash Landing conditions up to the accelerations prescribed in **G3—8, 2.** (See **G4—4** App., 1.4).

NOTE: This requirement assumes that the only means of restraint is a seat belt.

2.2.4 Adjustable, folding or rotatable seats shall be designed so that when locked they will not move under loads occurring in the stipulated loading conditions. The locking mechanisms of adjustable and folding seats shall be such as to lock automatically when released.

2.2.5 Any cushions, etc., designed for use with seats occupied by members of the flight crew on duty, shall be suitably secured in position so that it is impossible for them to move and in any way interfere with the use of the controls or with the normal free movement of the flight crew. The pilot's seat together with its upholstery shall be such as to react the loads applied to it by the pilot without deflecting to an extent that would prejudice his use of the controls. The pilot effort loads of **G3—6** apply in this case.

A.B

2.2.6 Seats not approved for occupation during take-off and landing need not be fitted with safety belts or harnesses to meet the Crash Landing conditions of **G3—8** but they shall be so designed and located as not to provide a source of danger in these circumstances.

2.3 **Strength**

2.3.1 The weight of each occupant is assumed to be 77 kg (170 lb) for design purposes; in addition allowance shall be made for the weight of the seat including any equipment which will be carried on it.

2.3.2 All seats, other than seats not approved for occupation during take-off and landing, shall, both whilst occupied and unoccupied, comply with the strength requirements for the rotorcraft as a whole as prescribed in **G3—2, G3—5** and **G3—8.**

2.3.3 Seats not approved for occupation during take-off and landing shall comply with the above requirements when unoccupied and shall be strong enough to withstand such loads as their form permits them to receive when occupied in the conditions of **G3—2.**

2.3.4 Due allowance shall be made for the loads taken by safety belts or harnesses as prescribed in **3.**

2.3.5 The seat local attachments shall achieve a factor of 1·33 on the accelerations prescribed in **G3—8, 2.**

2.4 **Installation.** The installation of the seats shall, as far as possible, be such as not unduly to restrict access to any part of the cabin in flight or emergency conditions. In particular they shall not obstruct access to, or use of, any essential or emergency equipment or exits.

3 SAFETY BELTS AND HARNESSES

3.1 **Applicability.** The requirements of this paragraph **3** apply to safety belts and harnesses provided in accordance with **G6—1.** An additional requirement is included, applicable to safety belts and harnesses intended for use by the Authority's pilots during test flights.

3.2 **Approval.** Safety belts and harnesses shall be of Approved types.

NOTE: An "Approved type" of safety belt or harness is one complying with a specification approved by the Authority. Acceptable specifications* for safety belts and safety harnesses can be obtained on request from the Civil Aviation Authority, Airworthiness Division, Brabazon House, Redhill, Surrey, RH1 1SQ.

3.3 **Strength**

3.3.1 The minimum strength acceptable for safety belts and harnesses is prescribed in 3.5.1(a). In well-designed accommodation, however, considerably greater crash protection is given by stronger restraints. The strength of stronger installations may be certified in terms of the *g* against which they provide restraint.

3.3.2 Local attachments restraining the occupants shall achieve a factor of 1·33 on the accelerations of **G3—8, 2.**

*Airworthiness Division Specification No. 1, Safety Belts, and Airworthiness Division Specification No. 4, Safety Harnesses.

A.B 3.4 **Strength Assumptions**

3.4.1 The wearer of the safety belt or harness shall be assumed to weigh 77 kg (170 lb).

3.4.2 Assumptions regarding the load distribution on, and the geometry of, the safety belt or harness shall be reasonably conservative. No relief shall be assumed from muscular forces.

3.4.3 In the case of safety harnesses similar in form to those in the Specification obtained from the Authority, assumptions shall be in accordance with 3.4.4 and 3.4.5. Alternative assumptions shall be laid down in any other specifications submitted for approval.

3.4.4 It shall be assumed that the prescribed upward load may be applied (a) by the thighs only, (b) by the shoulders only unless it can be clearly shown that such load distribution cannot be achieved.

3.4.5 The minimum range of forward load distribution which shall be considered is:—

(a) 100% of the forward load applied to the belt, and

(b) 60% of the forward load applied to the belt and 40% to the shoulder straps.

3.5 **Installation**

3.5.1 **General**

(a) Bearing in mind the geometry of the installation, the safety belt or harness and its local attachments shall retain the factors of at least 1·0 and 1·33 respectively based on the certified strength when, in conjunction with the seat, it is restraining the wearer against the accelerations of **G3—8, 2.**

(b) The certified strength which is required for each member of a safety belt or harness shall be stated on the drawings relating to its installation.

NOTE: A safety belt or harness is regarded as being divisible into various members (e.g. left thigh strap, right thigh strap, release mechanism, etc.) which are liable to be detached from one another for purposes of storage or replacement.

(c) It is acceptable, in certain cases, to make provision for relaxing the upper restraints of a safety harness to enable the wearer to increase his reach or field of view, but if this is done, it shall be possible for the wearer to re-secure them without difficulty. (See **G4—2, 4**).

(d) Where there is a risk that a safety belt or harness might, when not in use, foul the controls or impede the crew, suitable stowage shall be provided.

3.5.2 **Safety Belts.** (See **G4—4** App., **2**). The belt shall be installed in accordance with the approved specification; in the case of belts conforming to the Specification obtained from the Authority, the belt, when worn, shall lie across the groins of the wearer. The belt when so worn shall lie in a plane which is approximately at 45° to the plane of the longitudinal and lateral axes of the rotorcraft.

NOTE: When designing accommodation incorporating a safety belt it is important to ensure that the occupant, if pivoting forward about the belt under the conditions of 3.5.1 (a), will not be liable to come into contact with potentially dangerous objects.

3.5.3 **Safety Harnesses.** The harness shall be installed in accordance with the approved specification, and when correctly adjusted to the wearer—

(a) the straps or belts shall remain in position irrespective of variation of load,

(b) the upper part of the torso shall be restrained sufficiently to ensure that the wearer's head and trunk are safeguarded, under the conditions of 3.5.1(a), from contact with potentially dangerous objects.

A.B 3.6 **Authority's Pilots.** The Authority may require its test pilots to wear parachutes when piloting rotorcraft undergoing airworthiness flight tests. In such cases the pilot's seat(s) and the safety belt or harness or the pilot's seat(s) of a rotorcraft submitted for flight tests shall be suitable for use when a parachute is worn.

SUB-SECTION G4—DESIGN AND CONSTRUCTION

CHAPTER G4—4 SEATS, SAFETY BELTS AND HARNESSES

Revised, 7th November, 1975

A.B 1 INTRODUCTION This Chapter prescribes detailed requirements related to seats, to safety belts and harnesses, and to the restraint of occupants in normal and emergency conditions.

NOTE: Suitable methods of testing seats to establish compliance with the strength requirements of this Chapter are contained in CAA Airworthiness Division Specification No. 3, 'Tests for Seats with Safety Belts Attached', which is obtainable on request from the CAA, Airworthiness Division, Brabazon House, Redhill, Surrey, RH1 1SQ.

2 SEATS AND ADJACENT ACCOMMODATION

2.1 Types

2.1.1 This paragraph **2** applies to seats, and, so far as its provisions are applicable, to all parts of the rotorcraft forming the passenger accommodation adjacent to the seat.

2.1.2 Seats shall be of Approved types.

NOTE: An Approved seat is one of a type individually approved by the Authority or is one certified as suitable for a particular rotorcraft type by an Approved Design Organisation (Aircraft). In the former case "an Approved Organisation" supervising the installation is responsible for selecting seats the forms and certified strengths of which are appropriate to the particular installation.

2.2 **Design** (see **G4—4** App., **1**)

2.2.1 Seats shall be of a form such as to fulfil the duty for which they are installed, and to provide, as far as possible, the maximum safety in emergency conditions for the occupants and other persons thrown against the seats. In particular, there shall be no hard edges or excrescences in a position likely to cause head injuries to the occupants of the rotorcraft in emergency conditions. The design of seats shall be such that in emergency conditions they are unlikely to trap or injure the legs of the occupants or other persons (e.g. a seat of unsuitable design might cause unnecessary risk of injury to the legs of a person seated behind).

NOTE: On rotorcraft where two pilots' stations are provided, and where inertia-reel harnesses with locking mechanisms are installed, it is recommended that the means of operating both harness locking and seat adjusting mechanisms are fitted on the inboard side of each pilot seat.

A.B 2.2.2 Seats facing aft shall have suitable backs and head-rests to assist in the safe restraint of the occupants in emergency conditions. (See **G4—4** App., 1.2).

2.2.3 Side-facing seats shall be arranged so that not more than two occupants can lean against any third in Crash Landing conditions up to the accelerations prescribed in **G3—8, 2.** (See **G4—4** App., 1.4).

NOTE: This requirement assumes that the only means of restraint is a seat belt.

2.2.4 Adjustable, folding or rotatable seats shall be designed so that when locked they will not move under loads occurring in the stipulated loading conditions. The locking mechanisms of adjustable and folding seats shall be such as to lock automatically when released.

2.2.5 Any cushions, etc., designed for use with seats occupied by members of the flight crew on duty, shall be suitably secured in position so that it is impossible for them to move and in any way interfere with the use of the controls or with the normal free movement of the flight crew. The pilot's seat together with its upholstery shall be such as to react the loads applied to it by the pilot without deflecting to an extent that would prejudice his use of the controls. The pilot effort loads of **G3—6** apply in this case.

A.B

2.2.6 Seats not approved for occupation during take-off and landing need not be fitted with safety belts or harnesses to meet the Crash Landing conditions of **G3—8** but they shall be so designed and located as not to provide a source of danger in these circumstances.

2.3 **Strength**

2.3.1 The weight of each occupant is assumed to be 77 kg (170 lb) for design purposes; in addition allowance shall be made for the weight of the seat including any equipment which will be carried on it.

2.3.2 All seats, other than seats not approved for occupation during take-off and landing, shall, both whilst occupied and unoccupied, comply with the strength requirements for the rotorcraft as a whole as prescribed in **G3—2, G3—5** and **G3—8.**

2.3.3 Seats not approved for occupation during take-off and landing shall comply with the above requirements when unoccupied and shall be strong enough to withstand such loads as their form permits them to receive when occupied in the conditions of **G3—2.**

2.3.4 Due allowance shall be made for the loads taken by safety belts or harnesses as prescribed in **3.**

2.3.5 The seat local attachments shall achieve a factor of 1·33 on the accelerations prescribed in **G3—8, 2.**

2.4 **Installation.** The installation of the seats shall, as far as possible, be such as not unduly to restrict access to any part of the cabin in flight or emergency conditions. In particular they shall not obstruct access to, or use of, any essential or emergency equipment or exits.

3 SAFETY BELTS AND HARNESSES

3.1 **Applicability.** The requirements of this paragraph **3** apply to safety belts and harnesses provided in accordance with **G6—1.** An additional requirement is included, applicable to safety belts and harnesses intended for use by the Authority's pilots during test flights.

3.2 **Approval.** Safety belts and harnesses shall be of Approved types.

NOTE: An "Approved type" of safety belt or harness is one complying with a specification approved by the Authority. Acceptable specifications* for safety belts and safety harnesses can be obtained on request from the Civil Aviation Authority, Airworthiness Division, Brabazon House, Redhill, Surrey, RH1 1SQ.

3.3 **Strength**

3.3.1 The minimum strength acceptable for safety belts and harnesses is prescribed in 3.5.1(a). In well-designed accommodation, however, considerably greater crash protection is given by stronger restraints. The strength of stronger installations may be certified in terms of the *g* against which they provide restraint.

3.3.2 Local attachments restraining the occupants shall achieve a factor of 1·33 on the accelerations of **G3—8, 2.**

*Airworthiness Division Specification No. 1, Safety Belts, and Airworthiness Division Specification No. 4, Safety Harnesses.

A.B 3.4 **Strength Assumptions**

3.4.1 The wearer of the safety belt or harness shall be assumed to weigh 77 kg (170 lb).

3.4.2 Assumptions regarding the load distribution on, and the geometry of, the safety belt or harness shall be reasonably conservative. No relief shall be assumed from muscular forces.

3.4.3 In the case of safety harnesses similar in form to those in the Specification obtained from the Authority, assumptions shall be in accordance with 3.4.4 and 3.4.5. Alternative assumptions shall be laid down in any other specifications submitted for approval.

3.4.4 It shall be assumed that the prescribed upward load may be applied (a) by the thighs only, (b) by the shoulders only unless it can be clearly shown that such load distribution cannot be achieved.

3.4.5 The minimum range of forward load distribution which shall be considered is:—

(a) 100% of the forward load applied to the belt, and

(b) 60% of the forward load applied to the belt and 40% to the shoulder straps.

3.5 **Installation**

3.5.1 **General**

(a) Bearing in mind the geometry of the installation, the safety belt or harness and its local attachments shall retain the factors of at least 1·0 and 1·33 respectively based on the certified strength when, in conjunction with the seat, it is restraining the wearer against the accelerations of **G3—8, 2.**

(b) The certified strength which is required for each member of a safety belt or harness shall be stated on the drawings relating to its installation.

NOTE: A safety belt or harness is regarded as being divisible into various members (e.g. left thigh strap, right thigh strap, release mechanism, etc.) which are liable to be detached from one another for purposes of storage or replacement.

(c) It is acceptable, in certain cases, to make provision for relaxing the upper restraints of a safety harness to enable the wearer to increase his reach or field of view, but if this is done, it shall be possible for the wearer to re-secure them without difficulty. (See **G4—2, 4**).

(d) Where there is a risk that a safety belt or harness might, when not in use, foul the controls or impede the crew, suitable stowage shall be provided.

3.5.2 **Safety Belts.** (See **G4—4** App., **2**). The belt shall be installed in accordance with the approved specification; in the case of belts conforming to the Specification obtained from the Authority, the belt, when worn, shall lie across the groins of the wearer. The belt when so worn shall lie in a plane which is approximately at 45° to the plane of the longitudinal and lateral axes of the rotorcraft.

NOTE: When designing accommodation incorporating a safety belt it is important to ensure that the occupant, if pivoting forward about the belt under the conditions of 3.5.1 (a), will not be liable to come into contact with potentially dangerous objects.

3.5.3 **Safety Harnesses.** The harness shall be installed in accordance with the approved specification, and when correctly adjusted to the wearer—

(a) the straps or belts shall remain in position irrespective of variation of load,

(b) the upper part of the torso shall be restrained sufficiently to ensure that the wearer's head and trunk are safeguarded, under the conditions of 3.5.1(a), from contact with potentially dangerous objects.

A,B 3.6 **Authority's Pilots.** The Authority may require its test pilots to wear parachutes when piloting rotorcraft undergoing airworthiness flight tests. In such cases the pilot's seat(s) and the safety belt or harness or the pilot's seat(s) of a rotorcraft submitted for flight tests shall be suitable for use when a parachute is worn.

APPENDIX TO CHAPTER G4—4

Revised, 7th November, 1975

SEATS AND SAFETY BELTS—ACCEPTABLE PRACTICE

I 1 DESIGN OF SEATS (see G4—4, 2.2)

1.1 **General**

1.1.1 It is recommended that seats should be designed with a view to absorbing as much energy as possible before total failure in a Crash Landing.

1.1.2 Attention is drawn to the fact that the strength prescribed in **G4—4,** 2.3 only caters for airworthiness and thus caters for flight and ground cases, and Crash Landing cases up to the accelerations prescribed in **G3—8, 2.** In meeting such cases sufficient robustness for general handling and usage in service will not necessarily be provided. It is recommended that such extra robustness should be provided. In particular, consideration should be given to the case of a heavy occupant pulling himself up by applying a sudden heavy load to the top of the back of the seat in front.

1.1.3 It is recommended that pilots' seats should be designed so that possible long term injurious effects to health, as a result of incorrect posture and vibration, are reduced to a minimum.

1.2 **Aft-facing Seats** (see **G4—4,** 2.2.2)

1.2.1 For general use the highest point of the seat back or head-rest should be not less than 915 mm (36 in) above the deflected seating surface when occupied by a 77 kg (170 lb) person.

1.2.2 The head-rest of an aft-facing seat should be designed to support adequately the occupant's head against the maximum sideways acceleration of **G3—8** which can be associated with the forward acceleration.

1.3 **Forward-facing Seats**

1.3.1 In emergency conditions sharp edges or excrescences on the seats or parts of the passenger accommodation might prove a source of danger not only to the occupants of the seats but particularly to the occupants seated to the rear. Attention should be paid, therefore, to the passenger accommodation and to those areas of a seat back lying within the arc of travel of the head of an occupant seated to the rear and restrained by a safety belt.

1.3.2 The radius of the arc of travel, representing the extremity of the occupant's head should be taken as 710 mm (28 in). This allows for tall occupants and stretch in the safety belt. The centre of the radius of the arc of travel should be taken as 460 mm (18 in) forward and upward of the junction of the seat back and bottom at 35° to the latter (see Fig. 1 (G4—4 App.)).

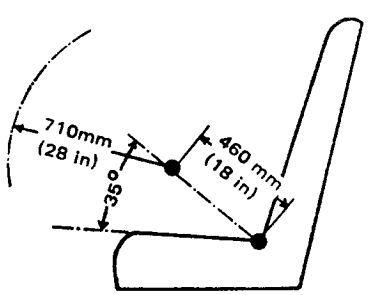


Fig. 1 (G4—4 App.)

1.3.3 Within these areas, all surfaces should be smooth and either flat or of large radius.

1.3.4 If the top of the seat back occurs within the arc of travel of the head, it should be padded to at least 25 mm (1 in) radius, with at least 12·5 mm (0·5 in) of firm felt or balsa (or their equivalent) as well as any normal soft upholstery padding.

1.3.5 Any substantially horizontal members other than seat backs occurring within the areas defined by 1.3.2 should either be padded as recommended in 1.3.4 or should be so arranged that the head will be deflected past them rather than strike them a direct blow. (The arrangement suggested in the latter alternative may be provided by a smooth covering of the seat back using plywood, metal or fibre sheet underneath the finishing material). The tops of vertical members occurring within these areas should be so protected as to be at least as safe as horizontal members. No member should occur where it might be struck by the throat.

1.3.6 It is recommended that seat backs should be pivoted so as to move forward under Crash Landing conditions so that the occupant of the seat behind only strikes a glancing blow on the seat back.

1.4 **Side-facing Seats** (see **G4—4,** 2.2.3). In installing side-facing seats, so that not more than two occupants lean against a third in Crash Landing conditions up to the accelerations prescribed in **G3—8, 2,** either the safety belt attachment points should be suitably spaced or a bulkhead should be provided between each three occupants.

2 INSTALLATION OF SAFETY BELTS (see G4—4, 3.5.2) Safety belts should be so installed that they are released by operating the means of release from left to right.

SUB-SECTION G4—DESIGN AND CONSTRUCTION

CHAPTER G4—5 LANDING GEAR DESIGN

Revised in part, 17th December, 1980

A.B 1 INTRODUCTION This Chapter prescribes requirements for the design and construction of landing gear and for wheel brakes. The Authority may waive some of the requirements in the case of auxiliary wheel units if it is clear that incorrect functioning or failure to function of such units would not be dangerous.

NOTE: See also G2—7, 2.4.

2 GENERAL The design of the landing gear shall be such that undesirable or dangerous resonant frequencies with the Rotor System are avoided. Compliance shall be demonstrated by ground tests at rotor speeds up to Rotor Maximum RPM (Power On).

3 ENERGY ABSORPTION (see G4—5 App., 1)

3.1 **Limit Case.** The design of each unit of the landing gear shall be such that it is able to absorb without permanent deformation the energy equivalent to a vertical velocity of descent at touch down:—

(a) for single-engined rotorcraft, 2·6 m/sec (8·5 ft/sec), or the maximum probable vertical velocity of descent likely to occur at ground contact in a normal power-off landing if less, but not less than 2·0 m/sec (6·5 ft/sec).

(b) for multi-engined rotorcraft 2·0 m/sec (6·5 ft/sec).

3.2 **Ultimate Case.** The design of the landing gear shall be such that it is able to absorb 150% of the energy of 3.1, without failure.

4 RETRACTABLE LANDING GEAR

4.1 **Operating Conditions**

4.1.1 It shall be possible to retract and extend the landing gear satisfactorily under the most adverse flight conditions occurring throughout a range of:—

(a) **Airspeeds.** From zero to the Landing Gear Operating Speed (V_{LO}).

(b) **Accelerations.** From 0·8g to 1·3g.

NOTE: See G2—2, 5.7.

4.1.2 Where other than manual operation of the landing gear is employed the mechanism shall be such that if the movement of the landing gear is arrested, during retraction or extension, by transient accelerations outside the limits of 4.1.1 (a) and (b), it shall recommence automatically and move to completion as soon as the acceleration conditions are again within the limits.

NOTE: See G4—8, 3.

4.2 **Securing of Landing Gear.** Reliable automatic means shall be provided to secure the landing gear in the correct landing position. Reliable means shall also be provided to secure the landing gear and its doors in the correct retracted position, unless it is established that inadvertent movement of the landing gear or doors from that position in flight, over the full range of speeds up to V_{DF}, would not adversely affect the safe operation of the rotorcraft.

A.B 4.3 **Position Indicators** (see **G4—5** App., **2**). Means shall be provided, easily visible to the pilot or appropriate members of the flight crew, to show when each retractable unit of the landing gear is:—

(a) secured in the correct extended position, and

(b) secured in the correct retracted position.

4.4 **Emergency Operation.** Where other than manual operation of the landing gear is employed, emergency means of extending and securing the landing gear in the correct extended position shall be provided. The means provided shall be capable of operating the landing gear in the event of any Reasonably Probable Failure in the normal system, including the failure of any single source of hydraulic, electric or equivalent energy.

4.5 **Strength Conditions**

4.5.1 When the landing gear and its doors are secured in the retracted position, they shall comply with the flight-strength requirements prescribed in G3 for the rotorcraft as a whole.

4.5.2 When the landing gear is locked in the extended position, it shall comply with the ground-load requirements, and with the flight-strength requirements up to the Landing Gear Operating Speed, V_{LO} prescribed in G3 for the rotorcraft as a whole.

4.5.3 The operating mechanism of the landing gear and its supporting structure, together with the landing gear doors, their operating mechanism and supporting structure, shall have sufficient strength to withstand possible combinations of loads resulting from (a), (b), (c) in all landing gear positions.

(a) All air speeds within the limits of 4.1.1 (a).

(b) The manoeuvring and gust conditions of **G3—2, 1, 2** and **3.**

(c) The loads imposed by the power source of the operating mechanism.

4.6 **Tests.** Proper and safe functioning of both normal and emergency landing gear operating mechanism shall be established, to the satisfaction of the Authority, by rig testing and by flight, landing and taxying tests on the complete rotorcraft.

5 WHEELS It shall be demonstrated that all wheels have adequate strength under the loads prescribed in **G3—5.**

6 TYRES Tyres shall be such that, when fitted to the rotorcraft wheels and inflated to the recommended pressures, they will be capable of withstanding the loading and temperature conditions which would be likely to be encountered during the permitted operation of the rotorcraft.

7 WHEEL BRAKES

7.1 **General**

7.1.1 Wheel brakes shall be installed on the main wheels of all rotorcraft with wheeled landing gear, and shall be usable during all landings, including power-off landings. They shall also be capable of counteracting any normal unbalanced torque during starting and stopping the rotor(s).

A.B 7.1.2 Brakes shall be suitably protected from the ingress of any foreign matter (e.g. water, dirt or oil) which might interfere with their satisfactory functioning.

7.1.3 **Parking Brake Force.** The braking force shall be sufficient to keep the rotorcraft stationary on a slope of 1 in 6.

7.2 **Controls.** Operation of the brake controls shall not prejudice ability to manipulate other controls.

7.3 **Tests**

7.3.1 Prototype brake installations shall be tested over the full range of operating pressure during ground handling, landing and take-off as necessary to demonstrate the satisfactory functioning and behaviour of the brake installation, and of the rotorcraft when braked.

7.3.2 Series brake installations shall be tested to a schedule agreed by the Authority.

8 TAIL GUARDS If in any normal landing attitude, the possibility exists that main structural components (e.g. tail rotor, tail surfaces) may otherwise be damaged by contact with the ground, a tail skid or guard shall be provided. The strength requirements for such guards shall be agreed with the Authority.

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APPENDIX TO CHAPTER G4—5

Revised in part, 17th December, 1980

LANDING GEAR DESIGN

I ENERGY ABSORPTION (see G4—5, 3) Compliance with the requirement of G4—5, 3 may be established by the use of drop tests as described in 1.1 and 1.2.

1.1 Limit Case

1.1.1 **Rotor Lift.** For the purposes of the limit drop test it may be assumed that a rotor lift of not more than two-thirds of the weight of the rotorcraft is acting through the c.g. of the rotorcraft.

1.1.2 **Attitude.** Each landing gear unit should be tested in the attitude simulating the landing condition most critical from the standpoint of its energy absorption characteristics.

1.1.3 **Equivalent Mass.** Where an equivalent mass is used to show compliance, the following formulae may be used:—

$$We = W\left[\frac{h + (1-L)d}{(h + d)}\right]; \text{ and}$$

$$n = \frac{nj\ We}{W} + L$$

Where, We ..... lb ..... is the weight of the equivalent mass to be used in the drop test.

W ..... lbf ..... is (a) For main units, equal to W_M, the static reaction on the particular main unit with the rotorcraft in the most critical attitude.

(b) For nose units, equal to W_N, the vertical component of the static reaction that would exist at the nose wheel, assuming that the mass of the rotorcraft acts at the centre of gravity and exerts a force equivalent to 1·0 g downward and 0·25 g forward.

(c) For tail units, equal to W_T, equal to whichever of the following is critical—

(i) the static weight on the tail wheel with the rotorcraft resting on all wheels; or

(ii) the vertical component of the ground reaction that would occur at the tail wheel assuming that the mass of the rotorcraft acts at the centre of gravity and exerts a force equivalent to 1·0 g downwards with the rotorcraft in the maximum nose up attitude considered in the nose up landing condition.

h ..... is free drop height equivalent to that required to give the required vertical velocity of descent at touch-down.

L ..... is ratio of assumed rotor lift to the rotorcraft weight.

d ..... is deflection under impact of the tyre (at the correct inflation pressure) plus the vertical component of the axle travel relative to the drop mass.

n ..... is limit inertia load factor.

nj ..... is load factor developed during impact on the mass used in the drop test (i.e. the acceleration, expressed in terms of g, recorded in the drop test plus 1·0).

1.2 **Ultimate Case.** In the ultimate case the free drop height should be not less than 1·5 times the free drop height for the limit case. The lift in the rotors should not be greater than 1·5 times the lift assumed in the limit case.

2 POSITION INDICATORS (see G4—5, 4.3) An acceptable means of complying with the requirement of **G4—5,** 4.3 is as follows.

2.1 Indicators easily visible to the pilot or appropriate members of the flight crew should be provided for each retractable unit of the landing gear, and be arranged so that:—

(a) A green lamp is alight only when:—

(i) the unit is secured in the correct landing position, and

(ii) where it can be easily overlooked, the landing gear selector is in the landing position.

(b) A red lamp is alight at all times other than:—

(i) when the conditions of (a) are fulfilled, and

(ii) when the unit, its doors and its selector are in the correct retracted position.

SUB-SECTION G4—DESIGN AND CONSTRUCTION

CHAPTER G4—6 ELECTRICAL BONDING AND LIGHTNING DISCHARGE PROTECTION

Issued, 7th November, 1975

A.B

1 INTRODUCTION This Chapter prescribes requirements and its Appendices give recommended practices relating to the subjects described in 1.1 and 1.2.

1.1 The protection of the rotorcraft against lightning discharges.

1.2 The electrical bonding of the rotorcraft structure, components and equipment in order:—

(a) to prevent dangerous accumulation of electrostatic charges,

(b) to minimize the possibility of electric shock from the electricity supply and distribution system,

(c) to provide an adequate electrical return path on rotorcraft having earthed electrical systems*,

(d) to prevent electrical interference with the functioning of Essential Services or Essential Systems (e.g. radio communications and navigational aids), and

(e) to prevent deterioration of structural strength and fatigue characteristics, and to prevent deformation, particularly of composite material structures (see **G4—6** App. No. 1, **7**).

2 PRIMARY AND SECONDARY CONDUCTORS (see G4—6 App. No. 1, 5) For the purposes of this Chapter, Primary Conductors shall be those conductors which are required to carry lightning discharge currents, and Secondary Conductors shall be those conductors provided for other forms of bonding.

2.1 The cross-sectional area of Primary Conductors made from copper shall be not less than 3 mm^2 (0·0045 in^2) e.g. 0·25 inch by 26 s.w.g., except that where a single conductor is likely to carry the whole discharge from an isolated section, the cross-sectional area shall be not less than 6 mm^2 (0·009 in^2) e.g. 0·5 inch by 26 s.w.g. Aluminium Primary Conductors shall have a cross-sectional area giving an equivalent surge carrying capacity.

2.2 Primary Conductors shall be used for:—

(a) Connecting together the main earths of separable major components, (including gear boxes and transmission systems) which may carry lightning discharges.

(b) Connecting engines to the main earth (see **5**).

(c) Connecting to the main earth all metal parts presenting a surface on, or outside of, the external surface of the rotorcraft (see 3.1.2).

2.3 The electrical impedance of Primary Conductors to a lightning discharge shall be as low as is practicable.

*Section J, Chapter J3—3, 5 also prescribes requirements for the earthing of electrical systems.

A.B

2.4 The cross-sectional area of Secondary Conductors made from copper shall be not less than 1 mm^2 (0·0015 in^2). Where a single wire is used its diameter shall be not less than 1·2 mm (18 s.w.g.).

3 PROTECTION AGAINST LIGHTNING DISCHARGES (see G4—6 App. No. 1, 1, 3 and 7)

3.1 The rotorcraft shall be provided with means to conduct lightning strikes effectively, the characteristics of which are described in **G4—6** App. No. 1, so that the rotorcraft or its occupants will not be endangered. The means provided shall be such as to:—

(a) minimize damage to the rotorcraft structure or components,

(b) prevent the passage of such electrical currents as will cause dangerous malfunctioning of the rotorcraft or its systems and equipment, and

(c) prevent the occurrence of high potential differences within the rotorcraft.

NOTE: Guidance is given in **G4—6** App. No. 1, 3 as to the likelihood of a lightning strike at any particular location. Testing may be required to ensure that the requirements of 3.1 are satisfied. (See **G4—6** App. No. 1, 7.2).

3.1.1 **General.** Compliance with 3.1 shall be established by the provision of an electrically conducting cage in accordance with 3.1.4 (a), (b) or (c) as applicable. This cage shall constitute, or be electrically connected to, the main earth system.

3.1.2 **External Metal Parts**

(a) External metal parts shall either be:—

(i) electrically bonded to the main earth system by Primary Conductors, or

(ii) so designed and/or protected that a lightning discharge to the part (e.g. a radio aerial or pitot head) will cause only local damage which will not endanger the rotorcraft or its occupants.

(b) In addition to (a), where internal linkages are connected to external parts (e.g. rotor blades), the linkages shall be bonded by Primary Conductors, as close as is practical to the external part.

(c) Where a Primary Conductor is fitted across an operating jack (e.g. in control systems) it shall be of such an impedance and so designed as to limit to a safe value the passage of current through the jack.

NOTE: In considering external metal parts, consideration should be given to all flight configurations (e.g. lowering of landing gear) and also the possibility of damage to the rotorcraft electrical system due to surges caused by strikes to protuberances (such as pitot heads) which have connections into the electrical system.

3.1.3 **External Non-metallic Parts** (see also **G4—6** App. No. 1, **2**)

(a) External non-metallic parts shall be so designed and installed that:—

(i) they are provided with effective lightning diverters which will safely carry the lightning discharges described in **G4—6** App. No. 1, or

(ii) damage to them by lightning discharges will not endanger the rotorcraft or its occupants, or

(iii) the probability of a lightning strike on the insulated portion is Extremely Improbable because of the shielding afforded by other portions of the rotorcraft.

(b) Where lightning diverters are used the surge carrying capacity and mechanical robustness of associated conductors shall be at least equal to that required for Primary Conductors.

A.B

3.1.4 **Electrically Conducting Cage**

(a) **Rotorcraft of Metallic Construction.** In general the skin of an all-metal rotorcraft will be accepted as adequate to meet the requirements of 3.1.1 provided that the method of construction is such that it produces satisfactory electrical contact at joints.

NOTE: An electrical contact with a resistance less than 0·05 ohm will be considered as satisfactory.

(b) **Rotorcraft of Non-metallic Construction** (see **G4—6** App. No. 1, **4**)

(i) The cage shall consist of metallic conductors the surge carrying capacity and mechanical robustness of which are at least equal to that required for Primary Conductors. The conductors shall be as straight as practicable, and where changes of direction are unavoidable, sharp curves shall be avoided.

(ii) All metal parts shall be bonded to the cage with Primary Conductors as appropriate.

NOTE: Guidance on the likelihood of a lightning strike at any particular location, and hence the need to bond, is given in **G4—6** App. No. 1, **3.**

(c) **Rotorcraft of Composite Construction** (see **G4—6** App. No. 1, **4**). Where component parts of a rotorcraft are of non-metallic construction, protection shall be provided, as appropriate. If the protection is in the form of a cage, this shall meet the relevant requirements of 3.1.4 (b). When designing such protection the possible effects outlined in **G4—6** App. No. 1, **7** shall be taken into account.

3.2 **Rotor Blade and Control Surface Hinges and Bearings**

3.2.1 All rotor blade and control surface hinges and bearings shall either:—

(a) be of a type that is capable of withstanding a lightning discharge without dangerous damage or seizure, or

(b) be provided with at least one Primary Conductor across each bearing or hinge.

3.2.2 Where bonding conductors are provided in accordance with 3.2.1 (b) they shall be as flexible and as short and of as low an impedance as possible and shall not be tinned. Precautions shall be taken to prevent the possibility of their jamming the hinge or bearing.

4 PROTECTION OF FUEL SYSTEM (see G4—6 App. No. 1, 8)

4.1 The fuel storage system of the rotorcraft shall either be so situated that it is most unlikely to be struck by lightning or shall be so protected that in the event of it being struck by lightning a Catastrophic Effect is not likely to occur.

4.2 The outlets of venting and jettisoning systems shall be so located and designed that:—

(a) the probability of them being struck by lightning is Extremely Remote,

(b) they will not under any atmospheric conditions which the rotorcraft may encounter produce corona discharges of such magnitudes as will ignite any fuel/air mixtures of the ratios likely to be present,

(c) the fuel and its vapours in Flammable concentrations will not pass close to parts of the rotorcraft which will produce corona discharges capable of igniting fuel/air mixtures.

NOTE: (b) and (c) can most effectively be achieved by diluting the fuel/air mixture to a safe level before it leaves the vent pipe.

A.B

4.3 The fuel system of the rotorcraft shall be so designed in relation to the main earth system that the passage of lightning discharges through the main earth system will not produce, by the processes of conduction or induction, such potential differences as will cause electrical sparking through areas where there may be Flammable vapours.

5 ENGINES AND ENGINE MOUNTINGS Where the engine is not in direct electrical contact with its mounting the engine shall be electrically connected to the main earth system by at least two removable Primary Conductors, one on each side of the engine.

6 PROTECTION AGAINST THE ACCUMULATION OF STATIC CHARGES (see G4—6 App. No. 1, 7)

6.1 **Bonding to Main Earth Systems.** All items, which by the accumulation and discharge of static charges may cause a danger of electric shock, ignition of Flammable vapours, or interference with Essential Equipment and Essential Systems (e.g. radio communications, navigational aids, control systems) shall be adequately bonded to the main earth systems.

NOTE: See 7 for resistance values appropriate to various forms of bonding.

6.2 **Intermittent Contact.** The design of the rotorcraft shall be such as to ensure that no fortuitous intermittent contact can occur between metallic and/or metallized parts.

6.3 **Grounding of Main Earth System.** The main earth system shall be connected to ground automatically when the rotorcraft is on the ground. The resistance between the main earth system and the ground, when the rotorcraft is at rest, shall not exceed 10 megohms.

NOTE: The resistance should be measured between the main earth system and a metal plate on which the earthing means (e.g. tyre) is resting.

6.4 **Filling Points.** It shall readily be possible to bond refuelling equipment, including the refuelling nozzle, to the rotorcraft and to make the bonding connection before the filler cap is removed. The effectiveness of the bonding connection shall be independent of the particular type of refuelling equipment being used.

6.5 **Pressure Refuelling Systems.** (See also **G4—6** App. No. 1, **6**). Where provision is made for pressure refuelling it shall be established, by test, or by consultation with the appropriate fuel manufacturers that dangerously high voltages will not be induced within the fuel tank(s). If compliance with this requirement involves any restriction on the types of fuel to be used, the rate of refuelling or the use of additives, this shall be stated in the Flight Manual and placarded at the refuelling point.

7 ESSENTIAL RADIO/NAVIGATION EQUIPMENT The requirements of this paragraph 7 are applicable to the installation of essential radio/navigation equipment in rotorcraft.

NOTES: (1) In the case of rotorcraft fitted with essential radio/navigation receiving or transmitting apparatus an additional reason for bonding is to provide an earth system of low resistance and maximum self-capacity for the efficient operation of the radio/navigation equipment.

(2) See also **Section R,** Radio.

7.1 The metal frame and mounting structure carrying each radio/navigation unit shall be bonded to the main earth by at least one Primary Conductor or its equivalent.

A.B

7.2 Within a radius of 2·5 m (8 ft) of any unscreened radio/navigation transmitting equipment or its aerial lead, any long electrically conducting parts (including metallic pipe lines, metal braiding and conduit) which are not insulated from earth, shall be electrically bonded to the main earth system.

7.3 Provision shall be made for the bonding of all radio/navigation transmitting and receiving apparatus to the main earth by means of one or more Primary Conductors, or their equivalent. In the case of rotorcraft of non-metallic or composite construction, the main bonding strips shall be connected together near these points with Primary Conductors.

8 RESISTANCE AND CONTINUITY MEASUREMENTS (see also G4—6 App. No. 2)

The rotorcraft constructor shall prepare and submit to the Authority a schedule for resistance and continuity measurements. The measurements shall also be made on all series rotorcraft.

APPENDIX NO. 1 TO CHAPTER G4—6

Issued, 7th November, 1975

ELECTRICAL BONDING AND LIGHTNING DISCHARGE PROTECTION

1 ELECTRICAL CHARACTERISTICS OF LIGHTNING DISCHARGES (see G4—6, 3)

In the absence of better information the data contained in this paragraph **1** should be used for the purpose of assessing the adequacy of lightning discharge protection of rotorcraft.

TABLE 1 (G4—6 App. No. 1)

Charger transfer	Maximum Normal	600 coulombs 50 to 200 coulombs
Peak current	Maximum Normal	500 kA Approx. 50 kA
Duration of flash	Maximum	2 seconds
Duration of peak current	about 25 microseconds to half peak value, critically damped	

NOTES: (1) The duration of flash may be made up of a number of discharges.

(2) For the purposes of test or assessment, a discharge current having two components (as in Table 2 (G4—6 App. No. 1)) may be taken as being equivalent to a lightning strike from the aspects of heating and disruptive forces.

TABLE 2 (G4—6 App. No. 1)

Component	Peak Current (kA)	Duration	Charge transfer (coulombs)
1	200	To peak value in 15 microseconds decaying to 50 kA in 30 micro-seconds from initiation	4
2	0·5	1 second rectangular wave	500

2 THE PROTECTION OF EXTERNAL NON-METALLIC PARTS (see G4—6, 3.1.3)

2.1 Where non-metallic parts are fitted externally to the rotorcraft in situations where they may be exposed to lightning discharges (e.g. radomes or rotors) the risks include:—

(a) the disruption of the materials because of rapid expansion of gases within them (e.g. water vapour),

(b) the rapid build up of pressure in the enclosures provided by the parts resulting in mechanical disruption of the parts themselves or of the structure enclosed by them, and

(c) fire caused by the ignition of the materials themselves or of the materials contained within the enclosures.

2.2 The materials used should have low water absorption characteristics, should not occlude gases, and should be of high dielectric strength in order to encourage surface flash-over rather than puncture. Laminates made entirely from solid material are preferable to those incorporating laminations of cellular material.

2.3 Those external non-metallic parts which are classified as Primary Structure should be protected by Primary Conductors.

2.4 Where damage to an external non-metallic part which is not classified as Primary Structure may endanger the rotorcraft, the part should be protected by adequate lightning diverters.

2.5 In some cases (e.g. radomes or rotors) confirmatory tests may be required to check the adequacy of the lightning protection provided.

3 AREAS VULNERABLE TO LIGHTNING STRIKES (see G4—6, 3)

3.1 Based on aeroplane experience and limited rotorcraft experience, the following areas are considered most likely to need protection from direct strikes:—

(a) the main rotor blades,

(b) auxiliary rotors or tail extremities extending outside the main rotor area,

(c) within 0·5 m (18 in) of any sharp edge which is likely to form a point of attachment for lightning strikes,

(d) unprotected projections (e.g. nose of rotorcraft, end of skid tubes), and

(e) any other projecting part which may constitute a point of attachment.

3.2 Additionally there is a possibility of strokes being swept rearward from such points of direct stroke attachment as are given in 3.1. Therefore, if a hazard, which could have a Catastrophic Effect could result from such swept strokes, the areas extending 0·5 m (18 in) laterally to each side of fore and aft lines passing through these points should also have adequate protection.

3.3 Guidance on the most vulnerable areas for a particular rotorcraft configuration may be obtained by simulated lightning strike tests on a model rotorcraft.

4 MAIN EARTH SYSTEMS FOR ROTORCRAFT OF NON-METALLIC OR COMPOSITE CONSTRUCTION (see G4—6, 3.1.4 (b) and (c))

4.1 Fuselage

4.1.1 Four or more conductors, extending the whole length of the fuselage, should be provided. The number and disposition of these conductors should be such that they are not more than 1·83 m (6 ft) apart as measured round the periphery of the fuselage at the position of greatest cross-sectional area. The conductors should be placed on or near the outer skin at approximately equal intervals and joined together at their ends in the manner described in 5.1.

4.1.2 The conductors described in 4.1.1 should be interconnected by similar conductors at positions corresponding to the terminals provided for interconnecting the Rotor and fuselage main earth systems and intermediately at intervals not exceeding 6 m (20 ft).

4.2 **Rotors and Aerodynamic Surfaces.** Conductors, extending from root to tip, should be provided in accordance with Table 3 (G4—6 App. No. 1). The blade or surface root end of each conductor should be connected to the fuselage main earth system, and the outboard ends should be connected in the manner described in 4.4. The strips should be transversely interconnected by similar strips at intervals not exceeding 6 m (20 ft).

TABLE 3 (G4—6 App. No. 1)

Rotor Blade or Aerodynamic Surface Root Chord (metres)	Minimum Number of Conductors	Approximate position
Less than 0·5	1	Located so as to provide adequate protection.
0·5 to 2·5	2	At leading edge and trailing edge.
2·5 to 4·5	3	At leading edge, trailing edge and mid chord.

4.3 **Vertical Tail Surfaces.** A conductor should be provided at the leading edge and at the trailing edge of the vertical tail surface.

4.4 **Lightning Strike Plates.** Lightning strike plates, extending round the edge of each extremity of each rotor blade and aerodynamic surface, and round the nose and tail of the fuselage, should be provided on the exterior of the rotorcraft structure except where existing metallic structure can serve the same purpose. The strike plates may be covered with dope, fabric, paint, etc., if desired. Each strike plate should consist of a strip of copper of not less than 25 mm width × 0·45 mm thickness (1 inch width × 26 s.w.g.) or other material of equivalent surge current capacity and mechanical robustness; the plate should be of sufficient length to extend on both sides to a distance of 610 mm (24 in) as measured from the outer extremity, and should form the means of joining together the ends of the main earth conductors at these extremities.

5 PRIMARY CONDUCTORS (see G4—6, 2)

5.1 The joints detailed in this paragraph 5.1 are acceptable as parts of the Primary Conductors.

5.1.1 Provided that all insulating finishes are removed from the contact area before assembly, metal-to-metal joints held together by threaded devices, riveted joints, structural wires under appreciable tension, and bolted and clamped fittings.

NOTE: A surface anodised in accordance with Specification DEF.151 is an almost perfect insulator for a portential difference of less than 130 volts, but the surface is readily broken by the rotation of a bolt head or the forming of a rivet. In these latter cases it is unnecessary to remove the anodic finish. However, when two anodised parts are clamped together without any relative motion being involved, the anodised surface should be removed over an area strictly limited to that necessary to ensure efficient electrical contact, and the assembly coated with a suitable protective material such as a jointing compound containing barium chromate.

5.1.2 Most cowl fasteners, locking and latching mechanisms, metal-to-metal hinges for doors and panels and metal-to-metal bearings, provided that the current path is of sufficiently low impedance.

6 ELECTROSTATIC VOLTAGE INDUCED DURING PRESSURE REFUELLING (see G4—6, 6.5)

6.1 With standard refuelling equipment and standard aircraft turbine fuels, voltages high enough to cause sparking may be induced between the surface of the fuel and the metal parts of the tank at refuelling rates above approximately 1136 litres/min (250 gals/min). These induced voltages may be increased by the presence of additives and contaminations (e.g. anti-corrosion inhibitors, lubricating oil, free water), and by splashing or spraying of the fuel in the tank.

6.2 The static charge can be reduced in the following ways:—

(a) by measures taken in the refuelling equipment such as increasing the diameter of refuelling lines and designing filters to give the minimum of electrostatic charging,

(b) by changing the electrical properties of the fuel by the use of anti-static additives and thus reducing the accumulation of static charge in the tank to a negligible amount, and

(c) by filling each tank from the bottom.

6.3 The critical refuelling rates are related to the rotorcraft refuelling installations, and the designer should seek the advice of fuel suppliers on this problem.

7 THE USE OF NON-METALLIC MATERIALS RELATIVE TO ATMOSPHERIC ELECTRICAL HAZARDS (see G4—6, 1.2 (e), 3 and 6)

7.1 Some of the materials used and possible effects on the rotorcraft and its systems are considered in this paragraph 7.1.

7.1.1 **Non-conducting Materials such as Fibre Glass or All-plastic Honeycomb.** Mechanical damage may be caused to such materials by the passage through them of a lightning strike, with possible resultant effects upon the airframe and on other systems (see also **2**). Loss of the intrinsic screening otherwise provided by a metal airframe should also be considered and the possible interference, by lightning strikes or static discharges with, for example, critical control systems taken into account.

7.1.2 **Composite Materials such as Metal-skinned Plastic Honeycomb or Plastic-skinned Metal Honeycomb.** Effects similar to those in 7.1.1, depending upon the materials used and their location.

7.1.3 **Carbon (or Boron) Fibre-reinforced Plastics.** Effects similar to those described in 7.1.1 with, in addition, possible severe degradation of the mechanical strength of the material if it is used in such a way as to make it possible for the conducting fibres to carry lightning currents. Present evidence indicates that, in such cases, the material must be protected by a suitable conducting cage.

7.1.4 **Paint Finishes.** Certain paints are particularly good electrical insulators and experience has shown that an appreciable static build up can occur with resultant interference with rotorcraft systems. There are also indications that such paint finishes can affect the path and restrike locations of swept lightning strokes.

7.2 **Tests** (see **G4—6,** 3.1). Where non-metallic materials are used in such a manner that damage to them from lightning strikes may hazard the rotorcraft, it may be necessary to make high voltage/current tests to give confidence that no hazard will arise. Close attention will be needed both in the design of the airframe and of the systems to ensure that electrical interference effects are minimized. Where appropriate, tests may be necessary to ensure that these design aims have been satisfied.

8 PROTECTION OF FUEL TANKS (see G4—6, 4)

8.1 **Integral Tanks.** In order to avoid the risk of lightning discharge to fuel tanks the surfaces of which are effectively part of the external surface of the rotorcraft, the following precautions should be observed:—

(a) Fuel should not be stored in the leading or trailing edges of such items as stub wings and sponsons, or in the extremities of the fuselage.

(b) Fuel should not be stored within 0·5 m (18 in) of the tips of stub wings, etc.

(c) The exposed external surfaces of the tanks should be free of sharp projections, edges or small radii.

8.2 **External Tanks**

8.2.1 **Metal Tanks.** The following precautions as appropriate should be taken:—

(a) Measures should be taken to prevent explosive mixtures from occurring within the tank, or

(b) It should be established that an explosion occurring within the tank would not cause a Catastrophic Effect, or

(c) Where exposed to lightning strikes, the tank wall thickness should be not less than 2 mm (0·08 in). Additionally, the exposed extremities of pod tanks should not contain fuel. The exposed external surfaces of the tanks should be smooth, or

(d) The exposed ends of pod tanks should not contain fuel and the tanks should be fitted with adequate lightning diverters. In such cases the walls of the tank should be not less than 1 mm (0·04 in) thick.

8.2.2 **Non-metallic Tanks.** The exposed ends of pod tanks should not contain fuel and the external surfaces of the tank should be protected by lightning diverters at least to the standard required for non-metallic rotorcraft. (See **G4—6,** 3.1.4 (b)). The inside of the tank should be kept as free as possible of metal work and such metal work should be bonded by primary conductors to the main earth system of the rotorcraft. The internal bonding system should be so designed and arranged in relation to the lightning diverters that it will not constitute a path for the discharge in the case of the tank being struck by lightning.

APPENDIX No. 2 TO CHAPTER G4—6

Issued, 7th November, 1975

RESISTANCE AND CONTINUITY MEASUREMENT

I SCHEDULE OF RESISTANCE AND CONTINUITY MEASUREMENTS (see G4—6, 8)

The schedule prepared in accordance with **G4—6, 8** should contain the data prescribed in 1.1 to 1.3.

1.1 A description of the measuring apparatus to be used with a statement of the accuracy which is claimed for the equipment.

1.2 A description of the method, or methods, to be employed for attachment of the test apparatus to the rotorcraft and its equipment.

NOTE: Where the type of apparatus employed and/or its method of attachment produces test values in excess of those given in Table 1 (G4—6 App. No. 2) and Table 2 (G4—6 App. No. 2), the background evidence to show the acceptability of such methods should be given.

1.3 A detailed list of all points on the rotorcraft, including its equipment, for which measurements are required and for each set of measurements the maximum acceptable resistance. Measurements are required to determine the efficacy of bonding and connection between at least, (a) to (g) of 1.3.1 and 1.3.2.

1.3.1 **Primary Bonding.** Typical resistance values for primary bonding are given in Table 1 (G4—6 App. No. 2).

(a) the extremities of the fixed portions of the rotorcraft,

(b) the fixed structure and removable external panels,

(c) the fixed structure and fixed external panels where the method of construction and/or assembly leads to doubt as to the repeatability of the bond,

(d) the engines and the main rotorcraft earth,

(e) the extremities of metal rotor blades or other moveable external surfaces and the main rotorcraft earth,

(f) the bonding conductors of non-metallic rotor blades or other moveable external surfaces and the main rotorcraft earth, and

(g) internal components for which a Primary Bond is specified and the main rotorcraft earth.

1.3.2 **Secondary Bonding.** Typical resistance values for secondary bonding are given in Table 2 (G4—6 App. No. 2).

(a) Metallic parts, normally in contact with Flammable fluids, and the main rotorcraft earth.

(b) Isolated conducting parts subject to appreciable electrostatic charging and the main rotorcraft earth.

(c) Electrical panels and other equipment, accessible to the occupants of the rotorcraft, and the main rotorcraft earth, to avoid the danger of electrical shock from circuits of 50 volts (RMS or d.c.) or more.

(d) Earth connections, which normally carry the main electrical supply, and the main rotorcraft earth. (See also **Section J,** Chapter **J3—3, 5**).

(e) Electrical and electronic equipment and the rotorcraft main earth, where applicable, and as specified by the rotorcraft constructor.

(f) Static discharger wicks and the main rotorcraft structure.

(g) The main rotorcraft earth system and ground, measured when the rotorcraft is at rest.

2 MEASUREMENT OF ELECTRICAL RESISTANCE AND CONTINUITY (see G4—6, 8)

2.1 Several methods of measuring low values of resistance are available, but the following three methods are commonly used:—

2.1.1 A bonding tester with integral battery and indicator with voltage and current coils.

NOTE: This instrument is normally supplied with connection leads and prods.

2.1.2 A double bridge milliohmmeter method using a current of not less than 10 amperes in the bond.

NOTE: Joints should be made using bolted connections.

2.1.3 Ammeter-voltmeter method using calibrated ammeter and voltmeter and bolted connections or a combination of bolted connections and prods.

2.2 Large variations, up to approximately an order of difference, in measured results can be obtained, when measuring the same resistance, depending on the test equipment and connections used. Table 1 (G4—6 App. No. 2) and Table 2 (G4—6 App. No. 2) which are based on the use of bolted connections, give guidance on the values of resistance which experience has shown to give satisfactory results. Where other methods of attachment are used, which produce higher resistance values, these may be acceptable subject to evidence of their satisfactory use.

TABLE 1 (G4—6 App. No. 2)

PRIMARY BONDING

G4—6 App. No. 2 Paragraph No.	Condition	Maximum Resistance Using Bolted Connections (Milliohms)
1.3.1 (a), (b) and (c)	Between extremities of the fixed portions of the rotorcraft and between fixed panels and components as specified	1 for light alloy 10 for stainless steel
1.3.1 (d)	Between engines and rotorcraft earth	1 for light alloy 10 for stainless steel
1.3.1 (e)	Between external components and rotorcraft earth	5 for light alloy 10 for stainless steel
1.3.1 (f)	Between conductors on external non-metallic parts and rotorcraft earth	5
1.3.1 (g)	Between internally mounted primary bonded components and rotorcraft earth	2

TABLE 2 (G4—6 App. No. 2)

SECONDARY BONDING

G4—6 App. No. 2 Paragraph No.	Condition	Maximum Resistance Using Suitable Test Equipment (Milli-ohms unless otherwise stated)
1.3.2 (a)	Between metallic parts normally in contact with Flammable fluids and rotorcraft earth	10 for light alloy 100 for stainless steel
1.3.2 (b)	Between isolated conducting parts subject to appreciable electrostatic charging and rotor-craft earth	0·5 Megohm or not exceeding 10^5 Ohm/square surface resist-ivity for non-conducting surfaces in contact with the metal air-frame
1.3.2 (c)	For the avoidance of electrical shock from equipment which carries 50 volt (RMS or DC) or more	500
1.3.2 (d)	Main electrical gear connections	50mV drop for normal currents
1.3.2 (e)	Between electrical and electronic equipment and rotorcraft earth	Where applicable to be specified by the rotorcraft constructor
1.3.2 (f)	Between static discharger wicks and structure	1000
1.3.2 (g)	Between rotorcraft earth and ground	10 Megohms

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SUB-SECTION G4—DESIGN AND CONSTRUCTION

CHAPTER G4—8 CONTROL SYSTEM DESIGN

Issued, 20th January,* 1975

A.B 1 GENERAL

1.1 Control systems shall be capable of operation with sufficient ease, smoothness, and positiveness to permit the proper performance of their function, and shall be so arranged and identified:—

(a) to provide satisfactory convenience in operation, and

(b) to prevent the possibility of confusion and inadvertent operation.

1.2 Where practicable, the sense of motion involved in the operation of all controls shall correspond with the sense of the response either of the rotorcraft or, if the rotorcraft response is relatively unimportant, of the part operated.

NOTE: Specific directional movement of particular controls is prescribed elsewhere in the Requirements, e.g. 2.3.2 for primary flight controls; G5—7 for Power-plant controls.

1.3 The design and location of operating controls shall be such as to minimize the risk of inadvertent operation either by personnel entering or leaving the rotorcraft or by the flight crew during normal movement in the flight-crew accommodation.

1.4 Control systems shall be designed so that they function satisfactorily under the extremes of temperature and humidity which are likely to be encountered in flight or on the ground.

1.5 In the case of control systems incorporating cables, the designer shall declare the tension at which the cables are to be rigged on the ground to avoid undue slackness under all likely extremes of temperature and humidity. Proper allowance shall be made in the design of the system for such a degree of tension.

1.6 Operating controls intended for operation by the pilot during take-off, approach and landing and during discontinued approach and balked landing shall be arranged so that their operation during these manoeuvres does not necessitate the pilot having to change hands on the cyclic pitch control.

1.7 Essential Services and their control systems shall be so designed that when a movement to one position has been selected, a different position can be selected without having to wait for completion of the initially selected movement. It shall not be necessary for the pilot to follow other than a normal control sequence in selecting the new position. Following this selection, the service being operated shall start to move to the finally selected position without further action by the flight crew. The movement(s) which follow and the time taken shall not be such as to affect adversely the airworthiness of the rotorcraft.

1.8 The co-ordination of the controls essential to the safe operation of the rotorcraft shall not require undue skill.

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*The marginal line rule in the Foreword 4.2 has not been applied to this Chapter. The material not marginally lined was previously contained in G4—2.

A.B 1.9 Operating controls other than those which when in use are under constant supervision (e.g. primary flight controls) shall maintain any chosen setting without subsequent attention by the flight crew and shall not tend to creep under control loads or vibration.

NOTE: The fitting of a suitable adjustable friction device is an acceptable method of meeting this requirement.

1.10 (See **G4—8** App., **1** and **4**). All control systems and operating controls shall be designed and installed so as to prevent:—

(a) Jamming; chafing; interference by passengers, cargo or loose objects. This requirement shall be met with controls normally adjusted and with such slackening of cables as may occur and, where tensioning devices are incorporated, in the event of such malfunctioning or failure of the tensioning device as may occur.

(b) Slapping of chains, cables or tubes against parts of the rotorcraft.

Compliance with these requirements shall be demonstrated by suitable tests (see 2.3.6 for functioning tests on primary flight controls).

1.11 (See **G4—8** App., **1** and **4**). Pulleys and sprockets shall be guarded so as to prevent any cable or chain jamming or coming off when slack.

1.12 The range of blade pitch angle, motion of the control surfaces and other pilot's controls, shall be limited by stops. These stops shall be capable of withstanding the loads corresponding to the design conditions for the control system prescribed in **G3—6**. Motions resulting from flexibility, beyond the limits established by the stops, shall be kept to a minimum.

1.13 (See also **G4—8** App., **2**). Control systems shall be designed so as to minimize the risk of incorrect assembly.

2 FLIGHT CONTROLS (see G4—8 App., 1 and 3)

2.1 The primary flight control system (see 2.3.1), together with the trimming control system shall be such that the likelihood of Failure (including disconnection) of any element which could result in a dangerous measure of control being applied or lost at any speed up to V_{NO} is predicted to be:—

A (a) Extremely Improbable.

B (b) Extremely Remote.

A.B NOTE: The failure or disconnection of certain parts need not be assumed if their integrity, taking into account their properties and working conditions, is such as to provide an equivalent level of safety to that implied in the requirement.

2.2 The design of single vital control elements shall be such as to minimize the risk of failure and of disconnection due to incorrect assembly.

2.3 **Primary Flight Controls**

2.3.1 **Definition.** Primary flight controls are defined as those used by the pilot for the immediate control of the pitch, roll, yaw, climb and descent of the rotorcraft.

2.3.2 **Sense of Movement.** When the primary flight controls consist of a cyclic control stick in front of each pilot a collective pitch lever at the side of each pilot (see 2.3.4 (b)) and a pair of rudder pedals for each pilot, they shall operate as follows:—

(a) A forward displacement of the cyclic control stick to cause the rotorcraft to pitch nose down and/or produce forward movement of the rotorcraft.

(b) A displacement of the cyclic control stick towards the right to cause the rotorcraft to bank right hand down, and/or produce movement in the starboard direction.

A.B

(c) A forward displacement of the right hand rudder pedal to cause the rotorcraft to turn to the right.

(d) An upward displacement of the collective pitch lever to cause the rotorcraft to climb.

2.3.3 **Control System Locks.** Where a device is carried in the rotorcraft for locking a primary flight control while the rotorcraft is on the ground or water, the locking device shall be installed so that while it is engaged it will provide to the pilot an unmistakeable warning which it is impossible for him to ignore. Means shall be provided to preclude the possibility of the lock becoming engaged during flight.

2.3.4 **Location**

(a) The primary flight controls shall be so located with respect to any propellers that no portion of the flight crew or the controls, excluding cables and control rods, lies in the region between the plane of rotation of any propeller and the surfaces generated by a line passing through the centre of the propeller hub and making an angle of 5° forward and aft of the plane of rotation of the propeller.

(b) The operating control(s) for collective pitch shall be located at the left hand side of the pilot(s).

2.3.5 **Static Friction** (see also **G4—8** App., **5**). The design of the primary flight control system shall ensure that the static friction in the system has no material adverse effect on the stability and control characteristics necessary to comply with Sub-section G2.

2.3.6 **Tests.** A functioning test shall be conducted on the control system by operating the controls from the flight crew compartment with the entire system loaded to provide 80% of the control system limit loads at the pilot's control. During this test there shall be no unintentional jamming, excessive friction or excessive deflection.

NOTE: Particular attention should be given to any swash plate or control spider assembly.

2.3.7 **Power Operation.** Proposals for power-operated primary flight controls for rotors or other control surfaces shall be submitted to the Authority at an early stage in design. The system shall be such that the probability of a Catastrophic Effect due to a Failure in the system or total loss of engine power is predicted to be:—

A (a) Extremely Improbable.

B (b) Extremely Remote.

A.B 3 RETRACTABLE LANDING GEAR CONTROLS (see also G4—8 App., 6)

3.1 **Operating Control.** On other than manually operated systems one movement of one operating control shall be sufficient to initiate and complete the retraction or extension of the landing gear, under the conditions prescribed in Chapter **G4—5, 2.**

NOTE: The tripping of a simple safety catch on the control itself would not be regarded as a "movement of control".

3.2 **Emergency System.** The emergency system shall be such that, when the appropriate actions for extending the landing gear by the emergency method are correctly performed, the extension will then proceed to completion irrespective of any actions, correct or incorrect, which may have been carried out with the normal control (see also **G4—5, 2**).

APPENDIX TO CHAPTER G4—8

Issued, 20th January, 1975

CONTROL SYSTEM DESIGN

1 GENERAL (see G4—8, 1.10 and 1.11)

1.1 **Flexible Wire Ropes.** The design of installations incorporating flexible wire ropes should be such that the following main causes of failure and premature fraying of the ropes are avoided:—

(a) Fatigue arising from bending the rope over pulleys which are too small in diameter.

(b) Fatigue arising from increased stress concentrations caused by local reductions of wire area as a result of wires rubbing against wires within the rope and thus wearing local grooves in one another.

NOTE: This usually occurs where a rope passes over a pulley and it is a function of pulley diameter and intensity of steady load.

(c) Pulleys situated so as to necessitate reverse bends in ropes such that during control surface movements the same part of the rope traverses more than one pulley.

(d) A layout resulting in too small an angle of wrap.

NOTE: Experience shows that early failure occurs if the rope is not kept firmly in contact with the pulley.

(e) Wear resulting from poor cable and pulley alignment, from an incorrectly proportioned pulley groove, and from vibration of ropes.

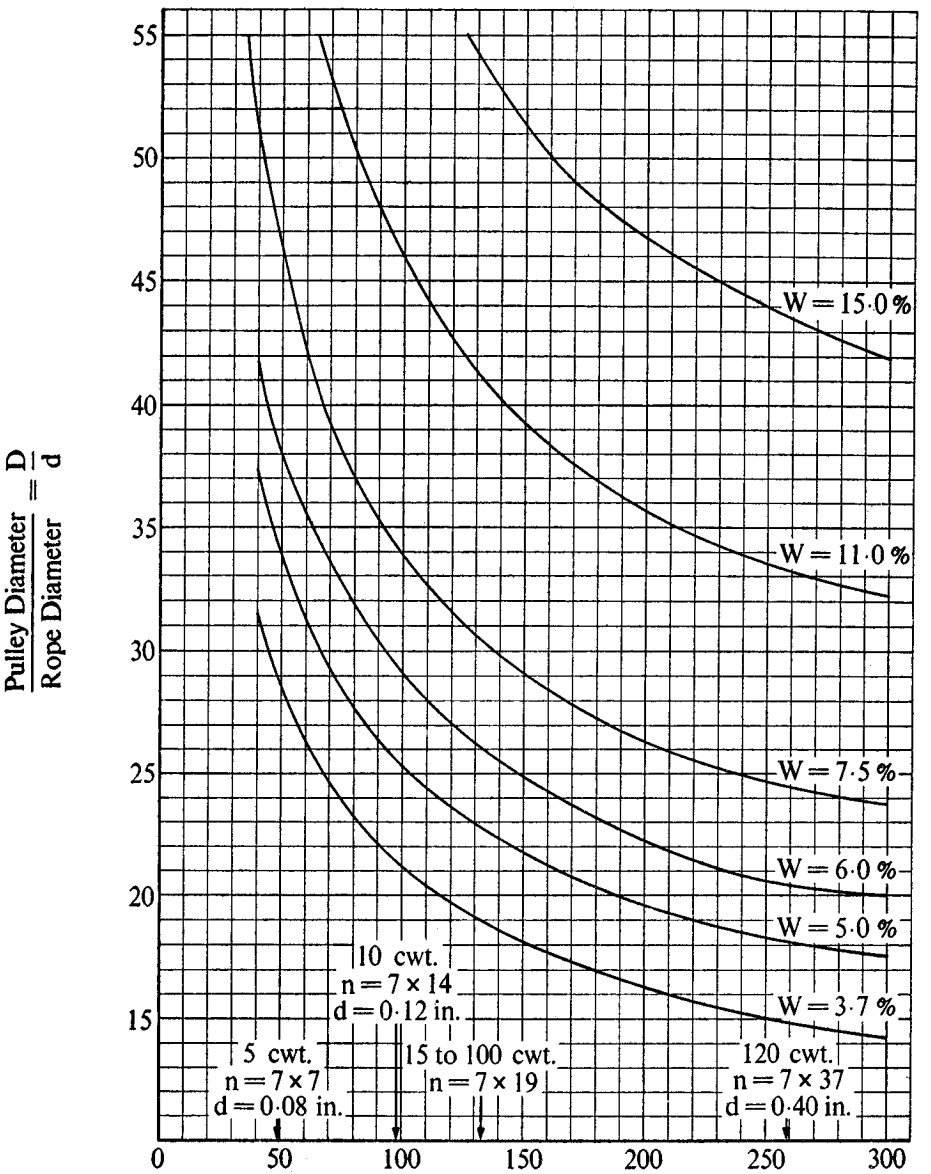
1.2 **Pulleys.** For pre-formed carbon steel wire rope to BS 2W9, the pulley diameter* measured at the bottom of the groove, should be at least as large as indicated by Fig. 1 (G4—8 App.).

(a) For conventional control systems the average value of W (see Fig. 1 (G4—8 App.)) has been found to be of the order of 2% to 6% and although Fig. 1 (G4—8 App.) is valid for values of W between 3·7% and 15%, it is nevertheless recommended that, in the absence of more reliable data, a value of at least 6% should be assumed for design purposes.

(b) The section at the bottom of the rope groove should be a circular arc over an angle of not less than 120°. The radius of the groove should be 7·5% larger than the nominal radius of the rope.

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*It is emphasised that these diameters are a recommended minimum; longer rope life is to be expected from larger pulleys.



RECOMMENDED MINIMUM PULLEY SIZES

Fig. 1 (G4—8 App.)

NOTE: W = rigging tension plus average hinge moment load expressed as a percentage of the nominal breaking strength of the rope.

2 INCORRECT ASSEMBLY (see G4—8, 1.13)

2.1 In meeting the requirement of **G4—8,** 1.13, the recommendations of 2.2 should be applied to all control systems, irrespective of the type of system (mechanical, electrical, hydraulic, etc.) except those which,

(a) if assembled incorrectly are unlikely to prejudice the safe operation of the rotorcraft,

(b) are operated before take-off can be commenced, in such a way that incorrect assembly would be obvious.

NOTE: Such operation before take-off does not include special "drills" but only those operations which must, of necessity, be made before a take-off.

2.2 Each such control should be so designed and constructed that, at all reasonably possible break-down points in the system, it is mechanically impossible to:—

(a) assemble the system to be disastrously out of phase or to assemble the system so that it operates in the reverse sense, or

(b) interconnect two systems where this is not intended.

2.3 All other controls, the faulty operation of which might affect the continued safe operation of the rotorcraft, should be so designed and constructed as to be mechanically difficult to misconnect or so that misconnection is obvious from the appearance of the system.

3 FAILURE OR DISCONNECTION OF ANY ELEMENT (see G4—8, 2)

3.1 For the assumption that a part will not fail or become disconnected to be acceptable, the design should be such that no failure or disconnection of the part could be foreseen under any practical circumstances including errors in operation, assembly or maintenance. Some of the considerations which should be taken into account in designing these parts are:—

(a) Choice of materials to avoid undue notch sensitivity, undue tendency to stress corrosion cracking and corrosion and its effects.

(b) Provision of sufficient robustness for all "handling" loads likely to occur, including those resulting from errors in operation, assembly or maintenance.

(c) Avoidance of design features tending to produce fatigue effects, such as, abrupt changes of section, natural periods of vibration of parts coincident with those induced by engines, transmissions, rotors or aerodynamic effects.

3.2 Where any part which it is assumed will not fail or become disconnected is a bolt, pivot or other connecting device it should either:—

(a) be an acceptable permanently locked (e.g. bench riveted with adequate dimensional control) connection, never broken down when assembled in the rotorcraft, or

(b) be provided with secondary means of retention such that once the item is placed in position, the secondary retaining device becomes automatically effective in preventing it from dropping out of position even though the usual retaining device may have been omitted. This secondary device should be automatic in operation and should not depend upon personnel remembering to carry out a separate action such as the bending of locking tabs or the fitting of locking wire.

NOTES: (1) It is recommended that the design of the system should avoid the use of such connecting devices.

(2) Secondary means of retention which depend upon friction or springs can usually be accepted.

4 FREEDOM FROM JAMMING (see G4—8, 1.10 and 1.11)

4.1 The design of the system should be such that jamming is unlikely to result from the incorrect fitting of connecting bolts or pins, e.g. in the opposite direction from that shown on the drawings. If jamming could occur with incorrect fitting of a bolt or pin, the design should be such that it is mechanically impossible to fit the bolt or pin other than as shown on the drawings.

4.2 Any connecting bolt or pin, the loss of which would not result in a Catastrophic Effect, by reason of leaving a control disconnected, should not cause jamming of the control whilst it is in the process of working out of position.

4.3 A control run to which 4.2 can be applied, should not become jammed as a result of the disconnected portions of the control circuit becoming caught on adjacent structure, etc., after they have become disconnected.

4.4 A survey should be made of the control circuits to ensure that so far as can be foreseen, loose tools, nuts and rivets, etc., are unlikely to cause jamming of the controls. Common examples of design predisposing towards trouble in this respect are:—

(a) Control mechanism running too close to flooring or other horizontal surfaces liable to act as a catchment area for loose items. Ends of levers working in either sump-like depressions or fairings also come within this category.

(b) Holes and slots in flooring, control consoles, etc., and structure and brackets being in such a location that items falling through or from them would be directed into parts of the control system.

(c) Multiple levers mounted on a common spindle; levers with lightening holes.

(d) Chains working over sprockets with horizontal pivots. (Experience indicates that such chains act as catchments for rivets, small screws, etc., which jam in the sprocket teeth.)

(e) Insufficient clearance between gears and casings or between gears running at different speeds.

(f) Pulleys and cable drums such that small screws, etc., can fall in and jam against guards.

4.5 The design of control circuits should be assessed from the point of view of whether or not accumulations of water in or on any part are likely to freeze and cause jamming. Particular attention should be paid to components in parts of the rotorcraft which could be contaminated by the water systems of the rotorcraft in normal or fault conditions; if necessary such components should be shielded.

5 FRICTION IN CONTROL SYSTEMS (see G4—8, 2.3.5) It is recommended that the forces on the controls necessary to overcome static friction, with rotors turning at normal operating speeds, should not exceed the values given in Table 1 (G4—8 App.). In the case of systems incorporating cables, this recommendation should be met with the cables rigged at the maximum and minimum limits of the declared tensions.

TABLE 1 (G4—8 App.)

Maximum Weight of Rotorcraft	Maximum Static Friction Force on Control			
	Longitudinal Cyclic Pitch	Lateral Cyclic Pitch	Collective Pitch	Rudder Pedal
5700 kg or less	15 N (3·3 lbf)	10 N (2·2 lbf)	20 N (4·4 lbf)	20 N (4·4 lbf)
Above 5700 kg	20 N (4·4 lbf)	15 N (3·3 lbf)	30 N (6·6 lbf)	30 N (6·6 lbf)

NOTE: For rotorcraft with powered controls, irrespective of weight, the above figures applicable to a weight above 5700 kg may be doubled when the source of power has failed.

6 DIRECTION OF MOVEMENT OF RETRACTABLE LANDING GEAR CONTROLS (see G4—8, 3) Landing gear controls should move downwards to extend the landing gear and should move upwards to retract the landing gear.

SUB-SECTION G4—DESIGN AND CONSTRUCTION

CHAPTER G4—9 ROTOR AND TRANSMISSION SYSTEMS

Revised in part, 7th November, 1975*

A.B

1 FUNCTIONING The Rotor and Transmission Systems shall function satisfactorily over the full range of conditions for which certification is sought.

2 ARRANGEMENT

2.1 The Transmission System shall be so arranged that the Rotor System will continue to function satisfactorily after the failure of all Power-units.

2.1.1 The Transmission System shall incorporate a free wheel for each Power-unit which will automatically disengage the Power-unit from the Rotor System to prevent it from driving the Power-unit. The free wheel shall be so located that failure of any component not part of the Rotor System cannot affect its continued operation.

2.2 The Transmission System of a multi-engined rotorcraft shall be so arranged that, in the event of failure of one or more Power-units, power from the operating Power-units will be supplied to enable the satisfactory functioning of Rotors and other units necessary for the operation and control of the rotorcraft.

2.3 The Rotor and Transmission Systems shall be protected against the application of dangerously high torques transmitted by the Power-unit(s) or resulting from control movements.

NOTE: The Authority will be prepared to consider the display of a suitable placard as a means of complying with this requirement if the inherent characteristics of the rotorcraft and instrumentation are such that the pilot can safely be left to provide the protection.

2.4 On rotorcraft in which it is necessary to maintain two or more Rotors in phase with one another, means shall be provided to maintain such relationship under all operating conditions. If there are any points in the Transmission System at which it is intended the correct relationship settings may be frequently disturbed (e.g. for stowage or transportation purposes) then the design of such points shall be such that it is mechanically impossible to reassemble the Transmission System so that the Rotors are disastrously out of phase. At all other points, the design shall be such as to minimize the possibility of reassembling the Transmission System so that the rotors are disastrously out of phase.

2.5 No accessory, other than Essential Accessories used for autorotative descent and landing, shall be driven from the Rotor System unless it can be shown that the presence of the additional drive or any failure or malfunction of the drive or accessory will not constitute a hazard to the Rotor System.

3 DESIGN CRITERIA (see G4—9 App., 1)

3.1 A fault analysis of single failures of the Rotor and Transmission Systems, together with any fault detection devices incorporated therein, shall be carried out. Further, consideration of single failures shall be extended to consideration of multiple failures when:—

(a) the first failure would not be detected during normal operation, including periodic checks which are carried out, the intervals between which are consistent with the degree of danger involved, or

(b) the first failure could lead to other failures before the first failure is rectified.

*The only changes made to this Chapter are editorial.

A.B

3.1.1 All components, the failure of which (as established in accordance with 3.1) could lead to a Catastrophic Effect, shall be designed (and such design substantiated to the satisfaction of the Authority) to have an established Safe Fatigue Life.

3.1.2 Where, in carrying out the fault analysis, reliance is placed upon a fault detector device to give an early warning of the impending failure of a part the failure of which could lead to a Catastrophic Effect, then such a device shall be provided with a means of checking its functioning.

3.2 The design of each part of the Rotor and Transmission Systems shall be such as to pass the tests of Sub-section G7—Transmission and Rotor Systems Tests.

3.3 The quality control system, applicable to all parts the failure of which could lead to a Catastrophic Effect, shall be subject to agreement in detail by the Authority (see **G4—9** App., **2**).

3.4 Those parts of the Transmission System which are within a Designated Fire Zone shall comply with **G5—8.**

4 ROTOR DESIGN

4.1 **Rotor Blade Clearance.** Adequate clearance shall be provided between any Rotor and all other parts of the rotorcraft to prevent the blades striking any part of the rotorcraft during any permitted ground or flight manoeuvre (see Chapter **G2—8**). The clearance shall also be such that the possibility of the blades striking any part of the rotorcraft during any foreseeable manoeuvre that might inadvertently occur shall be Extremely Remote.

NOTE: The combined effect of the manoeuvring loads and gust loads of the magnitudes prescribed in **G3—2, 2,** should be considered.

4.2 **Rotor Balancing.** Means shall be provided to enable the balance of the Rotor(s) and rotor blades to be adjusted to within the limits specified by the constructor.

NOTE: See also **G3—9.**

4.3 **Stops**

4.3.1 Where necessary to prevent damage, stops shall be provided to limit angular movement of the blades about their several hinges.

4.3.2 Adequate clearance shall be provided to prevent blades contacting any rigid droop stops except during the starting or stopping of the Rotor(s).

4.4 **Deformation.** The blades shall be so designed that they will maintain their aerodynamic contour and balance characteristics under all possible flight conditions. Consideration shall be given to the effects of variation of ambient conditions, e.g. pressure, temperature and humidity.

4.5 **Water Accumulation.** The blades shall be designed to prevent adverse water accumulation in any section of the blade.

5 CLUTCHES

5.1 The Rotor and Transmission Systems shall be such that any Power-unit can be started without driving the Rotor(s).

NOTE: In the case of turbine engines incorporating a free power-turbine which drives the Rotor and Transmission Systems, 5.1 need not apply provided it can be shown that the stresses involved in the Rotor and Transmission Systems during starting are acceptable.

5.2 Normal engagement of any clutch shall not cause excessive stresses in the Rotor and Transmission Systems. Inadvertent engagement of any clutch shall not produce dangerously high stresses in the Rotor System.

A.B **6** ROTOR BRAKE Limitations on the use of the Rotor brake shall be specified and included in the Flight Manual. Means acceptable to the Authority shall be provided to minimize both the possibility of a take-off with the brake applied and the possibility of inadvertent application of the brake in flight.

7 COOLING FANS (see G4—9 App., 3)

A 7.1 **Group A.** Cooling fans shall either:—

(a) be so designed or so located that any failure will not jeopardise the safety of the occupants or prevent continued flight to either the aerodrome at which it is intended to land or any alternate aerodrome, or

(b) be designed to possess an integrity of the same order as that of the Rotor System.

B 7.2 **Group B.** Cooling fans shall either:—

(a) be so designed or so located that any failure will neither jeopardise the safety of the occupants nor in the case of:—

(i) **Single-engined Rotorcraft.** Prevent an Emergency Landing being made;

(ii) **Multi-engined Rotorcraft.** Prevent flight for the maximum time required to enable an Emergency Landing to be made, or

(b) be designed to possess an integrity of the same order as that of the Rotor System.

A.B 7.3 If compliance with 7.1 (a) or 7.2 (a) is established it shall be shown that such a failure will not occur with an unacceptable frequency.

8 ACCESSORY DRIVES

8.1 The design of the Transmission System shall be such that each accessory drive has provision for a weak link to be fitted which will prevent a malfunctioning accessory from applying a dangerously high torque to the system. All other parts of the Transmission System shall be capable of withstanding safely the torque required to fail the weak link.

8.2 The torque at which each weak link is designed to fail shall be indicated on the relevant drawings.

8.3 The weak link shall be designed so that its failure will not result in flailing or in loose parts causing damage to the rotorcraft.

8.4 (a) When the power absorbed by a transmission-driven accessory, e.g. electrical generator, is such as to create a hazardous condition in the event of mechanical failure of the accessory in spite of the presence of the weak link in the drive, means shall be provided so that the accessory may be disengaged from the transmission while the transmission is still running, unless it can be shown that the possibility of mechanical failure of the accessory is remote and is unlikely to lead to a hazardous condition. (See also **G6—1,** 3.2.1 (m)).

NOTE: The weak link has to be designed to accommodate the highest peak torque and where the torque on the drive varies considerably with r.p.m., load, accelerations, etc., especially as in the case of electrical accessories, the weak link may not provide an effective safeguard at the normal operating torque.

(b) Where a means for disengagement is provided the conditions under which the accessory may be re-engaged shall be established and should these provide for re-engagement in flight the declared technique to be employed shall be demonstrated to prove safe operation.

A.B 9 PROVISION FOR INSTRUMENTS

9.1 All necessary provision shall be made in the Transmission System for the fitment and operation of the mandatory items of equipment prescribed in **G6—1.**

NOTE: Additional provision for the instruments necessary in type tests will have to be made on the Transmission and Rotor Systems or parts thereof submitted for type approval.

9.2 Oil pressure gauge connections shall be arranged so that the gauge will measure the pressure of the oil to the main feeds. There shall be no filter or relief valve between the oil pressure gauge connection and the main feeds.

APPENDIX TO CHAPTER G4—9

Revised in part, 7th November, 1975

ROTOR AND TRANSMISSION SYSTEMS

1 DESIGN CRITERIA (see G4—9, 3) It is recommended that the designer should pay particular attention to the following:—

(a) reducing the number of parts the failure of which will cause a Catastrophic Effect to a minimum, e.g. by the adoption of fail safe techniques, the most advantageous use of free-wheel mechanisms, etc.,

(b) the fitting of devices which will warn the flight crew of impending failure, e.g. bearing temperature warning devices.

2 CONTROL OF HIGH INTEGRITY PARTS (see G4—9, 3.3)

2.1 All relevant data on the factors (design, materials, processes) which led to or could have influenced the standard of integrity of any parts, the failure of which could lead to a Catastrophic Effect, should be established. The effect of any subsequent changes to such influencing factors should also be established and agreed by the Authority.

2.2 The detailed manufacturing processes and the standards for acceptance which are necessary to ensure that the integrity of such parts is maintained on all production parts should be described clearly by means of written instructions and/or specifications. Any subsequent changes to such instructions and/or specifications shall be agreed with the Authority.

2.2.1 The relevant drawings should define those features that are significant in achieving at least the minimum standard required (e.g. radii, surface finish, location of part numbers and other markings (where permitted), extent and location of permissible flaws).

2.2.2 Where, for example, any of the following are necessary to ensure the integrity of the parts, the drawings and the associated documents should specify:—

(a) Process specifications (e.g. forging processes, machining, heat treatment, protective treatment).

NOTE: It will be necessary for the constructor to devise his own process specifications where general specifications (e.g. DTD, BS) are inadequate.

(b) The equipment and test facilities necessary, together with the acceptable limits of accuracy for such equipment.

(c) Construction instructions or assembly techniques.

(d) Special inspection techniques (e.g. radiography, ultrasonic testing).

(e) The extent of duplicate inspection or independent check-testing of parts.

2.3 All the factors considered in 2.2 are equally applicable to parts and equipment obtained from outside the Applicant's Approved Organisation.

3 COOLING FANS (see G4—9, 7) Compliance with the requirements of **G4—9,** 7.1 (b) or 7.2 (b) may be established by:—

(a) demonstrating by test that no dangerous resonant conditions can occur in the hub or the complete fan, as appropriate, within the normal range of rpm of the fan, and

(b) demonstrating by test that the hub or the complete fan, as appropriate, can withstand rotation at 1·25 times the fan rpm corresponding to either:—

(i) the declared maximum overspeed for the power-unit or the Rotor Never Exceed R.P.M. (whichever is applicable), or

(ii) the operating speed of an overspeed limiting device,

whichever is applicable, and

(c) establishing a Safe Fatigue Life of the hub or the complete fan, as appropriate, under suitably factored loads, and

(d) applying to the parts concerned a quality control system which is agreed in detail by the Authority.

SUB-SECTION G4—DESIGN AND CONSTRUCTION

CHAPTER G4—10 EMERGENCY ALIGHTING ON WATER

Issued, 20th January, 1975

A.B 1 APPLICABILITY The requirements of this Chapter are applicable where approval for flight over water is desired.

2 GENERAL Such design measures as are compatible with the general characteristics of the rotorcraft, shall be taken where these are necessary to ensure as far as possible, that, where an Emergency Alighting on water is made, in accordance with the recommended procedures (see 3),

(a) the behaviour of the rotorcraft in the declared conditions would not be such as to cause immediate injury to the occupants or make it impossible for them to escape from the exits provided;

(b) the flotation time and trim of the rotorcraft in the declared conditions and allowing for damage will be such as to give reasonable assurance that the occupants will not be prevented from leaving the rotorcraft by the exits provided and entering life-rafts (see also **G4—3, 5**).

2.1 In assessing the general characteristics of the rotorcraft, any projecting features, or other factors likely to affect hydrodynamic characteristics, shall be taken into account.

2.2 External doors and windows shall be designed to withstand the probable maximum local water pressures occurring during an alighting on water conducted in accordance with the established technique (see 3.1).

3 ALIGHTING (see G4—10 App., 1.1)

3.1 **Techniques and Procedures.** Techniques and procedures shall be established for alighting the rotorcraft on water, in the event of:—

(a) the failure of all Power-units,

B (b) the failure of one Power-unit.

A.B 3.2 **Method of Compliance.** Satisfactory Emergency Alighting characteristics shall be demonstrated in accordance with (a) or (b) as appropriate:—

A (a) **Group A.** In accordance with (i) or (ii) as selected by the Applicant:—

(i) By flight tests in the declared conditions.

(ii) By investigation and model tests conducted so that the results would be valid for the declared conditions.

B (b) **Group B.** By flight tests in the declared conditions. However where correlation between model testing and flight testing is established in moderate sea states, demonstration of the rotorcraft characteristics in the declared conditions may be conducted using a representative model.

A.B

4 FLOTATION AND TRIM (see G4—10 App., 1.2) Satisfactory flotation and trim characteristics shall be demonstrated by investigation and model tests conducted so that the results would be valid in the declared conditions. Where a sea anchor is used in demonstrating compliance, the design of the anchor shall be such as to permit ready deployment and operation.

5 PROCEDURES AND LIMITATIONS

5.1 **Procedures.** The techniques and procedures established in accordance with 3.1 shall be included in the Flight Manual.

5.2 **Limitations.** The conditions in which compliance with the requirements have been demonstrated if less than those detailed in the Appendix shall be included in the Flight Manual as limitations.

APPENDIX TO CHAPTER G4—10

Issued, 20th January, 1975

EMERGENCY ALIGHTING ON WATER

1 SEA STATES

1.1 **Alighting** (see **G4—10, 3**). The Emergency Alighting characteristics should be investigated throughout a range of sea states from 0 to 4 of Table 1 (G4—10 App.).

1.2 **Flotation and Trim** (see **G4—10, 4**). The flotation and trim characteristics should be investigated throughout a range of sea states from 0 to 7 (but limited to 9·15 m (30 ft)) of Table 1 (G4—10 App.), and should be satisfactory in waves having height/length ratios in accordance with (a) to (c).

(a) 1:10 for rotorcraft in Group B.

(b) 1:15 for rotorcraft in Group A2.

(c) 1:20 for rotorcraft in Group A1.

NOTE: The height of a wave is considered as the vertical distance between trough and crest.

TABLE 1 (G4—10 App.)

Sea State	Height of Waves	Description of Sea	Sea State	Height of Waves	Description of Sea
0	0 or less than 0·305 m (1 ft)	Glassy-calm Rippled	5	2·439 m to 3·658 m (8 to 12 ft)	Very Rough
1	0·305 m to 0·610 m (1 to 2 ft)	Smooth	6	3·658 m to 6·096 m (12 to 20 ft)	High
2	0·610 m to 0·915 m (2 to 3 ft)	Slight	7	6·096 m to 12·192 m (20 to 40 ft)	Very High
3	0·915 m to 1·524 m (3 to 5 ft)	Moderate	8	12·192 m (40 ft) and over	Precipitous
4	1·524 m to 2·439 m (5 to 8 ft)	Rough	9	All Heights	Phenomenal (Confused Sea)

SUB-SECTION G4—DESIGN AND CONSTRUCTION

CHAPTER G4—11 AGRICULTURAL EQUIPMENT*

Issued, 20th January, 1975

A.B

1 HOPPERS The requirements of this paragraph 1 apply to unpressurised hoppers.

1.1 **General**

1.1.1 Hoppers and their attachments to the rotorcraft structure shall have proof and ultimate factors of safety of not less than 1·0 and 1·5 respectively under the loads corresponding to the relevant requirements of Sub-section G3, when the hoppers are filled with all weights of chemicals up to the maximum weight for which they were designed.

1.1.2 Hoppers intended for the carriage of noxious materials shall be installed in a manner such as to avoid contamination of the flight crew in normal operations taking account of spillage, drift, filling of the hoppers and leakage as a result of faults.

1.2 **Surging.** Means shall be provided to minimize surging of the hopper load unless it can be demonstrated that the shape or construction of the hopper makes such provision unnecessary. In showing compliance with this requirement, account shall be taken of the possible effect on handling characteristics and trim of movement of the hopper load for all quantities of chemical in the hopper.

1.3 Where applicable, precautions shall be taken to prevent asymmetrical discharge of hopper contents such as could result in c.g. limitations being exceeded.

1.4 **Weight**

1.4.1 A Maximum Landing Weight less than the Maximum Take-off Weight may be acceptable provided that it is possible to reduce the weight below the Maximum Landing Weight within 3 seconds, e.g. by jettisoning the hopper load (see 1.10).

1.4.2 The maximum permissible weight of the contents of the hoppers shall be stated in the Flight Manual and shall be marked on or adjacent to the filling orifice cover.

1.5 **Pressure Tests**

1.5.1 **Prototype Hoppers.** Prototype hoppers shall be capable of withstanding without failure the internal pressure developed during the maximum accelerations corresponding to the Ultimate Loads in the rotorcraft which can occur if the hopper is filled with the maximum weight of contents for which it was designed. Where the contents are in liquid form, the hopper shall also withstand without failure or leakage an internal pressure condition of 20·7 kN/m² (3 lbf/in²).

1.5.2 **Series Hoppers.** The drawings shall contain a note specifying the test pressure and procedure to be adopted for testing series hoppers.

1.6 **Filling Orifices**

1.6.1 Filling orifices shall be so arranged that spilled chemical will drain overboard and will not gain access to the interior of the rotorcraft (see also 3.1.3).

1.6.2 Filling orifice covers shall be constructed so as to minimize the possibility of their being damaged during use and shall be such that leakage will not occur under normal conditions of operation.

*See Index for other requirements relating to rotorcraft fitted with agricultural equipment.

A.B

1.7 **Vents.** Vents shall terminate at points where chemicals discharged from vent outlets would neither constitute a hazard nor allow chemicals to enter the interior of the rotorcraft (see also 3.1.3).

1.8 **Hopper Contents.** Where the level of the hopper contents cannot be checked visually, a suitably calibrated indicator shall be provided.

1.9 **Location of Hoppers.** Where practicable, hoppers shall be so positioned that should they break away in a Crash Landing, the risk of injury to the flight crew is reduced to a minimum.

NOTE: Where it is intended that noxious materials are to be used, hoppers should be so positioned that, in the event of a Crash Landing, the flight crew would be unlikely to be contaminated to a degree likely to cause serious injury.

1.10 **Jettisoning.** Where a jettisoning system is installed it shall, as far as possible, discharge the contents of the hopper clear of all parts of the rotorcraft, and the satisfactory operation of the system shall be demonstrated in flight (see also 3.1.3).

2 SPRAY BOOMS

The design and arrangement of spray booms shall, so far as is practicable, be such that no failure of the spray booms from any cause, including striking either the ground or an obstacle, will result in either injury to the flight crew or a Catastrophic Effect.

3 CHEMICAL DISTRIBUTING SYSTEM

3.1 General

3.1.1 Precautions shall be taken to prevent chemicals gaining entry into any part of the power-plant installation, rotorcraft structure or equipment (e.g. engine vents, air intakes, drains, ignition switches) where their presence could lead to structural collapse, total Power-unit failure or loss of control of the rotorcraft.

NOTE: In any case the possibility of entry of moisture into such locations, together with the entry of chemicals, should be taken into account since this may result in a corrosive reaction.

3.1.2 Chemicals shall be discharged in such a manner that Flammable substances will not find their way to potential sources of ignition (e.g. exhaust pipe).

3.1.3 Parts of the rotorcraft liable to come into contact with Flammable substances shall be of a non-absorbent nature. Means shall be provided to discharge spilled chemicals overboard clear of potential sources of ignition.

3.1.4 Account shall be taken in the design of the rotorcraft for the need for internal decontamination.

NOTE: Decontamination usually involves washing down the affected parts with copious supplies of water.

3.1.5 Where installations are designed for the distribution of dust substances, any rotating or sliding parts of the rotorcraft, the complete or partial seizure of which could result in an Effect greater than a Major Effect shall be adequately shielded or protected from dust accumulation.

3.1.6 Where it is intended that noxious fluids are to be used, it shall be demonstrated by means of a flight test that the fluids are discharged clear of the outer surfaces of the rotorcraft. In carrying out this demonstration a coloured fluid shall be discharged in a representative manner from the rotorcraft at a representative droplet size and rate of flow under representative flight conditions.

A.B

3.2 **Pipes and Pipe Couplings**

3.2.1 Pipes and pipe couplings shall be demonstrated to be able to withstand without fracture or bursting 3·0 times the normal working pressure of the system.

3.2.2 Joints of the hose-and-clip type shall not be used in systems used for the distribution of noxious or Flammable substances in regions where their failure could result in contamination of the flight crew or in fire hazard.

3.3 **Controls.** Controls, governing the distribution of chemicals, which are intended for operation by the pilot at the beginning and end of each distribution run shall be so arranged that their operation during these manoeuvres does not necessitate the pilot removing his hands from the primary flight controls.

SUB-SECTION G4—DESIGN AND CONSTRUCTION

CHAPTER G4—12 EXTERNAL LOADS

Issued, 7th November 1975

A.B

1 GENERAL

1.1 The requirements of this Chapter are applicable to rotorcraft for which certification for the carriage of external loads is desired. Requirements for rotorcraft/load combinations other than those of 1.2 shall be agreed with the Authority for the particular case.

1.2 The requirements of this Chapter **G4—12** apply to rotorcraft/load combinations classified as either Class A or Class B as follows:—

(a) **Class A.** A rotorcraft/load combination in which the load may be carried either inside the rotorcraft but with some portion extending outside the fuselage, or wholly externally, and, in both cases where the load:—

(i) cannot be jettisoned by remote control,

(ii) cannot normally move relative to the rotorcraft,

(iii) does not extend below the landing gear, and

(iv) would not touch the ground in any of the landing cases of **G4—5.**

(b) **Class B.** A rotorcraft/load combination in which the external load is:—

(i) freely suspended from the rotorcraft by means of a single attachment point,

(ii) lifted clear of the land or water during the operation subsequent to the rotorcraft becoming airborne, and

(iii) provided with a means of jettisoning the load by remote control.

2 STRENGTH

2.1 **General.** The rotorcraft/load combination shall be such that compliance is shown with the relevant structural requirements of Sub-section G3.

2.2 **Class B only.** The external load attaching means shall withstand a static limit load of 2·5 times the maximum external load for which certification is sought, applied at any angle from the vertical expected in service but not less than:—

(a) **From Directly Ahead to 90° Either Side.** An angle of 15° to the vertical axis of the rotorcraft, and

(b) **From 90° Either Side to Directly Rearwards.** An angle which increases from 15° to a maximum of 30° directly rearwards.

NOTE: If it can be shown that a lesser angle cannot be exceeded, such a lesser angle may be used with the agreement of the Authority.

A.B

3 LOAD RELEASE DEVICES—CLASS B ONLY

3.1 **General.** The requirements of this paragraph **3** apply to the operating controls of the release devices. General requirements relating to operating controls are contained in **G4—2, 4** and **G4—8, 1.**

3.2 **Release Devices**

3.2.1 The external load attaching means shall incorporate a device to enable the pilot quickly to release the load, whether it is suspended or in contact with the ground.

3.2.2 The operating control for the release device shall be incorporated in one of the pilot's hand operated primary flight controls, in such a position and in such a manner that its operation will not impair the pilot's ability to maintain control of the rotorcraft during an emergency.

3.2.3 In addition to the release device prescribed in 3.2.1, an emergency mechanical release shall be provided, and shall be installed in a position readily accessible to the pilot.

3.2.4 Release devices and their controls shall be arranged so as to minimize the possibility of inadvertent operation.

3.2.5 Release devices shall function satisfactorily when the attaching means is supporting loads up to and including the maximum external load weight and in all conditions of flight for which certification is sought.

3.3 **Automatic Release Means.** Any means by which the load is automatically released when it touches the ground shall, to avoid inadvertent release (e.g. in turbulence) be such that the pilot is able to prevent the means from operating in flight. The minimum safe weight of the external load when such a means is in use shall be established, relative to still air. The incorporation of such an automatic release means shall not prejudice the ability to release the load by means of the release devices required by 3.2.1 and 3.2.3.

4 LOADING

The permissible range of rotorcraft weight and c.g. positions under all loading conditions shall be established for the particular rotorcraft/load combination.

5 FLIGHT CHARACTERISTICS (see G4—12 App., 1)

5.1 **General.** The flight envelope of any rotorcraft/load combination shall not exceed that laid down in the Flight Manual for the rotorcraft when not carrying external loads.

5.2 **Load Configuration.** Load densities and shapes shall be so selected that the flight characteristics of the rotorcraft/load combination are satisfactory within the flight envelope for which certification is sought for the rotorcraft/load combination(s).

NOTES: (1) The maximum air speed may need to be varied with the selected load densities and shapes (but see 5.3 (a) (ii)).

(2) Limits on strop length (i.e. distance of load from rotorcraft external load attaching means) may have to be specified.

(3) Resonant frequencies of suspended loads should be considered in relation to any dynamic inputs, including rotorcraft forcing frequencies, and it may be necessary to specify the material and type of strop.

A.B

5.3 **Flight Characteristics.** Rotorcraft/load combinations shall be safely controllable and manoeuvrable during all phases of flight within the flight envelope for which certification is sought. The following phases of flight shall be demonstrated using representative loads (see **G4—12** App., **1**).

(a) **Class A and B**

(i) Climb and descent, including transitions.

(ii) Horizontal flight, including gentle turns, at an air speed at least 10% or 9·0 km/h (5 knots), whichever is the greater, above the maximum air speed for which certification is sought. This certification speed shall be such that it is not necessary to exceed the Normal Operating Speed, V_{NO}.

(b) **Class A.** Take-off and landing.

(c) **Class B.** Hovering manoeuvres relating to the carriage of external loads, including the attaching, picking up, winching and releasing, as appropriate, of representative loads.

5.4 **Jettisoning.** The ability to jettison representative Class B loads, up to the maximum load weight, by means of the devices required by 3.2.1 and 3.2.3, shall be demonstrated in flight (see **G4—12** App., **1**).

5.5 **External Load Attaching Means.** The external load attaching means shall be such that oscillatory movements of a Class B load do not transmit excessive motion to the airframe.

6 EMERGENCY EQUIPMENT AND EXITS The carriage of any external load shall not:—

(a) impair the operation of any mandatory emergency equipment or system required by **G6—1,** or

(b) obstruct any emergency exit required by **G4—2** or **G4—3,**

for the particular operation.

7 PROVISION OF INFORMATION (see G4—12 App., 1.2) The following information applicable to the carriage of external loads shall be incorporated into the Flight Manual:—

(a) The Class of rotorcraft/load combination which has been approved.

(b) All operating limitations applicable to the Class, including:—

(i) the maximum weight of external load,

(ii) the maximum air speed established in accordance with 5.3 (a) (ii), and

(iii) the normal and emergency procedures.

(c) Any information on particular handling qualities or other techniques applicable to operating particular rotorcraft/load combinations.

(d) Advice regarding precautions against static electricity discharges when operating Class B combinations (in relation to ground personnel).

(e) Any other information essential for safe operation.

APPENDIX TO CHAPTER G4—12

Issued, 7th November, 1975

CARRIAGE OF EXTERNAL LOADS

1 FLIGHT CHARACTERISTICS (see G4—12, 5)

1.1 For the purpose of demonstrating acceptable flight characteristics, tests should be made with a load selected from each of the following general categories:—

(a) High Density Low Volume (e.g. full drums of liquid, plant, machinery).

(b) Low Density High Volume (e.g. large empty containers).

(c) Long loads (e.g. telegraph poles, pipes, timber).

Any peculiarities of in-flight behaviour applicable to any category of load should be included in the Flight Manual (see **G4—12,** 7 (c)).

1.2 A maximum windspeed for any particular type of rotorcraft/load combination may need to be determined (see **G4—12,** 7).

SUB-SECTION G5—POWER-PLANT INSTALLATIONS

CHAPTER G5—1 GENERAL

Revised, 1st June, 1976

A.B

1 INTRODUCTION* This Chapter contains general requirements applicable to Sub-section G5 as a whole together with those requirements which cannot readily be included in Chapters **G5—2** to **G5—8.** There may be cases where a general requirement given in this Chapter has to be over-ridden by a detailed requirement in a particular Chapter; the text used in the particular Chapter will make this clear.

2 GENERAL

2.1 **Normal Acceleration.** Compliance shall be shown with the requirements of **G4—1** relating to normal accelerations.

2.2 **Incorrect Assembly** (see **G5—1** App., **1**)

2.2.1 Precautions shall be taken in the design and arrangement of the Power-plant installation to minimize the risk of incorrect assembly.

2.2.2 Where non-return valves are such that their correct functioning is essential for the safe operation of the system, design precautions shall be taken to minimize the risk of the valve being assembled or connected so that it will operate in the reverse sense.

2.3 **Cleanliness.** The Power-plant installation shall, so far as is practical, be arranged so that dirt cannot accumulate in inaccessible places.

2.4 **Markings**

2.4.1 The word "Fuel" or "Oil" or the name of any other liquid, as appropriate, shall be marked on or adjacent to the filler cap or filling point. Where practicable, the specifications and/or brands of the Approved liquids for the engine(s) installed shall be marked near the filler cap or filling point, otherwise the information shall be made available in the flight-crew compartment in a form suitable for immediate reference during replenishment of the rotorcraft liquid systems. A reference to where this information can be found shall be marked on or adjacent to the filler cap or filling point.

2.4.2 The usable tank capacity for fuel tanks, and the tank capacity of oil tanks and the tanks of other liquid systems shall be marked near the filler cap or filling point.

2.5 **Bonding.** The bonding of the Power-plant installation shall satisfy the requirements of Chapter **G4—6.**

2.6 **Turbine Engine Installations.** Provision shall be made, where necessary, for thermal expansion, both axially and radially, and the extent of such expansion shall not affect the safety of the installation.

*See also **G4—1.**

A.B 3 FUNCTIONING AND SAFETY ASSESSMENT The Power-plant shall be constructed, arranged and installed so as to ensure, as far as is practicable, its continued safe functioning.

3.1 A safety assessment of the Power-plant systems shall be made to establish the probability and consequence of Failures.

NOTES: (1) This requirement is not intended to relate to the probability and consequences of non-containment of engine debris.

(2) Part of the safety assessment is a re-assessment of an analysis (which will have been made on the engine in accordance with **Section C**, Chapter **C2—2** or **C4—2**, as appropriate) to take account of the characteristics of the engine as installed in the actual rotorcraft as compared with the typical installation assumed by the engine constructor.

3.2 **Power-unit Independence.** The Power-plant systems shall be arranged so that the Power-units can be isolated from each other so that failure or malfunctioning of any Power-unit or of any system or component that could affect the Power-unit will not:—

(a) require immediate action by any member of the flight crew for continued operation of the remaining Power-units (see Note (2)), or

(b) prevent the continued safe operation of the remaining Power-units.

NOTES: (1) The above requirements are not applicable to a multiple engine failure resulting from non-containment of debris from the failure of any one engine.

(2) With regard to (a), throttle movements of other engines, after an engine failure, to make use of contingency ratings, or any other Approved ratings, are acceptable.

4 STARTING

4.1 **General**

4.1.1 A means shall be provided for re-starting each engine in flight.

4.1.2 Design precautions shall be taken to minimize the probability of fire or of mechanical damage to an engine or the rotorcraft as a result of starting in any conditions in which starting is permitted. Any techniques and associated limitations shall be established by test. Any delay that may be necessary before attempting to restart the engine shall not hazard the rotorcraft.

4.2 **Turbine Engine Installations** (see **G5—1** App., **2**). In addition to compliance with 4.1, compliance shall also be shown with the requirements of this paragraph 4.2.

A 4.2.1 An envelope of altitude and air speed within which it is possible consistently to restart the engine shall be established by flight test and shall be such that it is adequate for the safe operation of the rotorcraft. The envelope shall not exceed that recommended by the engine constructor unless otherwise agreed by the Authority.

4.2.2 If, with all engines inoperative, the windmilling speed of the engine is insufficient to provide the power required for restarting, a power source shall be provided for in-flight restarting of engines without undue delay within the relight envelope. Compliance shall be demonstrated in flight, simulating the required conditions.

NOTE: The purpose of the requirement is to ensure that the existing hazard is not further aggravated by undue delay in restarting, or inability to restart, the engines.

A.B 4.2.3 It shall be demonstrated in flight that compliance is shown with the requirements of (a) and (b) when restarting engines after a False Start:—

(a) That fuel discharged either as liquid or vapour will not create a fire hazard.

(b) The possibility of fuel discharged from the jet pipe, or of exhaust efflux, entering the jet pipe shroud or any part of the airframe such as to cause a fire hazard is precluded.

A.B

4.2.4 The minimum drainage period following an Abortive Start or False Start before a further attempt to start may be made shall be established. Successive attempts to restart up to the maximum number permitted shall not involve a risk of fire.

4.2.5 A means of indicating to the flight crew when a starter is energized shall be provided, unless it can be established that if the starter remains energized after the engine has started, or subsequently is energized as a result of a Failure, no hazard would result.

5 ENGINE FAILURE—HAZARDOUS ROTATION

5.1 Means shall be provided for stopping combustion and for preventing hazardous rotation of any engine both on the ground and in flight (see also **G5—3, 8**).

5.2 Where components provided for stopping combustion and preventing hazardous rotation are located in a Designated Fire Zone, compliance shall be shown with the requirements of **G5—8,** 4.4.1.

6 PROPELLER CLEARANCE (see G5—1 App., 3)

Adequate propeller clearance shall be provided under the most critical operating conditions.

NOTE: Requirements concerning rotor blade clearance are given in **G4—9,** 4.1.

7 COMPONENTS AND EQUIPMENT

7.1 **Group 2 Equipment.** Group 2 equipment shall be approved for use on or with the type of engine concerned and shall be correctly located and installed. (See **Section A,** Chapter **A3—1** App.).

7.2 **Components.** All components of the Power-plant installation shall be designed, constructed and installed so as to ensure as far as is practicable their continued safe operation.

7.3 **Pipelines and Fittings**

7.3.1 Pipelines and fittings shall be so installed and supported as to prevent excessive vibration, and to withstand without failure the operating loads to which they may be subjected.

7.3.2 Inverted U bends shall be avoided in all pipelines where vapour or air locks might cause malfunctioning of the system.

7.3.3 Each pipeline connected to components of the rotorcraft between which relative motion may occur shall incorporate adequate provision for flexibility.

7.3.4 Flexible connections in fluid lines, which are under pressure or subjected to axial load, shall employ flexible hose assemblies or equivalent means. The use of hose clip connections under these conditions is only acceptable when it can be shown that no hazard would result from disconnection.

7.3.5 Flexible pipelines and their couplings shall be of an Approved type or shall be shown to be suitable for the particular installation.

A.B 7.4 **Drains**

7.4.1 Service draining points shall be designed and positioned so as to enable systems to be safely drained, with the rotorcraft in the normal ground attitude, until any residue is of negligible magnitude. During draining, no fluid shall enter or remain in any part of the rotorcraft to such an extent as to constitute a fire hazard or risk of corrosion.

7.4.2 Service draining points shall be readily accessible and shall be provided with means for positive manual or automatic locking in the closed position.

7.4.3 Drains shall be provided so that those sections of the Power-unit cowling and adjacent airframe compartments, where leaking Flammable or corrosive fluids could otherwise accumulate, are drained both in flight and on the ground.

7.5 **Fluid Control Valves**

7.5.1 **General.** The requirements of this paragraph 7.5 are applicable to valves for controlling the flow of fluids (see also 2.2.2).

(a) Valves shall be provided with positive stops at, or locating provisions in, the "ON" and "OFF" positions. The valves shall be so supported that loads resulting from their operation are not transmitted to the pipelines connected to them, or the pipelines shall be of adequate strength to withstand the maximum valve operating loads, including those occurring in the case of valve seizure.

(b) Operating levers or switches shall be designed and installed so as to give clear and unambiguous indication, both visually and where necessary by feel, of the selected valve position.

(c) It shall be possible for the appropriate member of the flight crew at his station to open and close the shut-off valves.

7.5.2 **Mechanically-operated Valves**

(a) The design of mechanically-operated valves shall be such that they will be positive in operation, easy to operate and will not change position as a result of vibration.

(b) Where the correct functioning of a mechanically-operated valve is essential for the safe operation of the rotorcraft, design precautions shall be taken to minimize the risk of assembling the valve and its associated controls with the operating lever out of phase with the valve.

7.5.3 **Valves other than Mechanically-operated Valves.** Where the correct functioning of such a valve is essential for the safe operation of the rotorcraft, means shall be provided to give unambiguous indication of the valve position, unless other adequate indications are given to the flight crew that the valve has moved to the selected position.

7.6 **Heat Exchangers.** Heat exchangers and their mountings shall be designed, constructed and installed so as to withstand without failure all vibration, inertia and other loads to which they may be subjected in the rotorcraft design conditions.

7.7 **Cowlings.** Cowlings shall be constructed and supported to withstand without failure all vibration, inertia and air loads to which they may be subjected in the rotorcraft design conditions.

NOTE: See also **G5—8**, 4.5 for fire resistance qualities of materials.

7.8 **Instruments.** In addition to the instruments specified throughout this Sub-section G5 and those prescribed in **G6—1**, such additional instrumentation as is considered necessary for any unusual features of the Power-plant shall be installed.

A.B

7.9 **Gas Turbine Starters.** The installation of gas turbine starters shall comply with the relevant requirements of this Sub-section G5.

7.10 **Auxiliary Power-units.** Auxiliary power-unit installations shall comply with the relevant requirements of this Sub-section G5.

8 TESTS

8.1 System Tests

8.1.1 The tests required to demonstrate compliance with this Sub-section G5 shall be made for each system in the Power-plant.

8.1.2 On Series rotorcraft the tests on fluid systems shall consist of tests at the maximum working pressure on each complete system from which leakage of fluid or vapour could occur.

NOTE: The tests for Prototype and Series systems are detailed in the appropriate Chapters.

8.2 Ground and Flight Tests

8.2.1 The satisfactory functioning of the Power-plant over (as far as possible) the range of operating conditions for which certification is required shall be demonstrated by ground and flight tests. This will normally include tests in hot climatic conditions.

NOTE: Where tests are necessary to demonstrate compliance with **3**, these should be incorporated in the test schedule.

8.2.2 The tests shall establish that:—

(a) The engines are free from any operating characteristics which might seriously affect their safe functioning, such as stall, surge, instability, flame-out or excessive turbine entry temperature. If an alternative intake is provided, additional tests shall be made to demonstrate compliance with the requirements of this paragraph (a) with that intake in use.

(b) The temperatures of the Power-plant, including engines, components, equipment, liquids, together with nearby structural components are maintained within values established as safe for operation. (See also **G5—4** for cooling requirements).

(c) The engine/rotor speed control systems function satisfactorily.

(d) The propellers and their associated control systems function satisfactorily. (See also **G5—7, 4**).

8.3 Starting Tests

8.3.1 **General.** Safe starting techniques both on the ground and in flight and appropriate to the range of climatic conditions for which certification is desired shall be established and, where necessary, demonstrated by tests.

8.3.2 **Low Temperature Starting.** The minimum oil temperature for safe starting for all grades of oil for which certification is sought shall be declared and shall be not lower than the minimum oil temperature declared for starting in accordance with **Section C.** Where necessary, the minimum safe starting temperature shall be determined by low temperature starting tests which, in the case of piston engines, may involve the determination of oil dilution and "boiling off" techniques.

NOTE: In making tests to determine the minimum oil temperature for starting, the temperature of the engine should normally be equal to that of the ambient air; thus the engine oil temperature quoted as a minimum for starting can be regarded also as the minimum ambient air temperature for starting. However, this will not prevent the starting of engines in lower ambient air temperatures where arrangements have been made for the engine temperature to be not less than the minimum oil temperature established as safe for starting.

A

8.3.3 **Relighting of Turbine Engines—Period Between Starts.** Flight tests shall be made to determine the minimum period to be allowed following a False Start before another attempt to start is made. It shall be demonstrated that the minimum period so established is such that successive attempts to relight, up to a maximum permitted number will not introduce a hazard.

A.B

9 VIBRATION SURVEY—TURBINE ENGINES It shall be established that there is no dangerous vibration in the Power-units in the rotorcraft design conditions, including:—

(a) the complete range of rotorcraft speeds, attitudes, altitudes and Power-unit operating conditions, and

(b) all conditions of steady and transient operation on the ground and in flight (including autorotation).

NOTES: (1) Non-critical conditions of operation which need not be considered should be agreed with the Authority.

(2) The vibration survey is complementary to the tests carried out on the engine in accordance with **Section C**, Chapters **C4—4** and **C4—6**.

9.1 If the air flow conditions at the intake of an engine can be affected by the operating conditions of adjacent engine(s), the investigations shall include an exploration of the effects of running the adjacent engine(s) at the same and at different conditions over the whole range of engine operating conditions. An investigation of the effect of malfunctioning of adjacent engine(s) shall also be included.

9.2 Compliance with the requirement of **9** shall be established by one or by a combination of the methods of this paragraph 9.2.

(a) A demonstration:—

(i) that the variation in the engine inlet airflow conditions that would occur in the conditions specified in **9** (a) and (b) and in 9.1, and

(ii) the variations in turbine exit conditions that could normally occur in operation, are within the limits established on the particular engine type.

(b) An investigation of the vibration characteristics by the method and of the scope indicated in **Section C**, Chapters **C4—4, 3** and **C4—6, 3**, carried out on a representative installation on the ground using test equipment where the actual conditions of operation in the rotorcraft are reproduced.

(c) An investigation of the vibration characteristics by the method and of the scope indicated in **Section C**, Chapters **C4—4, 3** and **C4—6, 3**, carried out on a representative rotorcraft on the ground and in flight, as appropriate to the conditions being investigated.

(d) The completion of sufficient flying with representative installations, prior to certification, such as to demonstrate that the vibration levels are satisfactory.

(e) Any other method acceptable to the Authority.

APPENDIX TO CHAPTER G5—1

Issued, 1st June, 1976

POWER-PLANT INSTALLATIONS—GENERAL

1 INCORRECT ASSEMBLY (see G5—1, 2.2)

1.1 All Power-plant systems, except those of 1.2, should be so designed and constructed that at all reasonably possible breakdown points, it is mechanically impossible to,

(a) assemble control systems to be disastrously out of phase,

(b) assemble control systems so that they operate in the reverse sense,

(c) interconnect the controls of two systems where this is not intended,

(d) interconnect the pipelines of one Power-plant system to those of another Power-plant system or some other system of the rotorcraft.

1.2 The recommendations of 1.1 need not be applied to systems which,

(a) if assembled incorrectly are unlikely to prejudice the safe operation of the rotorcraft,

(b) are operated before take-off can be commenced and are of a type where incorrect assembly would be obvious.

NOTE: Such operation before take-off does not include special drills but only those operations which will of necessity be made before a take-off.

1.3 All Power-plant systems, the faulty operation of which might affect the continued safe operation of the rotorcraft, should be so designed and constructed as to be mechanically difficult to misconnect or so that misconnection is obvious from the appearance of the system.

2 TURBINE ENGINE RESTARTING (see G5—1, 4.2)

2.1 **Envelope of Altitude and Air Speed.** For the envelope of altitude and air speed to be acceptable as adequate for the safe operation of the rotorcraft, sufficient flight tests should be made to demonstrate that restarting can be achieved consistently over the range of conditions from sea level to the maximum restarting altitude, in the normal configuration appropriate to the particular phase of flight.

NOTE: Allowance should be made for take-off from high altitude airfields.

2.2 **Delay Tests.** The tests referred to in 2.1 should include the effect on engine restarting performance of delay periods between engine shut-down and restarting of:—

(a) up to 2 minutes, and

(b) at least 15 minutes.

3 PROPELLER CLEARANCE (see G5—1, 6)

3.1 In determining the minimum propeller blade clearances, the most adverse combination of weight, c.g. position and propeller pitch should be assumed.

3.2 The following minimum clearances should be provided under all operating conditions for which certification is required, including the maximum permissible cross-wind speed declared in the Flight Manual.

3.2.1 **Ground Clearance**

(a) With the landing gear statically deflected and the rotorcraft in the most critical ground attitude,

(i) for rotorcraft equipped with nose-wheel type landing gear 178 mm (7 in) clearance between the propeller and the ground,

(ii) for rotorcraft equipped with tail-wheel type landing gear 229 mm (9 in) clearance between the propeller and the ground.

(b) With the rotorcraft in the most critical ground attitude and the tyre(s) on the critical landing gear unit completely deflated and the corresponding landing gear strut completely bottomed, positive clearance between the propeller and the ground.

(c) With the rotorcraft in the most critical ground attitude and with the critical landing gear unit(s) and tyre(s) deflected corresponding to the design limit load conditions of **G3—5**, positive clearance between the propeller and the ground.

3.2.2 **Structural Clearance**

(a) Not less than 25 mm (1 in) radial clearance between the blade tips and the structure of the rotorcraft. Additional radial clearance should be provided if necessary to preclude harmful vibration.

(b) Not less than 13 mm (0·5 in) longitudinal clearance between the propeller blades and cuffs and stationary parts of the rotorcraft.

(c) Adequate clearance between other rotating parts of the propeller and spinner and stationary parts of the rotorcraft.

SUB-SECTION G5—POWER-PLANT INSTALLATIONS

CHAPTER G5—2 FUEL SYSTEMS

Revised in part, 16th August, 1982

A.B 1 GENERAL

1.1 The fuel system shall be constructed and arranged so as to ensure an adequate supply of fuel to each engine at the required flow rate and pressure under the rotorcraft design conditions. (See also **2.**)

NOTE: See Chapter **G4—1** for requirements relating to normal accelerations.

1.2 Fuels approved for use shall be such that any likely interaction between them and the materials used in the system will not adversely affect the fuel system. Where doubt exists compatibility shall be demonstrated by test.

2 ARRANGEMENT OF SYSTEM

2.1 **Independence of Systems.** The fuel feed system to each engine shall be arranged so as to permit the supply of fuel to each engine through a system independent of the systems supplying fuel to the other engines.

B 2.2 Where a single tank is provided in multi-engined rotorcraft there shall be:—

(a) at least two independent vents,

(b) a separate outlet to each engine, and

(c) a shut-off valve at each outlet.

A.B 2.3 **Leakage and Spillage.** Tank vent outlets, jettisoning outlets, drains, and all other such components from which fuel may leak or be spilled shall be positioned so that spilt or leaking fuel cannot enter engine intakes or any part of the rotorcraft in such quantities as to cause a fire hazard (See also **G5—8**, 3.1.2 and 3.2.2.)

2.4 **System Components in Personnel Compartments.** Personnel compartments shall not contain fuel system components (e.g. fuel tanks and pipelines) unless they are enclosed in a fuel-proof and vapour-proof shroud which is vented and drained to the exterior of the rotorcraft and protected against the risk of inadvertent damage.

2.5 **Air Locks and Vapour Locks**

2.5.1 **General.** The fuel system shall be arranged:—

(a) so as to prevent the formation of air locks and vapour locks that could cause malfunctioning of the engine in the rotorcraft design conditions, and

(b) so that it is not possible for any pump to draw fuel from more than one tank at the same time unless means are provided to prevent the introduction of air into the pipelines.

A.B

2.5.2 **Tests**

NOTE: The tests may be made on a ground installation that closely simulates flight conditions.

(a) There shall be no evidence of air locks, vapour locks or other malfunctioning when the rotorcraft is operated with an approved fuel at a temperature of 45°C and is climbed from sea level at the maximum rate of climb likely to be achieved in operation, to the operational ceiling or to the maximum altitude for which certification is sought, using the normal fuel feed arrangements to the engines. Where auxiliary tanks are provided which can be used in the climb for direct feed to the engines or for fuel transfer to the main tanks, additional tests may be required to demonstrate compliance with the requirement.

(b) The weight of the rotorcraft during the tests shall be that with all fuel tanks full, minimum crew and only that ballast necessary to maintain the c.g. within limits.

(c) The tests shall be made with all engines operating:—

(i) for the duration permitted at the maximum rating Approved for take-off, followed by

(ii) the maximum rating Approved for the remainder of the climb.

(d) The tests shall be made:—

(i) with all the fuel pumps in each tank operating, and

(ii) with one pump in each tank inoperative.

If only one pump is provided, the test shall be made with that pump inoperative.

NOTE: In the case of (d) (ii), a lower minimum altitude than that required by the Authority to satisfy 2.5.2 (a) may be acceptable.

2.6 **Fuel Contamination**

2.6.1 Adequate filtration shall be provided in the fuel system to the engine (see also **Section C,** Chapter **C4—2,** 2.1.4). Filters shall be easily accessible for draining and cleaning.

2.6.2 Unless there are means in the fuel system to prevent the accumulation of ice on the filter and other components susceptible to blockage by ice, there shall be means to maintain automatically the required fuel flow if ice clogging occurs (see also 11.3).

2.7 **Pipeline Pressure Relief.** Fuel pipelines which can be isolated from the remainder of the fuel system, e.g. by means of valves at each end, shall incorporate provisions for the relief of excessive pressure.

2.8 **Fuel Supplies to Auxiliary Devices**

2.8.1 **General.** If the fuel supply to any fuel consuming device (other than the main engines) is taken from the main rotorcraft fuel system, it shall, unless equivalent safety can be shown, be taken direct from a tank and not from a tapping on an engine fuel line.

2.8.2 **Auxiliary Power-units.** Fuel systems for auxiliary power-units intended for the operation of Essential Services in flight during emergency conditions shall be arranged so that:—

(a) the quantity of fuel available is sufficient to ensure continuous operation of the auxiliary power-unit for a period appropriate to the intended use, and

(b) a means is provided to preclude any likely contaminants (e.g. water, ice deposits) affecting the functioning of the auxiliary power-unit.

A.B

2.9 **Crash Protection**

2.9.1 Each fuel tank and its installation shall be designed or protected so as to retain fuel without leakage under the Crash Landing conditions of **G3—8.** In particular, it is desirable that fuel tank installations should be such that the tanks will not be ruptured by the rotorcraft rolling over, nor by a collapsed landing gear, nor by a landing gear or engine mounting tearing away. Fuel tanks within the fuselage contour shall be installed so that exposure of such tanks to scraping action with the ground is unlikely.

NOTE: See also **G5—8,** 3.4.

2.9.2 Each fuel line within the fuselage that might be susceptible to damage caused by deformation of the fuselage in a potentially survivable crash shall be designed and installed to allow a reasonable degree of deformation and elongation without leakage.

2.10 **Engine Refrigerant* Injection Systems**

2.10.1 Engine refrigerant injection systems shall comply with the appropriate requirements of this Chapter **G5—2,** and **G5—1,** 2.4.

2.10.2 The engine refrigerant quantity available for the use of each engine shall be sufficient to allow operation of the rotorcraft under the procedures for the use of the augmented power system.

3 FUEL SUPPLY

3.1 **General**

3.1.1 The supply system shall be so arranged that in the event of a failure of any main fuel supply pump, the requirements of 2.1 and 3.2 are met. (See **Section J,** Chapter **J2—1, 2** for requirements relating to electrical supplies.)

3.1.2 Means shall be provided for warning the flight crew when the fuel supply pressure at the inlet of an engine-driven pump is less than the approved minimum.

3.1.3 Malfunctioning of a flowmeter shall not result in unacceptable reduction in the rate of flow and pressure of the fuel supply.

NOTE: Normally the incorporation of a by-pass will be an acceptable means of meeting this requirement.

3.2 **Fuel Flow.** It shall be demonstrated that the fuel system will provide the fuel flow rates required by the engine for the rotorcraft design conditions and that the corresponding engine inlet fuel pressures are within the limits specified in the Engine Type Certificate Data Sheet.

3.2.1 The quantity of fuel in any tank supplying fuel to the system during the test shall be not greater than the unusable fuel quantity derived in accordance with 3.4, plus the minimum amount of fuel required to conduct the test.

3.2.2 Moving parts of flowmeters shall, for the purpose of the test, be fixed in a position that will produce the maximum pressure loss obtainable as a result of malfunctioning.

3.2.3 **Fuel Transfer.** The rate at which fuel can be transferred from any auxiliary tank to the associated main tank shall be demonstrated to be adequate under the rotorcraft design conditions in which the system is intended to be used.

*This term normally refers to water-methanol or water.

A.B 3.3 **Flow Between Tanks.** Where tank outlets are inter-connected or fuel transfer is possible from one tank to another, the system shall be designed to prevent the possibility of fuel flowing between the tanks in quantities sufficient:—

(a) to cause an overflow of fuel from the tank vents, when the tanks are full and the rotorcraft is operated under the conditions of 3.4.4, and

(b) for excessive tank pressure to occur due to overfilling.

3.4 **Unusable Fuel Quantity**

3.4.1 **Engine Feed Tanks.** In tanks which feed fuel directly to the engine, the unusable fuel quantity shall be the amount of fuel remaining in each tank when, with all fuel pumps operating, the first evidence of malfunctioning occurs in the conditions of 3.4.4.

3.4.2 **Transfer Tanks.** In tanks which transfer fuel to other tanks and do not feed engines directly, the unusable fuel quantity shall be that amount which is not transferable with all pumps operating in the flight conditions in which the fuel transfer is intended to take place.

3.4.3 **One Tank Pump Inoperative.** The effect on the unusable fuel quantity as a result of a pump failure shall be determined for each tank and included in the Flight Manual.

3.4.4 **Conditions.** The unusable fuel quantity for each tank shall be established under the most adverse fuel feed conditions occurring for each intended operational and flight condition involving that tank. The appropriate members of the flight crew shall be informed, either by placard or by instructions in the Flight Manual, of the conditions under which the full amount of usable fuel is available.

NOTE: Consideration should be given to the possibility of fuel starvation in all Reasonably Probable attitudes (e.g. after engine failure, or stability augmentation system failure).

3.5 **Fuel Exhaustion.** The requirements of this paragraph 3.5 are applicable to fuel systems where an engine can be supplied with fuel from more than one tank.

3.5.1 **Piston Engines.** When malfunctioning of an engine occurs through depletion of the fuel supply from one tank, it shall be possible to restore rapidly the required engine power at the required fuel pressure after selecting an alternative source of supply.

3.5.2 **Turbine Engines.** The fuel supply to each engine shall be arranged to prevent interruption of fuel flow to the engine, without attention by the flight crew, when any tank supplying fuel to that engine is depleted of usable fuel during normal operation, and any other tank that normally supplies fuel to that engine contains usable fuel.

4 FUEL TANKS

4.1 **General**

4.1.1 Each fuel tank shall have sufficient strength to withstand all combinations of vibration, inertia, fluid and structural loads to which it may be subjected at:—

(a) Limit Load conditions without leakage or detrimental deformation, and

(b) Ultimate Loads without unacceptable leakage or structural failure.

4.1.2 Each fuel tank shall be provided with an adequate expansion space which is not less than 2% of the tank capacity. The filling arrangement shall be such that the expansion space cannot be filled inadvertently when the rotorcraft is in the normal ground attitude. For pressure refuelling systems, compliance with this requirement may be shown with the means provided to comply with 7.2.

A.B

4.1.3 Each integral tank shall be provided with adequate access to permit the inspection and repair of the complete interior of the tank.

4.1.4 Each flexible tank shall be of an Approved type and suitable for the particular installation.

4.1.5 **Sumps and Water Drainage**

(a) Each tank shall be provided with drainable sumps of adequate capacity, or equivalent means, which will permit drainage of water from all portions of the tank, with the rotorcraft in the normal ground attitude, to prevent the accumulation of hazardous quantities of water.

NOTE: A sump capacity of not less than 0·10% of the tank capacity is recommended.

(b) The design of flexible tanks shall be such as to prevent changes in the shape of the tank in service that would invalidate the provisions of this paragraph 4.1.5.

4.1.6 **Outlets**

(a) Each fuel supply outlet from the tank shall be provided with a coarse mesh screen. The screen shall:—

(i) have a diameter at least equal to that of the fuel tank outlet,

(ii) have a clear area at least equal to five times the cross-sectional area of the outlet line, and

(iii) be accessible for inspection and cleaning.

(b) Additionally, on turbine engine installations, where the screen is likely to be subject to ice accretion, a means shall be provided to ensure an adequate fuel flow to the engine in these conditions.

4.1.7 **Filler Caps**

(a) Filler caps shall not leak fuel when subjected to the pressure tests of 4.2.

(b) Filler caps shall be designed to minimise the probability of incorrect fitting and of leakage in flight. Filler caps and their attachments shall be designed to prevent an electrostatic discharge from the filler cap or its attachment within the tank.

4.1.8 **Materials, Sealants and Protective Coatings.** Tank materials, sealants and any protective coatings which may be used on tank interior surfaces shall be satisfactory for all normal conditions of operation.

4.1.9 **Microbiological Contamination.** Tanks shall be designed and protected to minimise the possibility of corrosion as a result of microbiological contamination of the fuel.

4.1.10 **Temperature of Components.** The maximum exposed-surface temperature of any component in the fuel tank shall not exceed 200°C under any normal, malfunction or failure conditions.

4.2 **Tests**

4.2.1 **Prototype Tanks—Proof Pressure Tests**

(a) It shall be demonstrated by tests that each type of fuel tank, as installed in the rotorcraft, can withstand without leakage or detrimental deformation the most critical of the pressures resulting from the conditions of (i) to (iv). In addition, it shall be shown by analysis or test that tank surfaces can withstand pressures resulting from the conditions of (v) and (vi) where these are more critical.

(i) An internal pressure of 24 kN/m² (3·5 lbf/in²).

A.B

(ii) 125% of the maximum internal air pressure which is developed in the tank by the effect of ram air.

(iii) The maximum pressure that could occur in a tank pressurisation system on the ground or in flight under all normal conditions and emergency conditions other than Extremely Remote.

(iv) The maximum internal pressure developed during refuelling or fuel transfer, taking into account the failure of the shut-off device required by 7.2.1.

(v) The total pressure developed during the most adverse combination of rotorcraft attitude and fuel load.

(vi) The pressure arising, together with such tank deflections as there may be, from the maximum normal acceleration(s) of the flight loads of **G3—2** with the tank full.

(b) In the case of flexible tanks the tests shall be made with the tank installed in the rotorcraft or in a representative structure.

4.2.2 **Prototype Tanks—Vibration and Surging Tests**

(a) Each metallic tank with large unsupported or unstiffened flat surfaces shall be subjected to vibratory and rocking tests to a schedule agreed with the Authority. Each tank shall withstand the tests without leakage or excessive deformation.

(b) Each non-metallic tank shall be subjected to rocking tests to a schedule agreed with the Authority, unless there is satisfactory operating experience with a similar tank in a similar installation.

4.2.3 **Series Tanks.** The drawings shall specify that each series metal tank, and each series flexible tank when installed in its compartment on the rotorcraft, shall be subjected to a static pressure test of not less than one third of the design proof pressure.

4.3 **Tank Installation**

4.3.1 Spaces adjacent to each tank shall be vented and drained to the outside of the rotorcraft so that no hazard is likely to result from fuel leakage into the surrounding space.

NOTE: For tank compartments that are isolated from other compartments of the rotorcraft, and in which the space surrounding the tank is small, the venting provided by the compartment drains is usually adequate.

4.3.2 The location of the fuel tanks in relation to the firewall shall comply with the requirements of **G5—8**, 3.2.

4.3.3 No portion of the rotorcraft skin which lies immediately behind a major air exit from an engine compartment shall act as the wall of an integral tank.

4.3.4 **Supports for Removable Tanks.** The requirements of this paragraph 4.3.4 are applicable to the means of supporting removable tanks.

(a) Each tank supporting structure shall have sufficient strength to withstand without failure any vibration, inertia or structural loads to which it may be subject in the rotorcraft design conditions, including the Crash Landing conditions of **G3—8**.

(b) The method of support for rigid fuel tanks shall be such as to avoid a concentration of loads resulting from the weight of fuel in the tank on unsupported tank surfaces.

(c) Means shall be provided to prevent chafing between the tank and its supports. Materials used for this purpose shall be non-absorbent.

(d) The method of support for flexible tanks shall be such that the tank is not required to withstand fluid loads.

A.B 4.3.5 **Interior Surfaces of Compartments.** Interior surfaces of compartments for flexible tanks shall be smooth and free of projections which could cause wear of the tank.

4.3.6 **Tank Vent Systems and Tank Pressurisation Systems**

(a) Fuel tank venting shall be effective under the rotorcraft design conditions, including climb and descent at the maximum rate, refuelling, defuelling and jettisoning.

(b) Each venting system shall be designed and arranged so that under the rotorcraft design conditions there will be:—

(i) no syphoning of fuel,

(ii) no prevention or restriction of fuel flow as a result of aerodynamic suction,

(iii) no point in the vent system where hazardous quantities of moisture can accumulate when the rotorcraft is in the normal ground attitude or any steady flight attitude,

(iv) no obstruction of the vent system by dirt or ice formation when the rotorcraft is in any ground or flight attitude, and

(v) no excessive pressure differentials between the interiors and exteriors of the tanks.

(c) The arrangement of tank vents shall be such that the discharge of fuel from the vent outlet would not constitute a fire hazard nor could fuel or vapour enter personnel compartments or other portions of the rotorcraft where a hazard of ignition may exist.

(d) Tanks, the outlets of which are interconnected, shall have their air spaces interconnected or shall have equivalent safeguards against unintended differential emptying of tanks.

(e) Where a system is provided to maintain and control fuel tank pressures on the ground and in flight, it shall be automatic in operation. Means shall be provided to enable the safety features of the system to be checked prior to flight.

5 MEANS OF CONTROLLING FUEL

5.1 Closure of the shut-off means required by **G5—8**, 4.3.5 for any engine, shall not make any of the fuel supply which is normally available, unavailable to the remaining engines or auxiliary power-unit capable of supplying Essential Services in flight.

NOTE: The need for shutting off the fuel supply from each tank or group of tanks should be considered, taking into account the general arrangement of the system and the fuel system management procedure.

A 5.2 Where a minimum flight crew of two or more are required the operating controls for the shut-off means shall be so positioned as to be operable by at least one pilot and another flight-crew member or, if no provision is made for the carriage of another flight-crew member, by two pilots, without leaving their seats.

A.B **6** SPILL VALVES—TURBINE ENGINES The arrangement of fuel systems incorporating spill valves shall be such that the discharge of fuel from the valve would not constitute a fire hazard. The quantity of fuel spilled shall be kept to a minimum consistent with safety particularly during Power-unit operation on the ground. (See **G5—1**, 7.4.)

A.B 7 PRESSURE REFUELLING SYSTEM (see G5—2 App., 1)

7.1 **General.** The complete pressure refuelling system shall have Proof and Ultimate Factors of not less than 1·33 and 2·0 respectively under the loads produced by the maximum measured surge pressure occurring during refuelling (see also 13.2.1). In establishing the maximum surge pressure, account shall be taken of the closure of any combination of tank valves, either intentionally or inadvertently.

NOTE: Bonding requirements are contained in Chapter **G4—6**, 6.5.

7.2 **Automatic Means of Shut-off**

7.2.1 An automatic shut-off means or its equivalent shall be provided to prevent the quantity of fuel in each tank from exceeding the maximum quantity approved for that tank.

7.2.2 A means shall be provided to prevent damage to the fuel system in the event of failure of the shut-off means of 7.2.1.

7.3 **Connections.** Each pressure refuelling system connection shall have means to prevent the escape of hazardous quantities of fuel from the system if the refuelling isolation valve at the connection fails.

7.4 **Discharge Pipes.** Discharge pipes shall terminate outside the rotorcraft so that fuel cannot be deposited on or in the rotorcraft in such quantities as to constitute a fire hazard.

7.5 **Functioning of Moving Parts.** It shall be possible before each refuelling operation to check the functioning of any moving parts of the means provided in accordance with 7.2.2. The design of such parts shall be such as to preclude the risk of malfunctioning as a result of ice-accretion.

7.6 **Drainage.** Provision shall be made for the draining of residual fuel from the pressure refuelling system after refuelling so far as is necessary to remove any hazard.

7.7 **Markings.** The maximum permissible refuelling supply pressure and flow rate shall be marked adjacent to the rotorcraft refuelling point(s).

8 DEFUELLING SYSTEMS

8.1 The defuelling system shall have Proof and Ultimate Factors of not less than 1·33 and 2·0 respectively under the loads produced by the maximum depression at the defuelling point (see also 13.2.1).

8.2 Provision shall be made for the draining of residual fuel from the defuelling system after defuelling, so far as is necessary to remove any hazard.

8.3 The maximum permissible defuelling depression shall be marked adjacent to the rotorcraft defuelling point(s).

9 FUEL JETTISONING SYSTEMS

9.1 **General** (see **G5—2** App., **2**)

9.1.1 Where a jettisoning system is provided, it shall be shown that the fuel will be discharged safely.

A 9.1.2 A means shall be provided to prevent the quantity of available fuel being reduced inadvertently during jettisoning below that quantity that will allow climb, with all engines operating, from sea level to an altitude of 5,000 feet followed by 30 minutes cruise at a speed most suitable for maximum range. However, this means may be dispensed with if the jettisoning of fuel below this level can only be accomplished by the operation of a separate control after the normal jettisoning operation has been completed.

B NOTES: (1) For Group B rotorcraft reference should be made to the Authority.

A.B (2) See **G5—7, 8** for jettisoning system controls.

9.1.3 If the jettisoning system uses pumps or pipelines in common with the engine fuel feed system, compliance with 1.1 shall be determined while jettisoning.

9.1.4 A jettisoning system shall be such that when jettisoning is terminated and the system is no longer in use, an explosion in any part of the jettisoning system downstream of the shut-off valve will not spread into the fuel tanks.

A 9.2 **Jettisoning Systems Installed to Meet Operational Performance Requirements.** In addition to the requirements of 9.1, where a jettisoning system is provided in order to meet operational performance requirements following a power-unit failure:—

(a) The jettisoning rate shall be established, and

(b) The combined probability of Power-unit failure and a Failure precluding either:—

(i) jettisoning of the necessary weight of fuel, or

(ii) loss of the protection against over-jettisoning, or

(iii) the system achieving the established jettisoning rate,

shall not be greater than Extremely Remote.

A.B 9.3 **Flight Tests**

9.3.1 Satisfactory jettisoning of fuel shall be demonstrated in flight under the following conditions:—

(a) Climb at the maximum rate of climb with the operating Power-units at the maximum rating Approved for the climb.

(b) Descent (see **G5—2** App., 2.2).

(c) Level flight at the maximum speed for jettisoning.

9.3.2 During the flight tests it shall also be demonstrated that:—

(a) fuel is discharged safely, clear of all parts of the rotorcraft,

(b) control of the rotorcraft is not adversely affected, and

(c) that jettisoning can be terminated and restarted at any time during the jettisoning operation.

10 CARBURETTOR VAPOUR VENTS

10.1 Carburettor vapour vents shall terminate in a fuel tank. Where fuel tanks are used in a definite sequence, the termination of the vapour-vent return line shall be in that tank used for take-off and landing.

10.2 A means shall be provided to prevent the blockage of carburettor vapour-vents by ice in all likely operating conditions.

A.B 11 INSTRUMENTATION Fuel system instrumentation shall be provided in accordance with this paragraph **11** and Chapter **G6—1**.

11.1 **Fuel Quantity Indication**

11.1.1 Means shall be provided to indicate to the appropriate crew members during flight the quantity of usable fuel in each tank.

NOTE: Tanks, the outlets and air spaces of which are interconnected may be considered as one tank and need not be provided with separate indicators.

A 11.1.2 An independent means of checking the fuel quantity indication for gross errors shall be provided for use on the ground.

A.B 11.1.3 **Calibration**

(a) The performance of the fuel quantity indicator system shall be established for appropriate rotorcraft attitudes, including cruise and refuelling conditions. The appropriate system performance information shall be included in the Flight Manual.

(b) Indicators shall be clearly marked (in terms of standard units of quantity and not fractions of tank capacity) on the indicator dials. The "zero" mark on the indicator shall correspond to the condition of the tank when the quantity of fuel remaining in the tank is equivalent to the unusable fuel quantity.

(c) **Series Rotorcraft.** The drawings shall contain a note requiring the calibration to be checked on a proportion of series rotorcraft.

11.2 **Engine Refrigerant Quantity Indicators**

11.2.1 **Take-off Conditions Only.** Where refrigerant is intended for use only during take-off, means shall be provided to indicate when the rotorcraft is on the ground, the quantity of refrigerant in each tank.

11.2.2 **Take-off and Other Conditions.** Where refrigerant is intended for use during take-off and other flight conditions means shall be provided to indicate to the flight crew, both when the rotorcraft is in flight and on the ground, the quantity of refrigerant in each tank. The indicators shall comply with the appropriate requirements of 11.1.

11.3 **Ice Protection Means.** Means of checking readily on the ground and in flight the functioning of the fuel heater, if provided, or, if practicable, any other alternative means used to protect the system against icing (see **G6—1**, 3.2.1 (p)).

12 MARKINGS (see G5—1, 2.4)

13 TESTS A schedule of ground and flight tests (as appropriate) of the fuel system and its component parts shall be prepared and agreed with the Authority. The schedule shall cover those requirements of this Chapter **G5—2** for which compliance involves testing. For convenience the tests are listed in this paragraph **13**, together with any additional conditions applicable for special design features or conditions of testing, etc.

A.B

13.1 **Tanks**

13.1.1 **Pressure Tests.** The pressure tests prescribed in 4.2.1 and 4.2.3.

13.1.2 **Vibration and Surging Tests.** The vibration and surging tests prescribed in 4.2.2.

13.1.3 **Expansion Space.** Determination of the expansion space as prescribed in 4.1.2.

13.1.4 **Unusable Fuel Quantity.** Determination of the unusable fuel quantity as prescribed in 3.4.

13.1.5 **Tank Sump.** Determination of the capacity and effectiveness of the tank sump as prescribed in 4.1.5.

13.1.6 **Undrainable Fluid Quantity.** Determination of the quantity of fluid which cannot be drained from the tank as prescribed in 4.1.5.

13.1.7 **Tank Vents.** The tests necessary to demonstrate compliance with 4.3.6.

13.2 **Fuel System**

13.2.1 **Pressure Tests.** Tests for leaks or distortion in the fuel system at the following pressures:—

(a) **Pressure Refuelling System (Without Tank).** With the tank refuelling isolation valves closed, 1·33 times the maximum measured surge pressure.

(b) **Defuelling System.** 1·1 times the maximum declared depression at the defuelling point.

13.2.2 **Fuel Flow Rate.** Determination of the fuel flow rate from any tank supplying fuel to the engine including the cross-feed system, and that between transfer and main tanks as prescribed in 3.2.

13.2.3 **Fuel Flow Between Interconnected Tanks.** Demonstration of compliance with the requirements prescribed in 3.3.

13.2.4 **Fuel Contamination.** Demonstration of compliance with the requirements prescribed in 2.6, unless previously demonstrated on the engine unit.

13.2.5 **Air Locks and Vapour Locks.** Tests to demonstrate compliance with 2.5.

13.2.6 **Pressure Refuelling and Defuelling.** Such tests as are necessary to demonstrate compliance with **7** and **8**.

13.2.7 **Fuel Jettisoning.** The jettisoning tests prescribed in **9**.

13.2.8 **Fuel Exhaustion Recovery.** Tests to demonstrate compliance with 3.5.

13.2.9 **Fuel System Temperature.** Sufficient tests shall be undertaken:—

(a) to determine that the temperature of the fuel throughout the fuel system will at no time be so low as to affect the functioning of the fuel system adversely, and

(b) to check that any anti-icing or de-icing devices will afford adequate protection.

13.3 **Fuel Quantity Indicators.** Calibration of fuel quantity indicators in accordance with the requirements of 11.1.

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APPENDIX TO CHAPTER G5—2

Revised in part, 16th August, 1982

FUEL SYSTEMS

1 PRESSURE REFUELLING SYSTEMS (see G5—2, 7)

1.1 It is recommended that pressure refuelling systems, fuel tanks, and the means for preventing excessive fuel pressures, should be designed to withstand steady refuelling pressures of not less than 345 kN/m² (50 lbf/in²) at the coupling on the rotorcraft so as to minimise the possibility of the systems being damaged by use, inadvertently, of ground refuelling equipment capable of higher delivery pressures than those for which the systems have been designed.

1.2 Pressure refuelling systems should be arranged so that the fuel entry point is at or near the bottom of the tank so as to reduce the level of electro-static charge in the tank during refuelling.

2 FUEL JETTISONING (see G5—2, 9)

2.1 It is recommended that the average fuel jettisoning rate should be not less than 2·5% of the Maximum Weight per minute in the conditions of **G5—2**, 9.3.

2.2 (See **G5—2**, 9.3.1(b).) Unless otherwise agreed with the Authority, the minimum rate of descent should be approximately 500 ft/minute.

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SUB-SECTION G5—POWER-PLANT INSTALLATIONS

CHAPTER G5—3 OIL SYSTEMS

Revised, 1*st* June, 1975

A.B 1 GENERAL

1.1 An independent oil system shall be provided for:—

(a) each engine and

(b) for each transmission assembly the continued functioning of which is necessary following engine failure.

1.2 Oil systems shall be such as to supply an adequate quantity of oil at temperatures and pressures which are within the limitations established for continuous operation of the engine and of each applicable assembly of the Transmission System.

NOTES: (1) **G4—3, 3, 7 and 9, G4—9, G5—1 and G5—8** contain requirements affecting the location and construction of various items of the oil system.

(2) See **G4—1, 6** for requirements concerning reduction of normal acceleration.

1.3 The quantity of usable oil in each system shall be not less than the product of the maximum endurance of the rotorcraft under critical operating conditions and the corresponding maximum approved oil consumption rate.

NOTES: (1) The total system capacity should also take account of the additional quantity required for circulation and cooling.

(2) One of the factors to be taken into account is the need to ensure that the endurance of the rotorcraft with any one engine inoperative will not be limited by the oil supply available to the system in question.

2 TRANSMISSION SYSTEMS

2.1 Each oil system affecting a part the Failure of which could result in a Catastrophic Effect shall incorporate means to provide:—

(a) adequate warning of Failure of each system, and

(b) adequate lubrication after a single failure in the oil system to allow:—

A1 (i) A Group A rotorcraft to continue flight either to its original destination or any alternate.

A2.B (ii) A Group A2 or Group B rotorcraft to continue flight for the maximum time likely to be required to enable an Emergency Landing to be completed.

A.B NOTES: (1) See also **G4—1**, 2.2 (b) Footnote.

(2) See **G6—1**, 2.11 concerning the loss of fluid in the event of a failure of an instrument pipeline.

2.2 A strainer, which shall comply with **6**, shall be fitted at the suction side of each pressure and scavenge oil pump.

2.3 Transmission Systems having no oil tanks shall have provision to prevent the entry into the system of any foreign objects that could obstruct the flow of oil.

A.B 2.4 All atmospheric vents in the oil system shall be protected against the ingress of extraneous matter and blockage by ice.

2.5 Each transmission assembly shall be protected so that a defective accessory cannot cause contamination of the oil supply or hazardous loss of transmission oil.

3 TANKS

3.1 Construction

3.1.1 **Strength.** Oil tanks shall have sufficient strength to withstand all combinations of vibration, inertia, fluid and structural loads to which they may be subjected at:—

(a) Limit Load conditions without leakage or detrimental deformation, and

(b) Ultimate Loads without unacceptable leakage or structural failure.

NOTE: See also 11.1.

3.1.2 **Expansion Space**

(a) An expansion space sufficient to allow for foaming and expansion of the oil and for the oil displaced from the system during operation shall be provided.

(b) The expansion space shall not be less than:—

(i) **Turbine Engines.** 10% of the tank capacity.

(ii) **Piston Engines.** 10% of the tank capacity or 2·27 litres (0·5 gal), whichever is the greater.

(iii) **Transmission Assemblies.** 10% of the tank capacity.

(c) The design of the tank shall be such that it is not possible inadvertently to fill the tank expansion space with oil when the rotorcraft is in the normal ground attitude.

NOTES: (1) When determining the expansion space account should be taken of any provision for oil dilution.

(2) The scavenge oil return to the tank should be arranged to minimize the risk of excessive foaming.

3.1.3 **Flow Obstruction.** Provision shall be made to prevent the entry into the tank itself or into the tank outlet of any foreign objects that could obstruct the flow of oil. Any screen or guard enclosing the oil tank outlet shall not reduce the flow of oil below the required value at any operating condition.

3.1.4 **Filler Caps.** Filler caps shall be designed to minimize the possibility of incorrect closure and of leakage in flight.

3.2 Installation

3.2.1 Oil tanks shall be isolated from personnel compartments by means of leakproof enclosures.

NOTE: See also 7.3.2 for tanks installed in Designated Fire Zones.

3.2.2 Spaces adjacent to each oil tank shall be vented and drained to the outside of the rotorcraft so that no hazard is likely to result from oil leakage into the surrounding space.

3.2.3 The location of the tanks in relation to the firewall shall be such as to enable compliance with the requirements of **G5—8,** 3.2.

3.2.4 No portion of the rotorcraft skin which lies immediately behind a major air exit from an engine compartment shall act as the wall of an integral tank.

A.B

3.2.5 **Supports for Removable Tanks.** The requirements of this paragraph 3.2.5 are applicable to the means of supporting removable tanks.

(a) Each tank supporting structure shall have sufficient strength to withstand without failure any vibration, inertia, fluid, or the structure loads to which it may be subjected in the rotorcraft design conditions, including the Crash Landing conditions of **G3—8.**

(b) The method of support shall be such as not to result in a concentration of loads resulting from the weight of oil in the tank on unsupported tank surfaces.

(c) Means shall be provided to prevent chafing between the tank and its supports. Materials used shall be non-absorbent.

(d) Flexible tanks shall be supported so that the tank is not required to withstand fluid loads.

3.2.6 **Interior Surfaces of Compartments.** Interior surfaces of compartments for flexible tanks shall be smooth and free of projections which could cause wear of the tank.

3.2.7 **Tank Vents**

(a) Oil system venting shall be effective in the rotorcraft design conditions, including climb and descent at the maximum rate.

(b) Each oil system venting system shall be designed and arranged so that in the rotorcraft design conditions there will be:—

(i) no syphoning of oil,

(ii) no prevention or restriction of oil flow as a result of aerodynamic suction,

(iii) no obstruction of the vents by fluid (including condensed water vapour) or foreign matter when the rotorcraft is in the normal ground attitude or any steady flight attitude,

(iv) no obstruction of the vents by ice when the rotorcraft is in any ground or flight attitude, and

(v) no excessive pressure differentials between the exterior and interior of the tank.

(c) Oil system vents shall not terminate at points where the discharge of oil from the vent outlet would constitute a fire hazard or from which oil or vapour could enter personnel compartments or other portions of the rotorcraft where a hazard of ignition might exist.

(d) Tanks, the outlets of which are interconnected, shall have their air spaces interconnected (but see 1.1).

4 PROPELLER FEATHERING

4.1 Where the system for feathering a propeller makes use of the engine oil supply, provision shall be made to trap a quantity of oil in the tank sufficient to complete one feathering cycle (i.e. feather and unfeather). The trapped oil shall be available only for this purpose (see also 11.3).

4.2 Provision shall be made to prevent any likely sludge or other foreign matter entering the propeller feathering system from the oil tank.

A.B

5 OIL BREATHER PIPELINES

5.1 Oil breather pipelines shall be so arranged that oil or condensed water vapour cannot collect at any point and either obstruct the line or freeze. The breather discharge outlet shall be designed to preclude blockage by foreign matter or ice.

5.2 Oil breather discharge outlets shall be designed and arranged so as not to constitute a fire risk or have detrimental effects on the rest of the rotorcraft.

6 OIL FILTERS

6.1 **General.** Filters shall be provided of adequate filtration qualities and capacity for the particular installation.

6.2 **Piston Engines.** Each filter shall be so constructed and installed that complete blockage of the filter element will not prevent the circulation of oil at the normal rate through the system.

7 ENGINE OIL SHUT-OFF MEANS

7.1 A means shall be provided to shut-off the oil supply to the engine, except for turbine engine installations where the tank and all oil system components external to the casing of the engine are Fireproof. The means provided shall be so designed, arranged and located that, in the event of failure of any oil system pipeline, it will, when operated, prevent the discharge of oil in such quantities and into such locations as would introduce a fire hazard or constitute a further hazard in the event of fire.

7.2 Operation of the shut-off means shall not prevent the utilization of any oil supply intended for the propeller feathering operation.

7.3 **Location of Oil Shut-off Means**

7.3.1 Where an oil tank is located outside a Designated Fire Zone, the shut-off means shall also be located outside a Designated Fire Zone.

7.3.2 Where the oil tank is located within a Designated Fire Zone, the tank, the shut-off means and the components of the oil system connecting the tank to the shut-off means shall be Fireproof (see also **G5—8,** 3.2.1).

7.4 **Controls**

7.4.1 Controls for shut-off means, which are located in a Designated Fire Zone shall be Fireproof but, if equivalent safety can be shown, may be Fire-resistant.

7.4.2 Precautions shall be taken in the design and arrangement of the controls to minimize the probability of starting the engine with the shut-off means closed.

8 ENGINE WINDMILLING WITHOUT OIL SUPPLY

For multi-engined rotorcraft it shall be established that the requirements of **Section C,** Chapter **C4—6, 25,** are not invalidated by the Power-plant characteristics of the particular rotorcraft.

A.B 9 OIL HEAT EXCHANGERS The air ducts for oil system heat exchangers shall be so constructed and located that, in the event of fire, flames issuing from normal openings of the engine compartment will not impinge directly on the heat exchanger matrix.

NOTE: See also **G5—1**, 7.6.

10 MARKINGS See **G5—1**, 2.4.

11 TESTS The tests of this paragraph **11** shall be made where tests are necessary in order to show compliance with the requirements of this Chapter.

11.1 **Oil Tank Tests**

11.1.1 **Prototype Tanks—Pressure Tests.** It shall be demonstrated that each type of oil tank complete with its filler cap can withstand without unacceptable leakage or structural failure the more critical of:—

(a) an internal pressure of 35 kN/m² (5 lbf/in²) more than the maximum operating differential pressure, or

(b) 1·5 times the maximum operating differential pressure of the tank.

11.1.2 **Series Tanks—Pressure Tests.** The test pressure and the procedure to be followed for testing series tanks shall be specified on the drawings.

11.1.3 **Prototype Tanks—Elevated Temperature Tests.** If the tank materials could be adversely affected by elevated temperatures, the appropriate tests shall be carried out on the tank at the maximum temperature likely to be experienced in service. If the appropriate maximum temperature is not determined the test shall be carried out with the fluid at a temperature of 120°C.

11.2 **Cooling Tests.** The tests for establishing compliance with **1** shall be made under the conditions governing the Power-plant cooling tests of **G5—4** and the transmission and rotor system ground and flight tests of **G7—3** and **G7—4.**

11.3 **Propeller Feathering.** The ability to complete one feathering cycle (i.e. feathering and unfeathering) when the supply of oil has been reduced to the level of the feathering reserve oil (see 4.1) shall be demonstrated either in flight or on the ground.

11.4 **Transmission System Tests.** The tests for compliance with 2.1 shall be agreed with the Authority. (See **G4—9**, 3.1).

SUB-SECTION G5—POWER-PLANT INSTALLATIONS

CHAPTER G5—4 COOLING SYSTEMS

Revised, 1st June, 1976

A.B

1 GENERAL

1.1 The design of the Power-plant shall be such that the temperatures of its component parts (Power-units, transmission assemblies, components, equipment, engine fluids, etc.) together with adjacent structural components can be maintained within the established safe values for all rotorcraft ground and flight conditions (including hovering in still air, and heat soakage after engine shutdown) when the rotorcraft is operated in the climatic conditions for which certification is desired. The climatic conditions shall be chosen in terms of the Standard Climates of **G1—2,** 1.4, and shall be not less than the ICAO Intercontinental Maximum Standard Climate of Fig. 1 (G1—2).

1.2 The climatic conditions in which the rotorcraft may be operated shall be stated in the Flight Manual.

2 LIQUID-COOLANT SYSTEMS—PISTON ENGINES Requirements for liquid-coolant systems shall be decided in consultation with the Authority. For this purpose the Authority shall be consulted at an early stage in the design.

3 TESTS (see G5—4 App.) Compliance with the requirements of **1** shall be demonstrated by tests.

3.1 A schedule of ground and flight tests, covering all critical conditions within the range for which certification is desired shall be prepared by the Applicant and shall be agreed by the Authority.

3.2 When the tests are conducted in atmospheric temperatures different from the maximum declared air temperatures, selected in accordance with **1,** the observed temperatures shall be corrected to the Standard conditions of atmospheric temperature appropriate to the altitude. The correction shall be applied by adding to the observed temperatures the difference between the true ambient air temperature and the Standard atmospheric temperature appropriate to the altitude unless a more rational correction can be substantiated. No corrected temperature shall exceed an Approved limitation.

3.3 **Fuel.** The fuel used during the tests shall be in accordance with (a) and (b), as appropriate and the engine fuel metering control settings shall be appropriate to normal operational practice.

(a) **Piston Engines.** The minimum octane rating or the lowest grade approved for the engine, and

(b) **Turbine Engines.** Any type approved for the engine.

4 ENGINE COOLING FANS Requirements for engine cooling fans are given in **G4—9, 7.**

APPENDIX TO CHAPTER G5—4

Issued, 1st June, 1976

COOLING SYSTEM TESTS

1 GENERAL (see G5—4, 3) Tests should be conducted in accordance with the general provisions of 2.1 and 2.2 and the test schedules should include the items detailed in 2.3 to 2.5.

2 TESTS

2.1 **Test Conditions**

2.1.1 Tests should not be made in conditions of rain or cloud unless it can be shown that the effect on the test results is insignificant or, alternatively, appropriate corrections to the satisfaction of the Authority can be made.

2.1.2 The initial weight of the rotorcraft during the flight tests should be as near as practical to the maximum permitted and where appropriate by the WAT curve limitations. Weight differences during the tests should be corrected using methods acceptable to the Authority.

2.1.3 The atmosphere temperature conditions in which the tests are made should be as near as practical to the limits of the temperature(s) for which compliance with the cooling requirements is to be shown.

2.1.4 For the purpose of these tests, automatically operated air flow control devices (e.g. oil cooler shutter controls) which can affect the cooling should not operate automatically but, where practicable, should be fully open. Such controls should be checked after the test to ensure that the range of automatic operation is adequate.

2.1.5 If adjustments which could affect fuel consumption or cooling are made during the tests, such tests as may be affected by the adjustments should be repeated.

2.1.6 The speed of the rotorcraft may be as high as, but not higher than, the speeds used in determining the corresponding performance in accordance with Sub-section G2.

2.1.7 **Ground.** Prior to take-off the engines should be run at the lowest speed recommended for running on the ground for 15 minutes or until the temperatures of the engines and equipment are stabilized, whichever is the sooner.

2.1.8 **Hover**

(a) Hovering tests should be made in calm air conditions.

(b) Hovering tests should be commenced with Power-plant temperatures as near as practical to the highest temperatures at which hovering is likely to be commenced in operation.

2.1.9 **Climb**

(a) Wherever possible, climb tests should not be made through inversions of temperature. Where this is not possible, supporting evidence for the correction factors used, should be provided.

(b) En-route climb should be commenced with Power-plant temperatures as near as practical to the highest temperatures at which en-route climb is likely to be commenced in operation.

2.1.10 **Power Offtakes.** Power offtakes such as engine air bleeds, accessory drives should be at the appropriate maximum for which cooling conditions are critical.

2.1.11 **Propeller Conditions.** The propeller conditions for the Critical Power-unit should be agreed with the Authority.

2.2 **Data.** The data of this paragraph 2.2 appropriate to the type of Power-plant and the type of test should be recorded. Observations should be made and the results recorded at frequent intervals during the climb, and until consecutive readings during level flight indicate that conditions have stabilized.

(a) Weight of the rotorcraft at the commencement of the test.

(b) Outside air and intake air temperature.

(c) Engine and rotor rotational speeds.

(d) Engine induction system manifold pressure.

(e) Engine induction system charge temperature.

(f) Torquemeter reading or parameters from which power/thrust can readily be determined.

(g) Turbine gas temperature or jet pipe gas temperature.

(h) Engine oil pressures—engine and cooler inlet and outlet.

(j) Engine oil temperature—engine inlet and outlet and cooler outlet.

(k) Transmission assembly oil pressures including gearbox and cooler inlet and outlet.

(l) Transmission assembly oil temperatures including gearbox inlet and outlet and cooler outlet.

(m) Cylinder head, and where appropriate barrel temperature, of each cylinder.

(n) Fuel consumption per engine.

(o) Engine fuel pressure—pump inlet, pump delivery and injector inlet.

(p) Fuel temperature at engine-driven pump inlet.

(q) A.S.I.R.

(r) Time of day.

(s) Rotorcraft altitude.

(t) Cooling gill position.

(u) Oil cooler flap position.

(v) Magneto temperatures.

(w) Temperatures of surfaces adjacent to the exhaust system and its efflux.

(x) Equipment temperatures.

(y) Engine bay and gearbox bay temperatures.

(z) Any other data which, on a particular rotorcraft, is relevant to cooling.

2.3 **Preliminary Tests.** Prior to the tests, preliminary tests should be made on the ground and where necessary, in flight, in order to establish that the engine systems and all equipment involved in, or subject to, test is functioning correctly.

2.4 **Ground Tests.** The schedule prepared in compliance with **G5—4,** 3.1 should cover:—

(a) The effect of heat soakage on the temperatures listed in 2.2 following engine shut down, and

(b) sustained engine operation at maximum powers and duration likely to be experienced in service on the ground.

NOTE: The most critical case for engine cooling may not be the most critical for the Transmission System, therefore if the critical case for engine cooling is with the rotor stationary, consideration should also be given to the critical transmission case.

2.5 **Flight Tests**

2.5.1 **General**

(a) Compliance with **G5—4,** 3.1, should include the tests of this paragraph 2.5 in the appropriate rotorcraft configurations at which the performance of the rotorcraft is established. Observations should be made on the Power-unit(s) shown by preliminary flight tests to be the most critical.

NOTE: The tests of paragraph 2.5 are based on demonstrations with all Power-units operating and with the Critical Power-unit inoperative. For rotorcraft having three or more Power-units, the need for cooling tests with two Power-units inoperative should be decided in conjunction with the Authority.

(b) The tests should include the effect of heat soakage on the temperatures listed in 2.2 (e.g. following the termination of the climb when engine power is reduced to cruising power).

2.5.2 **Rotorcraft Without Contingency Ratings—All Power-units Operating**

(a) **Hover.** Hover for a continuous period of 10 minutes in ground effect or until the temperatures have been stabilized for a period of 5 minutes, whichever is the greater.

(b) **Initial Climb.** Climb for a continuous period of 5 minutes at the maximum rating Approved for take-off.

(c) **En-route Climb.** Climb from 305 m (1,000 ft) at the maximum rating Approved for the climb:—

(i) until the rate of climb has fallen to 30·5 m/min (100 ft/min), or

(ii) for 5 minutes after the temperature has stabilized, or

(iii) until the maximum certificated operational altitude is reached.

(d) **En-route Cruise.** Fly in straight, steady, level flight at Maximum Weak Mixture Power or maximum rating Approved for continuous use or the power required to reach V_{NO}, as appropriate, until the temperatures stabilize.

(i) **Piston-engined Rotorcraft.** The altitude should be at or near the full throttle altitude for this power. If the full throttle altitude is at or near sea level, the test should be made at a height as near sea-level as is reasonably possible.

(ii) **Turbine-engined Rotorcraft.** The altitude should be representative of the normal operating range and should include tests at the upper and lower altitude limits.

2.5.3 **Rotorcraft Without Contingency Ratings—Critical Power-unit Inoperative**

(a) **Hover.** Repeat the test of 2.5.2(a) with the Critical Power-unit inoperative for the maximum duration for this condition.

(b) **Initial Climb.** Climb initially with all Power-units operating at the maximum rating Approved for take-off and simulate failure of the Critical Power-unit immediately after the Decision Point. Continue the climb for a period of 5 minutes with the Critical Power-unit inoperative and the remaining Power-unit(s) at the maximum rating Approved for take-off.

(c) **En-route Climb.** Repeat the test of 2.5.2(c) with the Critical Power-unit inoperative.

(d) **En-route Cruise.** Repeat the test of 2.5.2(d) with the Critical Power-unit inoperative. The test altitude should be representative of the normal operating range with one Power-unit inoperative.

2.5.4 **Rotorcraft With Contingency Ratings—Critical Power-unit Inoperative**

(a) **Hover.** Repeat the test of 2.5.3(a) but the maximum duration should not exceed the limitation for use of contingency rating.

(b) **Initial Climb.** Climb initially with all Power-units operating at maximum rating Approved for take-off and then simulate failure of the Critical Power-unit after the Decision Point. Continue the climb with the Critical Power-unit inoperative and the remaining Power-unit(s) at Maximum Contingency Power for 2·5 minutes and then at Intermediate Contingency Power to an altitude 305 m (1,000 ft) above the take-off surface.

(c) **En-route Climb.** Climb from 305 m (1,000 ft) at Intermediate Contingency Power:—

(i) until the rate of climb has fallen to 30·5 m/min (100 ft/min), or

(ii) for 5 minutes after the temperature has stabilized, or

(iii) until the maximum certificated operational altitude is reached.

(d) **En-route Cruise.** Fly in straight, steady, level flight at Intermediate Contingency Power until the temperatures stabilize. The test altitude should be representative of the normal operating range with one Power-unit inoperative.

SUB-SECTION G5—POWER-PLANT INSTALLATIONS

CHAPTER G5—5 AIR INTAKE SYSTEMS

Revised, 1st June, 1976

A.B

1 GENERAL

1.1 It shall be demonstrated (by ground or flight tests or both), that, under the rotorcraft design conditions, air is supplied to the Power-unit(s) in such a manner and in such quantity as will permit continued operation of the Power-plant within the established limitations.

1.2 Adequate flexibility shall be provided in ducts connected to components between which relative motion may occur.

1.3 Air intake drains shall comply with **G5—1,** 7.4.

2 LOCATION OF ENGINE AIR INTAKES

2.1 **General.** Engine air intakes shall be located or protected so that the risk of ingestion of foreign matter (e.g. stones, sand, water, snow, slush) during operation on or near the ground is reduced to an acceptable level.

2.2 **Ingestion of Parts.** All parts of the engine air intakes shall be designed and arranged so that the probability of any item becoming detached and entering the engine is minimized.

3 DE-ICING AND ANTI-ICING PRECAUTIONS

The requirements for de-icing and anti-icing precautions shall be agreed with the Authority.

4 DETAIL DESIGN—PISTON ENGINE INSTALLATIONS

4.1 **Alternative Engine Air Intake.** Each engine shall be provided with an alternative air intake source which, when selected, will prevent the entry of rain or any other likely foreign matter, and prevent the formation of ice in the induction system.

4.2 **Fire Precautions**

4.2.1 When engine air intakes open within the engine cowling, unless provision is made to prevent the emergence of backfire flames, the opening shall be isolated from the engine-accessory section by means of a Fireproof diaphragm or shoulder cowl.

4.2.2 Engine air intake system ducts upstream of the fuel metering device shall be provided with such drains as will prevent the hazardous accumulation of fuel or moisture when the rotorcraft is in the ground attitude.

4.2.3 Engine air intake system ducts shall have sufficient strength to prevent induction system failures resulting from backfire conditions of moderate severity. Where the ducts are subject to the full severity of the backfire conditions the strength should be such as to withstand a test pressure of 100 kN/m^2 (15 lbf/in^2). Account may be taken of devices which reduce the severity of backfire conditions.

A.B

4.3 **Engine Air Intake System Screens.** The requirements of this paragraph 4.3 are applicable to air intake system screens other than those which are both part of the bare engine and protected by local heat.

4.3.1 Screens shall be located upstream of the fuel metering device and in such a position that it is not possible for fuel to impinge on them.

4.3.2 Screens shall not be located in portions of the air intake system which constitute the only passage of air to the engine unless adequate means for continuous icing protection are provided for the complete flight.

4.4 **Carburettor Air Pre-heaters.** Each carburettor air pre-heater shall be designed and constructed such as to:—

(a) ensure ventilation of the pre-heater when the engine is operated in cold air,

(b) allow inspection of the exhaust manifold parts that it surrounds and

(c) allow inspection of critical parts of the pre-heater.

5 DETAIL DESIGN—TURBINE ENGINE INSTALLATIONS

5.1 Engine air intake system ducts shall have sufficient strength to withstand without failure loads arising in:—

(a) all conditions of engine operation, including surging, and

(b) the rotorcraft design conditions, including vibration.

5.2 It shall not be possible for leakage from any components or drains of Flammable fluid systems to enter the engine air intake system in quantities sufficient to create a hazard.

5.3 The engine air intake arrangement shall be such that no hazard will result in the event of any likely air flow reversal.

5.4 The engine air intake shall be such as to enable the requirements of **G4—1, 10** to be met (see also **Section C**, Chapters **C4—4, 18** and **C4—6, 19**).

SUB-SECTION G5—POWER-PLANT INSTALLATIONS

CHAPTER G5—6 EXHAUST SYSTEMS

Revised, 1st June 1976

A.B 1 APPLICABILITY The requirements of this Chapter are, as appropriate, applicable to exhaust systems, including jet pipes and exhaust heat exchangers.

NOTE: For components in the proximity of exhaust systems, see **G5—8**, 3.3.

2 GENERAL

2.1 **Materials.** Each exhaust system shall be constructed of materials suitable for continued operation at high temperatures and resistant to corrosion by the products of combustion.

2.2 **Design and Construction.** Each exhaust system shall be designed, constructed, arranged and supported so that:—

(a) the system will withstand without failure all vibration, pressure, inertia and other loads to which it may be subjected in the rotorcraft design conditions and no failure will occur in such a way that further hazard is caused under the Crash Landing conditions of **G3—8,**

(b) exhaust gases are safely discharged in all conditions of operation, including engine starting, without contamination of air in personnel compartments beyond the limits prescribed in **G4—3,** 7.4.1. Demonstration of compliance with this requirement shall be made by tests conducted in all normal ground and flight conditions including hovering,

(c) temperatures attained in operation will not significantly affect the mechanical reliability of an exhaust system and adjacent rotorcraft structure, and will not constitute a fire hazard,

(d) allowance is made for any expansion that will occur in all conditions of operation both on the ground and in flight, and

(e) adequate provision is made to permit, as necessary, flexibility, and relative movement between portions of an exhaust system.

2.3 **Drains.** Each exhaust system shall be provided with drains to prevent hazardous accumulation of moisture or fuel under all conditions, including Abortive and False Starts on the ground and in flight.

2.4 **Isolation.** Components of exhaust systems, when installed in compartments in which leakage of Flammable fluids could occur, shall be shrouded, insulated or ventilated as necessary, to preclude the possibility of ignition of the fluids.

2.5 **Glare from Exhaust.** On all rotorcraft for which certification for flight by night is sought there shall be no danger of the pilots' vision being seriously affected by glare from the exhaust.

A.B 3 EXHAUST HEAT-EXCHANGERS In addition to compliance with the appropriate requirements of **2**, exhaust heat-exchangers shall be designed, constructed and arranged so that:—

(a) when used in ventilating air systems the possibility is precluded that exhaust gases will enter the ventilating air in excess of the limits prescribed in **G4—3**, 7.4.1. To this end a secondary heat-exchanger shall be provided between the primary exhaust heat-exchanger and the ventilating air system, unless it can be demonstrated that equivalent safety can be obtained by other means,

(b) the heat-exchanger cannot be brought into use without the air supply which is to be heated flowing through it, if this could otherwise result in damage (see also **G5—5**, 4.4(a)), and

(c) provision is made for the inspection of all critical portions of exhaust heat-exchangers; particularly those portions in which welded construction is employed.

4 EXHAUST-DRIVEN TURBO-SUPERCHARGERS

4.1 Each exhaust-driven turbo-supercharger shall be installed such as to permit safe use under all operating conditions.

4.2 The turbine speed shall be limited automatically to the maximum allowable over-speed value.

SUB-SECTION G5—POWER-PLANT INSTALLATIONS

CHAPTER G5—7 CONTROL SYSTEMS

Revised, 1st June, 1976

A.B

1 GENERAL In addition to compliance with the general requirements for control systems and Operating Controls contained in **G4—2**, 4.2, **G4—8**, **1** and throughout this Sub-section G5, control systems and Operating Controls for the control of the Power-plant shall also comply with the specific requirements of this Chapter **G5—7**.

2 SAFETY ASSESSMENT The objectives of the safety assessment required by **G5—1**, 3 shall be met when complying with this Chapter **G5—7**. (See also **Section C**, Chapter **C4—2**.)

3 CONTROL OF ENGINE POWER

3.1 **General.** A separate system shall be provided to control the power of each engine and shall be such as to provide an adequately sensitive, immediate and progressive means of controlling the power over the whole operating range of the engine.

NOTE: For the purposes of this paragraph 3, "forward" is relative to the relevant member of the flight crew.

3.2 **Operating Controls**

3.2.1 The Operating Controls shall be so grouped and arranged as to permit both separate control of each engine and simultaneous control of all engines.

3.2.2 **Locks and Stops.** A positive lock or stop shall be provided at the minimum setting of the Operating Control which is permitted to be selected in flight to prevent inadvertent movement of the Operating Control beyond this position.

NOTE: A detent would normally be an acceptable means of compliance.

3.2.3 Engine power controls shall be such that:—

(a) for twist-grip power controls a clockwise movement as viewed from the free end of the collective pitch lever is necessary to increase power and an anticlockwise movement is necessary to decrease power,

(b) for twin-engined installations using twist-grip power controls the No. 1 engine twist-grip shall be nearest the free end of the collective pitch lever, and the No. 2 engine twist-grip shall be rearward of the No. 1 twist-grip,

(c) for power controls other than twist-grip power controls, a forward movement of the Operating Control is necessary to increase power and a rearward movement of the Operating Control is necessary to decrease power.

NOTE: The requirements of this paragraph relate to collective pitch levers which are pivoted at their rearward end.

A.B

4 CONTROL OF PROPELLERS

4.1 Speed and Pitch

4.1.1 A separate control system shall be provided for each propeller.

4.1.2 The propeller Operating Controls shall be so grouped and arranged as to permit both separate control of each propeller and simultaneous control of all propellers.

4.1.3 Operating Controls for effecting changes of propeller speed and pitch shall operate so that a forward movement of the Operating Control is necessary to increase rotational speed or to decrease the pitch of the propeller blades and a rearward movement is necessary to decrease rotational speed or to increase the pitch of the propeller blades.

NOTE: Propeller control systems which incorporate control movements for ground use only would be required to comply with 4.1.3 in respect of flight conditions only.

4.1.4 The controls shall allow synchronization of all propellers.

4.2 Feathering

4.2.1 A separate control system shall be provided for each propeller feathering system and suitable provision shall be made to prevent inadvertent operation.

4.2.2 If feathering is accomplished by movement of the normal Operating Controls for pitch- or speed- control, positive provision shall be made to prevent inadvertent operation of this control to the feathering position.

NOTE: The time to feather a propeller should not exceed 10 seconds at any operating altitude.

4.3 **Flight Pitch Locks.** Where a propeller is installed on which it is possible for the normal flight pitch lock to be withdrawn, means shall be provided for each such propeller to indicate to the flight crew when the propeller blade pitch is below the flight low pitch position for each propeller. The source of the indication shall sense blade position directly.

5 CONTROL OF IGNITION

5.1 Piston Engines

5.1.1 Ignition switches shall be provided for each ignition circuit on each engine and shall comply with either (a) or (b).

(a) **Toggle Type Switches.** Toggle type switches shall be such that when mounted on a vertical surface, ignition is "off" when the switch is down and "on" when the switch is up.

(b) **Rotary Type Switches.** Where a rotary type of combined ignition switch is used, the selection shall be clearly marked and the switch shall be installed such that it cannot rotate relative to these markings.

NOTE: It is recommended that the selection for both magnetos together should be on the right-hand side of the switch.

5.1.2 Each ignition circuit shall be independent of any other rotorcraft electrical system circuit, except for starting circuits and for circuits which may be used with equipment for analysing the operation of ignition circuits. The probability of a Failure in any circuit used for starting or for ignition analysis affecting the ignition circuit shall be Remote for a Failure which could affect one Power-unit and Extremely Improbable for a Failure which could affect more than one Power-unit.

A.B

5.1.3 Means shall be provided for rapidly switching off all ignition. This requirement shall be met either by grouping the switches or by providing a master control. If a master control is provided, a suitable guard shall be incorporated to prevent inadvertent operation.

5.2 **Turbine Engines**

5.2.1 Means shall be provided for the control of the ignition circuit(s) on each engine.

NOTE: Where two igniters are provided for each engine it is recommended that, except possibly for the selector switch, each ignition circuit should be independent.

5.2.2 At least one ignition circuit of each engine shall be independent of any other rotorcraft electrical system circuit.

5.2.3 At least one ignition circuit for each engine shall be capable of operation in flight independent of the functioning of the main electrical generating system.

6 CONTROL OF ENGINE INTAKE ICE PROTECTION SYSTEMS A separate system for the control of the ice protection system shall be provided for each engine.

7 CONTROL OF PISTON ENGINE FUEL/AIR MIXTURE

7.1 A separate system for the control of the fuel/air mixture shall be provided for each engine.

7.2 The Operating Controls shall be so grouped and arranged as to permit both separate control of each engine and simultaneous control of all engines.

7.3 Each fuel/air mixture control shall be provided with a guard or shall be so shaped or arranged as to prevent, by feel, its being confused with other controls.

8 CONTROL OF FUEL JETTISONING Fuel jettisoning Operating Controls shall be provided with guards to prevent inadvertent operation. The fuel jettisoning Operating Controls shall not be located in close proximity to fire extinguisher system Operating Controls or any other Operating Controls used in the fire drill declared in accordance with **G5—8**, 4.2.1 (b).

SUB-SECTION G5—POWER-PLANT INSTALLATIONS

CHAPTER G5—8 FIRE PRECAUTIONS

Revised, 1st June, 1976

A.B

1 APPLICABILITY The requirements of this Chapter are applicable to the installation of conventional piston or turbine-engined Power-units, and to auxiliary power-units.

2 GENERAL

2.1 **Designated Fire Zones.** Designated Fire Zones are:—

(a) **Piston Engine Installations**

(i) Engine power section.

(ii) Engine accessory section.

(b) **Turbine Engine Installations**

(i) Engine compressor and accessory sections.

(ii) Engine combustion, turbine and exhaust system sections.

(c) **Auxiliary Power-unit Installations**

(i) Auxiliary power-unit compartment, and exhaust system sections.

(d) Any other region which may be specified by the Authority.

2.2 **Test Conditions.** Where tests are prescribed to demonstrate that a component is Fireproof or Fire-resistant, the test conditions shall be those prescribed in BS 3G.100, Part 2, Section 3, Sub-section 3-13.

NOTE: The Authority may require that where vibratory conditions could be critical, components should be subjected to vibration during flame testing.

2.3 **Fire Tests.** Unless otherwise agreed by the Authority, fire tests shall be made on components of the engine installation as necessary to demonstrate compliance with the requirements of 4.4.1. If the arrangement of the Power-unit installation is unconventional and there is no previous experience, or there are any unusual design features that might present an increased fire risk and severity, the Authority may require tests to be made on a representative Power-unit installation or, alternatively, on a suitably adapted mock-up version, using a test facility which is capable of simulating, as necessary, the appropriate engine and rotorcraft operating conditions that are likely to be met in service.

3 PRECAUTIONS AGAINST FIRE

3.1 **General**

3.1.1 In addition to compliance with the detailed requirements of this paragraph **3**, all practical measures shall be taken to minimize the probability of fire both in flight and on the ground.

A.B

3.1.2 Absorbent materials in compartments where leakage or spillage of Flammable fluids (i.e. liquids, vapours, gases), could occur shall be covered or treated to prevent the absorption of hazardous quantities of fluid. Such compartments shall not contain Flammable materials.

3.1.3 In compartments other than Designated Fire Zones, where a Flammable mixture could occur the maximum temperature of exposed surfaces shall, in either normal conditions or Failure conditions, be such as to leave an adequate margin between the temperature of the surface and the spontaneous ignition point of the fluid in question.

NOTE: For fuel and fuel vapour, where there is little or no ventilating air flow, the maximum temperature of an exposed surface should not exceed 200°C. At higher ventilating air flow rates, a higher temperature limitation may be acceptable, depending upon the installation arrangement.

3.1.4 Group 2 Equipment not located in Designated Fire Zones, shall be so designed and installed that they will not in themselves create a risk of fire in either normal conditions or Failure conditions.

3.1.5 No system carrying Flammable fluid, which may be subject to leakage, shall be located in hazardous proximity to parts of the exhaust systems, jet pipes or other potential sources of ignition, including electrical equipment.

3.2 Flammable Fluid Systems

3.2.1 Tanks in Designated Fire Zones

(a) Tanks containing Flammable fluids shall not be installed in a Designated Fire Zone, except that engine fuel drain tanks, engine oil tanks and oil tanks associated with engine-driven equipment may be so installed provided that the tanks, their associated fittings and supporting structure are Fireproof. In addition, engine fuel drain tanks shall be explosion-proof.

NOTE: Small oil reservoirs need only be Fire-resistant if the release of oil as a result of damage to the reservoir would not significantly increase the fire hazard.

(b) Where necessary, tanks shall be adequately vented to the exterior of the rotorcraft by Fireproof vents, and any shut-off devices required by 4.3.5 shall be Fireproof and shall be mounted on the tank or connected to the tank by a Fireproof line.

B

(c) For piston engines with an integral sump of less than 22·7 litres (5 gal) capacity, the oil sump may be Fire-resistant only.

A.B

3.2.2 Filling points for Flammable fluids shall be designed so as to prevent unintended entry of the fluids into any portions of the rotorcraft other than the tanks.

3.2.3 The clearance between any tank and the firewall, where the tank contains Flammable fluids and is located on the outside of the Designated Fire Zone shall be such as to minimize the possibility of ignition of the fluids as a result of a fire in the Designated Fire Zone.

NOTE: Account should be taken of the risk of ignition of fluid which might leak from the tank and its associated fittings and contact the firewall.

3.3 Exhaust Systems

3.3.1 All components which might otherwise be affected by excessive temperature resulting from the proximity to exhaust system parts, or from exhaust gas impingement, shall be constructed of or shielded with a suitable heat-resistant material.

3.3.2 All exhaust system components which are outside the engine compartment shall be separated by a suitable heat-resistant material from adjacent parts of the rotorcraft.

A.B

3.4 Crash Fire Hazard

3.4.1 Precautions shall be taken to minimize the risk of fire in the Crash Landing conditions of **G3—8.** Particular attention shall be paid to the design, location and protection of all systems carrying Flammable fluids; the juxtaposition of such systems and items of electrical systems shall also be taken into account.

3.4.2 **Operation of Controls to Reduce Fire Risk in Crash Landing Conditions**

(a) So far as is practicable means shall be provided to enable precautions to be taken against the fire hazard in a Crash Landing. The means shall normally be brought into action by controls arranged such as to enable the flight crew to operate them:—

(i) with the minimum effort,

(ii) with the minimum number of actions, and

(iii) with the minimum risk of confusion.

(b) Parts of the installation intended to be brought into use in a Crash Landing shall, so far as is practicable, be designed, mounted and connected so that the parts will operate satisfactorily in the conditions prescribed in **G3—8.**

3.5 Ventilation and Drainage

3.5.1 Ventilation and drainage shall be provided, as necessary, for all portions of Designated Fire Zones and regions immediately adjacent to Designated Fire Zones, and for engine pod attachment structures to minimize any hazard resulting from leakage of any component containing Flammable fluid.

3.5.2 Openings such as vents, inlets and intakes shall be arranged so as to minimize the probability of entry of hazardous quantities of Flammable fluids resulting from leakage or spillage.

NOTE: Where there is a risk of leaking Flammable fluids re-entering the rotorcraft through joints in the cowling or other rotorcraft surfaces, the ventilation of such compartments should, where practical, be arranged to provide an air pressure within the compartment higher than that of the pressure of the ambient air.

3.5.3 It shall be demonstrated that the ventilation and drainage arrangements, are adequate under the rotorcraft design conditions.

3.5.4 The cooling air supply for generators and other electrical equipment shall be conveyed and discharged so as not to create a fire hazard following an internal failure of the equipment (e.g. by Fireproof ducting). (See also **Section J**, Chapter **J1—3**, 7.8.)

3.6 Auxiliary Power-unit Installations

3.6.1 Auxiliary power-units shall be so arranged that they cannot be operated with the cooling or exhaust systems or air supply shut off.

3.6.2 Where the burning through, by internal fire or overheat, of an auxiliary power-unit air intake system could result in a hazard to the rotorcraft, the air intake system shall be constructed to a Fireproof standard.

NOTE: In considering the possibility of overheat conditions account should be taken of airflow reversal through the auxiliary power-unit compressor.

3.6.3 Precautions shall be taken to ensure that hazardous quantities of Flammable fluid leaking from any region of the rotorcraft cannot enter the auxiliary power-unit engine intake system.

A.B

4 FIRE CONTAINMENT AND FIRE FIGHTING

4.1 Fire Detection (see G5—8 App., 1)

4.1.1 Turbine Engine Installations

(a) Each Designated Fire Zone shall be provided with a fire detector. The need for overheat or fire detection in areas immediately adjacent to a Designated Fire Zone shall be decided in consultation with the Authority.

(b) Fire detectors shall be of an Approved type.

(c) The fire detection system shall be of a resetting type.

(d) The fire detection system shall provide the flight crew with an adequate visual and audible warning of fire.

(e) Fire detector systems shall be so designed and installed that:—

(i) they withstand without failure all vibration, inertia and other loads to which they may be subjected both in flight and on the ground;

(ii) their efficiency is not impaired by exposure to fluids or vapours and, where applicable, any solar or artificial illumination which may be present;

(iii) indication of fire is given rapidly after its commencement and for the duration of the fire; indication of extinction of the fire is given with the minimum of delay;

(iv) those fire detection system components, including wiring, which are inside Designated Fire Zones and in regions immediately behind such zones are of at least Fire-resistant construction;

(v) no environmental temperatures encountered in normal operation will cause false fire warnings;

(vi) the functioning of the electrical circuit associated with the fire detection system may be checked by the flight crew.

NOTE: It is recommended that it be possible to check the complete system both on the ground and in flight.

(vii) so far as is practical, the failure of any part is more likely to render the system inoperative than to give a false warning, and

(viii) the system will remain operative in the event of severance of the detector system at any one point.

4.1.2 **Piston Engine Installations.** The necessity for and the requirements applicable to fire detection systems shall be decided in consultation with the Authority.

NOTE: Fire detection systems will not normally be required except possibly for relatively high-powered supercharged engines and for engines having a capacity greater than 0·015 m^3 (900 in^3).

4.2 Fire Extinguisher Systems (see also G5—8 App., 2.2.4)

4.2.1 **Turbine Engine Installations.** The design, general lay-out and detailed installation of all parts of the fire extinguisher systems shall be to the satisfaction of the Authority. The means by which the effectiveness of the systems can be demonstrated shall be decided in consultation with the Authority but will normally be confined to the measurement of the rate of discharge of the extinguishant and the distribution of the discharged extinguishant, although in certain circumstances the Authority may require rig tests or a fire tunnel test so as to include the extinguishing of representative engine fires. Each installation shall be designed or protected so as to operate satisfactorily under the Crash Landing conditions of G3—8, 1.

A.B

(a) **Arrangement of Systems** (see **G5—8** App., 2.1)

(i) Except for Power-unit installations which are not enclosed a fire extinguishing system shall be provided for each Designated Fire Zone, except for combustion, turbine and exhaust system sections of turbine engine installations that contain lines or components carrying Flammable fluids for which it can be shown that a fire originating in these sections can be otherwise controlled.

(ii) The need for a fire extinguishing system in areas immediately adjacent to a Designated Fire Zone shall be decided in consultation with the Authority.

(iii) Fire extinguisher systems shall be such as to provide an adequate supply of extinguishant to each region for which protection is provided.

(iv) Each Power-unit for which an extinguisher system is required shall have an individual system, arranged so as to permit the rapid discharge of extinguishant to the appropriate engine compartments.

(v) The fire extinguisher system shall be arranged so that it is possible to protect simultaneously each zone for which protection is provided.

(vi) Except for auxiliary power-units and for single engined rotorcraft, it shall be possible to direct a second adequate discharge of extinguishant to any Power-unit for which the first discharge of extinguishant has been used. The extinguishant provided for another Power-unit may be used for this purpose provided that selection of zones requires distinct action.

NOTE: The prevention of the possibility of confusion and inadvertent operation of controls is the subject of **G4—8, 1** and the juxtaposition of jettisoning controls and controls used in fire drills is the subject of **G5—7, 8.**

(vii) Each auxiliary power-unit shall have an individual system, which may be an individual one-shot system.

(viii) Fire detectors shall not operate main Power-unit extinguisher systems automatically.

NOTE: The purpose of this requirement is to enable the relevant member of the flight crew to delay commencement of the fire drill (and hence stopping the engine) in circumstances when engine shut-down might momentarily be more hazardous than an engine fire.

(b) **Fire Fighting Procedures.** (See **G5—8** App., 3). The procedures to be followed by the flight crew for fire fighting shall be established and included in the Flight Manual.

NOTE: It is recommended that placards should be provided giving fire drill instructions for the relevant crew members.

(c) **Fire Extinguishants** (see **G5—8** App., 2.2)

(i) The fire extinguishant shall have been demonstrated to have satisfactory extinguishing properties.

(ii) Provision shall be made to prevent harmful concentrations of the extinguishant or its vapours entering personnel compartments as a result of leakage during normal operation of the rotorcraft or of discharge of the extinguishant, and the arrangement shall be such that after discharge, the extinguishant will not be trapped in any portion of the rotorcraft which is not open to the atmosphere. Compliance with this requirement shall be demonstrated by tests where appropriate (see also **G4—3**, 7.4.3).

(d) **Fire Extinguishant Containers**

(i) Fire extinguishant containers shall be installed in locations where temperatures consistent with satisfactory operation of the system (including thermal stability of the extinguishant) will be maintained.

A.B

(ii) Each fire extinguishant container shall be provided with a pressure relief device to prevent bursting of the container as a result of excessive internal pressure.

(iii) Each pressure relief line shall discharge safely at a point outside the rotorcraft.

(iv) A discharge indicator shall be provided in a location convenient for inspection on the ground.

(e) **Fire Extinguisher System Materials.** Chemical reaction between the extinguishant and the materials used in the fire extinguisher system shall not be such as to have a deleterious effect on the system.

4.2.2 **Piston Engine Installations.** The necessity for, and the requirements applicable to, fire extinguisher systems shall be decided in consultation with the Authority.

NOTE: Fire extinguisher systems will not normally be required except possibly for relatively high-powered supercharged engines and for engines having a capacity greater than 0·015 m^3 (900 in^3).

4.3 **Containment of Fires**

4.3.1 **Isolation of Designated Fire Zones.** Designated Fire Zones shall be isolated from the remainder of the rotorcraft and from one another by means of firewalls in the form of Fireproof bulkheads, shrouds or equivalent means (see 4.3.3).

4.3.2 **Isolation of Other Regions.** Engine pod attachment structures and regions immediately adjacent to a Designated Fire Zone shall be isolated by suitable means from other regions of the rotorcraft to prevent ingress of hazardous quantities of Flammable fluids and vapours.

4.3.3 **Firewalls** (see **G5—8** App., **4**)

(a) Firewalls shall be constructed so as to preclude the passage of flames and hazardous quantities of Flammable Fluids and vapours from the Designated Fire Zone to any other part of the rotorcraft (see also 3.5).

(b) All openings in the firewall shall be sealed with suitable close fitting Fireproof grommets, bushings or fittings and the firewall periphery shall provide an adequate seal.

(c) Precautions shall be taken to prevent the possibility of hazardous distortion of the firewall under conditions of fire.

(d) Firewalls shall be Fireproof and corrosion resistant.

4.3.4 **Piston Engine Accessory Section Diaphragm (Shoulder Cowl).** A diaphragm shall be provided in radial air-cooled engine installations to isolate the engine power section and all portions of the exhaust system from the engine accessory section, unless equivalent fire protection can be demonstrated by other means or experience with a similar type of engine has shown this to be unnecessary. This diaphragm shall comply with the requirements for firewalls.

4.3.5 **Shut-off Means**

(a) Means shall be provided to enable the appropriate members of the flight crew to shut-off rapidly the flow of hazardous quantities of Flammable fluids into Designated Fire Zones. The shut-off means shall be located and attached so that it is unlikely to be damaged in the conditions of **G3—8.**

NOTE: Turbine engine installations are not required to have an engine oil system shut-off if the oil system complies with **G5—3,** 7.1.

A.B

(b) Each shut-off means shall be Fireproof or shall be protected or located so that a fire in a Designated Fire Zone will not affect their operation.

(c) The quantity of Flammable fluid that can drain into any Designated Fire Zone after closure of the shut-off means shall be minimized.

(d) The shut-off means prescribed in (a) and by **Section C**, Chapter **C4—2**, 2.1.7 shall be so installed that they can be operated as part of the engine fire drill.

(e) If closure of the shut-off means could result in excessive pressure in the system as a result of exposure to fire, provision shall be made for relief of pressure.

(f) Operation of the shut-off means shall not prevent the operation of any emergency equipment (e.g. auxiliary power-unit).

(g) Inadvertent operation of the shut-off means from both the "off" and "on" positions shall be adequately guarded against.

(h) Except in the case of a Crash Landing it shall be possible for the appropriate member of the flight crew at his station to re-open and close the shut-off means.

4.4 Protection

4.4.1 Inside Designated Fire Zones

(a) Destruction by fire of all installations within a Designated Fire Zone shall not interfere with the functioning of the remaining Power-units or their Essential Systems, or hazard the rotorcraft.

(b) Where the following items are located in a Designated Fire Zone, they shall be at least Fire-resistant:—

(i) All components of systems carrying Flammable fluids when under the most critical (for Fire-resistance purposes) pressure and flow conditions that are likely to occur.

(ii) Air ducts and other components the burning through of which would aggravate an existing fire.

NOTES: (1) See also 3.2.1.

(2) Vent and drain lines and their fittings, the failure of which would not result in, or add to, a fire hazard need not be Fire-resistant.

(iii) All Power-plant controls essential to fire fighting procedures. It shall not be difficult to operate such controls during and after a fire. Any damage resulting from a fire shall not cause any shut-off devices to re-open if this could cause a hazard.

(iv) All components of the fire detection system.

(v) The engine air intake system.

(c) Where the following items are located inside a Designated Fire Zone they shall be Fireproof:—

(i) All components of the fire extinguisher system.

(ii) Air or gas ducts and any other component which, if burned through, could result in a fire spreading to other regions of the rotorcraft.

NOTE: See also 3.2.1.

A.B

(iii) Structural members and any other parts the Failure of which could result in Catastrophe. Structural members shall be capable under these conditions of carrying the loads appropriate to gentle manoeuvres and any superimposed loads resulting from vibration normally experienced in flight.

NOTE: In the absence of further information normal acceleration achieved during flight in which only gentle manoeuvres are made and on which gusty weather is not encountered will not exceed 1·5*g*.

(iv) Controls for Essential Services which would be required to operate during or after an engine fire. It shall not be difficult to operate such controls during and after a fire.

(d) Designated Fire Zones, regions immediately adjacent to a firewall and engine pod attachment structures shall be designed and constructed to withstand without hazard any damage resulting from sudden increases in ambient pressure as a result of leakage of air or gases from defective joints or ducts (e.g. engine compressor bleed systems).

4.4.2 **Regions Immediately Adjacent to Designated Fire Zones and Engine Pod Attachment Structures.** (See **G5—8** App., **5.**) In addition to complying with the requirements of 4.4.1 (b) and (d) for Designated Fire Zones, components in regions immediately adjacent to firewalls and in engine pod attachment structures shall be of such materials and at such a distance from the Designated Fire Zone that they will not suffer damage that could hazard the rotorcraft if the inner surface of the firewall is enveloped in flames at 1100°C for 15 minutes.

4.5 **Cowlings, and Other Rotorcraft Surfaces** (see also **G5—8** App., **6**)

4.5.1 Cowlings, and all rotorcraft surfaces near and to the rear of Designated Fire Zones, shall be constructed of material at least equivalent in fire-resistance to aluminium alloy (see also 3.3).

4.5.2 Cowlings, and all other rotorcraft surfaces shall be designed and constructed so that fire originating in any Designated Fire Zone cannot re-enter through normal openings or burn through external surfaces of other regions where it could create an additional hazard. Such surfaces that are likely to be subjected to flame shall be constructed of or be protected by a suitable heat-resistant material.

NOTES: (1) Attention is drawn to the need to prevent flames from being sucked into the interior of the rotorcraft through holes.

(2) In deciding the surfaces over which flames might play, account should be taken of the possibility of portions of the cowling being melted.

(3) Account should be taken of the possibility of any discontinuity in the surfaces over which the flames may pass acting as a flameholder.

(4) In establishing compliance with 4.5.2, account should be taken of the damage that could result from non-containment of engine debris (e.g. punctured cowling or firewall, or local lifting of the cowling allowing fire to spread to other regions of the rotorcraft).

4.6 **Torching Flames.** Precautions shall be taken where necessary to minimize the possibility of torching flames from any likely burn-through of any part of the engine causing damage that could hazard the rotorcraft.

NOTE: Test requirements concerning torching flames are given in BS 3G.100, Part 2, Section 3, Subsection 3-13.

APPENDIX TO CHAPTER G5—8

Issued, 1st June, 1976

FIRE PRECAUTIONS

1 FIRE DETECTORS (see G5—8, 4.1)

1.1 It is recommended that where a thermal detector system is used, a continuous type detector, rather than a number of single-point detectors, should be installed.

1.2 The fire detection system should indicate a fire within 5 seconds of its ignition and should indicate extinction of a fire within 30 seconds of its extinction.

1.3 The location of detector sensing elements should include the main ventilating air exits from each region provided with a detector system.

2 ADEQUATE DISCHARGE OF EXTINGUISHANT (see G5—8, 4.2.1 (a))

2.1 **General.** For the purpose of the requirements of **G5—8**, 4.2.1 (a), an adequate discharge of extinguishant is a discharge of extinguishant such as to achieve a concentration not less than the minimum concentration for a period not less than the minimum prescribed period.

2.2 **Extinguishant Quantity** (see **G5—8**, 4.2.1 (c)). This paragraph 2.2 describes a method by which the amount of extinguishant necessary for compliance with 2.1 may be determined for systems in which the extinguishant is bromochlorodifluoromethane ($CBrClF_2$) where the minimum concentration, by volume, for a period of not less than 2 seconds is 10·5%.

2.2.1 The amount of extinguishant needed and the appropriate discharge period should be determined for sea-level conditions from the following formulae:—

(a) **During the Period of Discharge**

$$C = \frac{B}{A + B}\left(1 - e^{-t(A+B)}\right)$$

where C = concentration of extinguishant by volume at time t,

B = rate of extinguishant vapour discharge in $m^3/s/m^3$ ($ft^3/s/ft^3$) of zone volume,

A = ventilating airflow through the zone in $m^3/s/m^3$ ($ft^3/s/ft^3$) of zone volume,

e = base of Napierian Logarithms (a value of 2·7 may be used),

t = time from start of discharge in seconds.

(b) **After the Period of Discharge**

$$C = C_{max}\, e^{-A(t - t_{max})}$$

where C_{max} = concentration at end of discharge,

t_{max} = value of t when $C = C_{max}$

NOTE: To obtain the weight of extinguishant required, it may be assumed that, at 0°C at a pressure of $1{\cdot}01325 \times 10^5$ N/m^2 (29·92 in Hg) (1013·2 mbar), the volume of 1 kg (2·205 lb) of bromochlorodifluoromethane is 0·137 m^3 (4·85 ft^3).

2.2.2 The specified concentration should be reached within 2 seconds.

2.2.3 **Type of System and Distribution**

(a) The amount of extinguishant calculated in accordance with 2.2.1 may have to be increased by a factor dependent upon the method of discharge. The factor will vary between a value of 1·4, if the method of discharge is a single nozzle in a narrow annular zone the length of which does not exceed approximately two diameters, and a value of 1·0 if the method is a suitably routed spray pipe system. The purpose of this factor is to increase the discharge rate; the discharge period should remain unchanged from the original design value.

(b) Discharge nozzles should be located near to ventilating air inlets and, in an annular zone, should be positioned to direct the spray spirally around the zone.

2.2.4 **Tests.** In assessing the effectiveness of an installed system, in accordance with **G5—8**, 4.2, the period of specified concentration achieved should be determined.

3 CREW DRILL TO COMBAT POWER-PLANT FIRE (see D5—8, 4.2.1 (b))

3.1 The procedure to be followed by the flight crew in the event of a fire in a main Power-unit should be such that the actions described in (a) to (d) are completed in the sequence given as quickly as possible.

(a) Where applicable the stopping of the rotation of the affected engine.

(b) The shutting off of Flammable fluids (including the closing of both the HP and LP fuel cocks on turbine engines) to the affected engine compartment.

(c) Where applicable, the reduction to the minimum of the air flow through the compartment.

(d) The operation of the appropriate extinguishing system.

3.2 The number of separate operations which has to be made in accordance with 3.1 should be as few as practicable, and, if feasible, accomplished by the operation of a single Operating Control.

4 FIREWALL MATERIALS (see G5—8, 4.3.3) In complying with **G5—8**, 4.3.3, the following materials are acceptable:—

(a) stainless steel 0·38 mm (0·015 in) thick,

(b) mild steel 0·46 mm (0·018 in) thick and suitably protected against corrosion.

Other materials may be used providing their suitability can be demonstrated.

5 FIRE TESTS (see G5—8, 4.4.2) In demonstrating compliance with **G5—8**, the area of the firewall adjacent to the critical component should be subjected to flames at a temperature of 1100°C for 15 minutes, using as many standard test torches as is necessary.

6 ACCESS DOORS IN COWLINGS (see G5—8, 4.5) It is recommended that access doors should be provided in engine cowlings to facilitate the use of ground fire-fighting facilities (e.g. fire extinguisher nozzles).

SUB-SECTION G6—EQUIPMENT INSTALLATIONS

CHAPTER G6—1 GENERAL

Revised in part, 16th August, 1982

A.B 1 INTRODUCTION

1.1 The requirements of this Chapter are applicable to all rotorcraft unless otherwise stated. They cover the general requirements applicable to Equipment Installations and list mandatory equipment.

NOTES: (1) Certain detailed installation requirements are associated with individual items for ease of reference.

(2) The requirements for electrical systems are contained in **Section J**; the requirements for radio installations are contained in **Section R.**

1.2 The requirements of **G4—1** are applicable to this Sub-section G6; see **G4—1**, 1.1.

2 GENERAL*

2.1 Equipment, systems and installations shall be such that they do not hazard the safe operation of the rotorcraft, or the proper functioning of any Essential Service, even in the event of their malfunctioning or failure (e.g. by introducing a risk of fire or explosion; prejudicing the safe operation of Essential Equipment; causing unacceptable radio or compass interference).

2.2 Mandatory equipment, systems and installations (i.e. those installed for compliance with the Requirements, or with the Air Navigation Order, or those on the proper functioning of which the airworthiness of the rotorcraft may depend) shall be such as to ensure that the intended function will be performed safely and reliably even under the most adverse likely operating conditions. To this end, all such equipment, except that specifically exempted by the Air Navigation Order, shall comply with (a), (b) or (c):—

(a) it shall be Approved by the Authority generally for use on rotorcraft, or

(b) it shall be Approved by the Authority as part of the particular rotorcraft type, or

(c) it shall be Approved by the Authority in relation to the particular rotorcraft as part of the acceptance by the Authority of the rotorcraft including the equipment.

2.3 In the case of approval in accordance with 2.2 (c), the Approved Design and Inspection Organisation (usually the rotorcraft constructor) shall establish that the equipment is suitable for the purpose for which it is installed. The suitability of such equipment (including commercial equipment) shall be established by the employment of one or more of the following procedures:—

*See also **Section A**, Chapter **A3—3**, for approval procedures.

A.B

(a) A detailed examination of the equipment and its design.

(b) Suitable testing.

(c) Consideration of previous relevant experience.

2.3.1 The Approved Organisation accepting responsibility for equipment Approved in accordance with 2.2 (c) shall establish satisfactory quality control procedures for series items.

2.4 Equipment to which the requirements of this paragraph **2** apply shall be subject to such pre-installation inspection and, where applicable, functional testing as will ensure that any loss of accuracy, damage or deterioration resulting from transit or storage is revealed.

2.5 Installed equipment shall be checked for interference from other equipment such as radio apparatus (see **Section R**) and electrical apparatus (see **Section J**). Such interference as there may be shall not be such as to result in an unacceptable hazard.

2.6 **Instrument Location**

2.6.1 Instruments shall be located so that they can be read easily by the appropriate flight-crew member whilst secured in his seat. Indications given by instruments which provide information on similar subjects shall be compatible with each other.

NOTE: This requirement is intended, for example, to prevent duplicate or similar instruments working in opposite senses.

2.6.2 Such of the flight, navigational, Power-plant and transmission instruments as are used by each pilot shall be so arranged that from his station he may see them with the minimum practical deviation from his normal position and line of forward view.

2.6.3 Power-plant instruments shall be conveniently grouped on instrument panels in such a manner that the appropriate members of the flight crew may see them readily. Where there is more than one engine, Power-plant instruments for each engine shall be so located that the engine to which they relate is indicated with certainty.

2.6.4 Power-plant instruments shall be such as to permit, without difficulty, setting and maintenance of engine operating conditions to within acceptable tolerances agreed by the Authority. Due regard shall be given to the degree of accuracy attainable in reading the instruments arising from location and size of instruments, fineness of scale of the operating range, parallax, etc.

2.7 **Instrument Illumination**

2.7.1 The means of illuminating the instruments shall be such that the pilots' eyes are shielded from direct rays of light. There shall be no reflections which significantly impair the pilots' view.

2.7.2 The design of night shields for emergency lights shall be such that the lights will not be obscured inadvertently.

2.7.3 The colour of the instrument lighting shall be such that the colour coding of instruments and controls particularly those associated with emergency procedures, is readily identifiable.

A 2.7.4 For rotorcraft certificated for instrument flight, high intensity white lighting shall be provided for illumination of basic flight instruments, such that the pilot(s) are not dazzled by lightning discharge when the rotorcraft is being flown solely by reference to instruments.

A.B 2.8 **Instrument Panel Vibration Characteristics.** The vibration characteristics of instrument panels shall be such that the accuracy of the instruments will not be impaired.

2.9 **Duplicate Instruments.** Where duplicate instruments are prescribed, or where to some extent one instrument is a standby for another, two independent operating systems shall be provided. The systems shall be such that the probability of one fault impairing the operation of both systems is Extremely Remote.

2.10 **Flight Instruments Requiring a Power Supply**

2.10.1 Except on single-engined rotorcraft, all mandatory flight instruments requiring a power supply (e.g. gyroscopic instruments) shall be provided with at least two independent sources of supply (see also 5.3.5).

NOTE: It is recommended that, on single-engined rotorcraft, where a turn and slip indicator is provided in addition to a gyroscopic direction indicator and a gyroscopic bank and pitch indicator, the supply to the turn and slip indicator be independent of the supply to the bank and pitch indicator.

2.10.2 Means shall be provided to indicate the adequacy of each power supply.

2.10.3 Power supply systems shall be such that the failure of one instrument will not interfere with the proper supply of power to any remaining instrument(s) the information from which is essential to the continued safe flight of the rotorcraft.

2.11 **Engine and Transmission Instruments**

2.11.1 All mandatory engine and transmission instruments shall have independent operating systems, except where it can be shown that the failure of any system which serves more than one instrument will not jeopardise the continued safe operation of the rotorcraft.

2.11.2 All mandatory engine and transmission instruments requiring a power supply shall have at least two independent sources of supply, except where it can be shown that the loss of information resulting from the failure of a single source of supply will not jeopardise the continued safe flight of the rotorcraft.

2.11.3 Means shall be provided to indicate the adequacy of each power supply.

2.11.4 Power supply systems shall be such that the failure of one instrument will not interfere with the proper supply of power to any remaining instrument(s) the information from which is essential to the continued safe flight of the rotorcraft.

2.12 **Air-speed Indicating Systems**

2.12.1 The air-speed indicating system shall be calibrated to establish the difference between IAS and EAS, i.e. the total position error of the system.

A.B 2.12.2 This position error of the installation, in level flight at sea-level, at all speeds between the Take-off Safety Speed, V_2, and the normal cruising speed, shall not exceed 3% or 9·3 km/h (5 knots), whichever is the greater.

2.13 **Altimeter Systems.** The design and installation of pressure altimeter systems shall be such that the position error in pressure altitude at sea-level in the International Standard Atmosphere will not be more than 30 feet in the speed range from zero to 0·9 V_H under steady conditions.

2.14 **Pitot-static Systems**

2.14.1 The installation of all instruments with air pressure connections shall be such that their accuracy cannot be seriously affected by:—

(a) the rotorcraft forward speed, attitude or configuration,

(b) moisture or other foreign matter.

A 2.14.2 Pitot-static heads shall be capable of being heated to prevent malfunction or blockage as a result of icing.

B NOTE: For Group B rotorcraft, it is recommended that the pitot-static head should be heated so as to ensure its suitability during short periods of flight in ice-forming conditions.

A.B 2.14.3 The accuracy of air-speed or altitude indications shall not be adversely affected by yaw effects upon static systems.

2.14.4 Lag and the possibility of moisture blockage in pitot-static lines shall be kept to acceptable minima.

NOTE: In this connection tubing with an inside diameter of less than 6·35 mm (0·25 in) will not normally be acceptable.

2.14.5 Sufficient moisture traps shall be installed to ensure positive drainage throughout the whole of the system.

2.14.6 A separate pitot-static system shall be provided for additional instruments and equipment which—

(a) have not been Approved or shown to achieve the reliability prescribed for instruments and equipment by 2.2, or

(b) would introduce lag of an unacceptable order.

2.15 **Instrument Pipe Lines.** Instrument pipe lines shall comply with the relevant requirements of **G5—1.** In addition, lines carrying Flammable fluids or gases under pressure shall be provided with restricted orifices, or equivalent safety devices at the source of the pressure, such as to prevent escape of fluid or gas at an excessive rate in the event of line failure.

2.16 **Exposed Sight Gauges.** Exposed sight gauges shall be so installed, or guarded as to minimize the risk of breakage or damage.

A.B 2.17 **Safety Equipment.** Safety equipment, which the crew or passengers are expected to operate at the time of an emergency, shall be readily accessible and plainly marked as to its method of operation. Where safety equipment is carried in compartments or containers, such compartments and containers shall be marked to identify the contents.

2.18 **Flight Path Computing and Indicating Systems** (see **G6—1** App., **1**). Where a flight path computing and indicating system is installed the provisions of (a) to (c) apply.

(a) No single fault shall be able to affect dangerously both the flight path computing and indicating system and the system (or instruments) to which the pilot would turn in the event of its failure.

(b) Flight path computing and indicating systems shall, as far as possible, be so designed that warning of fault conditions which might otherwise lead to danger will be given to the pilot.

(c) The instrument panel shall be so arranged that no undue burden is placed on the flight crew in monitoring a flight path computer indicator by means of other instrument indicators.

NOTE: The phrase "flight path computing and indicating systems" is used to distinguish those systems where:—

(a) the discerning devices are remote from the indicator, and/or

(b) the outputs of the discerning devices are modified by other signals,

from those simple instruments where the discerning device and the indicator are intimately associated.

3 MINIMUM EQUIPMENT Items of equipment included in this paragraph **3** shall be installed in all rotorcraft.

3.1 **Flight and Navigation Instruments**

3.1.1 Air-speed Indicator.

3.1.2 Altimeter (see also 4.3 and 5.3.6).

3.1.3 Magnetic compass or its equivalent (see also **6**).

3.2 **Power-plant Instruments and Equipment**

3.2.1 **General**

(a) Fuel quantity indicator to indicate the quantity of usable fuel in each tank (see **G5—2**).

(b) Fuel pressure indicator for each engine, unless it can be shown that fuel pressure indication is unnecessary for the particular installation.

(c) Low fuel pressure warning for each engine, or a master warning means for all engines with provision for determining which engine is at fault.

(d) Engine refrigerant quantity indicator, to indicate the quantity of usable refrigerant in each refrigerant tank.

A.B (e) Means for measuring, when the rotorcraft is in the ground attitude, the quantity of oil in each oil tank and rotor drive gear box if lubricant is self-contained.

(f) Oil pressure indicator for each engine.

(g) Low oil pressure warning means for each engine or a master warning means for all engines with provision for determining which engine is at fault.

(h) Oil inlet temperature indicator for each engine.

(j) Oil pressure indicator and independent warning means for each pressure lubrication system in the Transmission System.

(k) Oil temperature indicator for each pressure lubrication system in the Transmission System.

(l) Fire warning indicators, when fire detection is required in accordance with **G5–8**.

(m) Where provision is made for the flight crew to be able to disconnect defective equipment from an engine or transmission system while the engine or transmission system is still running, suitable means shall be provided to warn the flight crew that the equipment should be disconnected (see **Section C**, Chapter **C2–2,** 2.3, and **C4–2,** 3.1).

(n) Where an engine may be used to drive equipment whilst the engine is disconnected from the main transmission, indication of whether the engine is in main or equipment drive.

(o) Means to indicate during flight when the propeller blade pitch is below the flight fine pitch position for each propeller.

(p) Means to enable the flight crew to check the operation of the Power-plant ice protection systems.

(q) Duplicate indication of the rotational speed of the Rotor System; only one indicator shall be driven direct from the Rotor System.

(r) An audible warning to indicate when the rotational speed of the Rotor System approaches a value below which a hazardous condition could exist, on all rotorcraft which:–

(i) do not have provision for automatically increasing the power on the operating engine(s) when one engine fails, such that rotor speed does not change to a hazardous extent, or

(ii) have rotor speed decay characteristics such that rapid pilot response is critical (see **G6–1** App., 2.1) or

(iii) do not have inherent aerodynamic characteristics which provide a clear warning of rotor speed approaching a hazardous value.

This warning shall be set to operate at a rotor speed such that when the pilot initiates corrective action in response to the warning, he can regain a safe rotor speed without difficulty. It shall be possible to silence the audible warning after actuation.

B NOTE: For single turbine engined rotorcraft, the audible warning of this paragraph (r) may also be actuated by engine failure. (See also 3.2.3(f)).

A.B (s) Such instruments, additional to those prescribed, as are necessary to enable compliance in operation with the limitations to which the engine is approved.

A.B 3.2.2 **Piston Engines**

(a) Tachometer to indicate the rotational speed of each engine, unless it can be established that the indicators provided in accordance with 3.2.1 (q) would be sufficient.

(b) Cylinder head temperature indicator to indicate the temperature of the hottest cylinder in the installation.

(c) Manifold pressure indicator for each engine where the proper control of engine power necessitates the use of such an indicator (e.g. on a supercharged engine).

(d) Induction system air temperature indicator for each engine equipped with a pre-heater that can provide a heat rise in excess of 60F°.

(e) Ignition switch for each ignition circuit on each engine.

(f) For each engine fitted with a turbo-supercharger, unless it can be shown that the relevant limitations for engine and supercharger will not be exceeded during normal operations:—

(i) engine air inlet temperature indicator,

(ii) exhaust gas temperature indicator.

(g) For each turbo-supercharger oil system that is separate from other oil systems:—

(i) oil pressure indicator,

(ii) oil temperature indicator.

3.2.3 **Turbine Engines**

(a) Tachometer to indicate the rotational speed of each compressor and turbine rotor, which is not indicated by other means as appropriate to the particular engine.

(b) Exhaust gas temperature indicators or equivalent for each engine.

(c) Means to indicate when an air or gas turbine starter is energised.

(d) Means for each engine to indicate the power output of that engine.

(e) (See **G6—1** App., 2.2 and 2.3). A visual warning for each engine to indicate engine failure.

B (f) (See **G6—1** App., 2.3). For single-engined rotorcraft, an audible warning to indicate engine failure. This warning shall be additional to the visual warning required by 3.2.3(e).

NOTE: Where the audible warning installed for compliance with 3.2.1(r) is also actuated by engine failure, it will be acceptable for compliance with this paragraph (f).

A.B (g) Such other instruments as are necessary to enable compliance in operation with limitations established during engine certification.

3.3 **Miscellaneous Equipment**

3.3.1 A safety belt or harness for each occupant (see also 5.7), except that a safety harness or diagonal shoulder strap shall be fitted to each pilot's seat.

3.3.2 One portable fire extinguisher for each enclosed passenger and crew compartment, so installed that one extinguisher is convenient to a member of the flight crew.

A.B

3.3.3 Spare electrical fuses for all electrical circuits, the fuses of which can be replaced in flight, consisting of 10% of the number of each rating or 3 of each rating, whichever is the greater.

3.3.4 Means of indicating the outside air temperature.

3.3.5 In rotorcraft used for agricultural purposes, a seat harness shall be provided for each occupant (see also **G4—4, 3**).

3.3.6 Such other equipment as the Authority may prescribe.

4 MINIMUM EQUIPMENT FOR TRANSPORT CATEGORY ROTORCRAFT (PASSENGER AND CARGO) In addition to the items of equipment prescribed in **3**, the items included in this paragraph **4** shall be installed*.

4.1 A slip indicator.

4.2 Means of indicating that the power supply to the gyroscopic instruments is working satisfactorily.

4.3 Sensitive altimeter adjustable for changes in barometric pressure, unless the altimeter installed in compliance with 3.1.2 meets these conditions.

4.4 A timepiece with a sweep second hand.

NOTE: This item does not have to be approved but is required by the Air Navigation Order to be suitable for its purpose and must be installed or carried in any manner which will ensure that it can be used effectively as and when required.

4.5 For multi-engined rotorcraft, a means of indicating to the pilot immediately any significant change in the power output of an engine as a result of fault conditions and also which engine is at fault.

4.6 **Transport Category (Passenger) Only.** Means of indicating to passengers when their safety belts or safety harnesses should be fastened, except that this may be omitted if the pilots' and passenger compartments are not separately enclosed.

5 MINIMUM EQUIPMENT—PARTICULAR CONDITIONS In addition to the items prescribed in **3** or **4**, as appropriate, on all rotorcraft for which extension of the Certificate of Airworthiness to include flight in one or more particular condition is sought, the items of equipment prescribed in this paragraph **5***, as appropriate to the certification and condition, shall be installed, except that equipment already installed for compliance with **3** or **4** need not be duplicated.

5.1 **Flights by Night—All Rotorcraft**

5.1.1 Navigation lights (see **G6—7**).

5.1.2 Adequate electrical illumination, supplied from the main source of supply, for the instruments (including OAT gauge) and equipment (including maps) the carriage of which is prescribed, and the illumination of which is necessary to enable use to be made of them during flight. (See also 2.7.)

*Whilst at the time of printing this list is intended to cover the requirements of the Air Navigation Order in respect of instruments, it does not list all items required by the Order (e.g. minimum radio equipment is not listed). Reference should be made to the Order both during design and at the time of certification.

A.B 5.1.3 A slip indicator, a gyroscopic bank and pitch indicator, and a gyroscopic direction indicator.

5.1.4 Means of indicating that the power supply to the gyroscopic instruments is working satisfactorily.

5.2 **Flights by Night—Transport Category Rotorcraft**

5.2.1 An electric lighting system to provide illumination in every passenger compartment.

5.2.2 Where the number of occupants permitted by the Flight Manual is greater than 19, two electric torches and an emergency lighting system to facilitate evacuation of the rotorcraft in the event of failure of the lights provided in accordance with 5.2.1. In the case of other rotorcraft, an electric torch for each member of the crew.

A 5.2.3 Where emergency lighting is provided it shall:—

(a) be independent of the main lighting system,

(b) illuminate each passenger emergency exit and locating sign, and

(c) provide enough general lighting in the passenger compartment so that the average illumination, when measured at 1016 mm (40 in) intervals at seat armrest height on the centre line of the main passenger aisle, is at least 0·54 lux (0·05 foot-candle).

Each light required by (b) and (c) shall be designed to operate:—

(i) Manually.

(ii) Automatically (when armed, if necessary) in a Crash Landing.

(iii) Whenever the normal electrical power to the normal lighting is interrupted.

NOTE: See also **G4—3.**

5.2.4 **Landing Lights**

(a) **Group A Rotorcraft up to 5700 kg Maximum Weight.** Either:—

(i) two single filament lamps, both of which are adjustable in the fore and aft plane, and one of which is adjustable in the lateral plane, or

(ii) one single filament lamp*, and two parachute flares†.

(b) **Group A Rotorcraft over 5700 kg Maximum Weight.** Either:—

(i) two single filament lamps, both of which are adjustable in the fore and aft sense, and one of which is adjustable in the lateral sense, or

(ii) one dual filament lamp, adjustable in the fore and aft sense, with separately energised filaments, and two parachute flares†, or

(iii) two single filament lamps, adjustable in the fore and aft sense, and two parachute flares†.

B (c) **Group B Rotorcraft up to 5700 kg Maximum Weight.** One single filament lamp* and two parachute flares†.

(d) **Group B Rotorcraft over 5700 kg Maximum Weight.** Either:—

(i) one dual filament lamp*, with separately energised filaments, and two parachute flares†, or

(ii) two single filament lamps*, and two parachute flares†.

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*Where fixed landing lamps are used, they should be set at an angle which would provide satisfactory lighting during an emergency autorotative landing.

†The purpose of the parachute flares is to provide adequate lighting in an emergency alighting area.

A.B 5.2.5 **Rotorcraft Exceeding 2000 kg Maximum Weight.** The equipment prescribed in 5.3 for flight under Instrument Flight Rules.

A 5.3 **Flights Under Instrument Flight Rules in Controlled Airspace**

NOTE: For certain limited conditions of flight under Instrument Flight Rules a lower standard than in this paragraph 5.3 is prescribed by the Air Navigation Order and is acceptable.

5.3.1 A slip indicator.

5.3.2 Two gyroscopic bank and pitch indicators.

5.3.3 A gyroscopic direction indicator.

5.3.4 Either a failure warning device for each gyroscopic instrument, or means of indicating that the power supply to gyroscopic instruments is working satisfactorily.

5.3.5 The requirements for emergency power supplies are contained in **Section J,** Chapter **J2—1, 5.** The duration of the emergency power supply for one bank and pitch indicator and its associated lighting shall be at least equal to half the endurance of the rotorcraft at the representative cruising true air speed of **G2—2,** 4.1.1.

5.3.6 Two sensitive altimeters adjustable for changes in barometric pressure, one of which may be the altimeter installed in compliance with 3.1.2 if this complies with these conditions.

5.3.7 Rate of climb and descent indicator.

5.3.8 Timepiece, with a sweep second hand, installed and suitable for procedural pattern flight.

5.3.9 For rotorcraft exceeding 5700 kg, two air-speed indicators, one of which may be that installed in accordance with 3.1.1.

5.4 **Flight in Instrument Meteorological Conditions.** Where a single stability augmentation system is provided to meet the stability requirements of **G2—10, 4,** the system shall have a completely separate gyro reference from the attitude indicators required by 5.3.

5.5 **Flights in Conditions Predisposing to Ice Formation—All Rotorcraft.** The equipment necessary to provide protection in the degree of ice-forming conditions for which endorsement of the Certificate of Airworthiness is sought.

A.B 5.6 **Flights during which the Air Navigation Order Requires Escape Apparatus to be Carried** (see **G4—3,** 5.3). An emergency escape chute, or similar means of escape, readily available for use at each external door which is intended for the normal or emergency disembarkation of passengers, and which has a sill that:—

(a) would be more than 1·82 m (6 ft) from the ground when the landing gear of the rotorcraft is in the normal position for taxying, or

(b) would be more than 1·82 m (6 ft) from the ground if any part of the landing gear should collapse, break, or fail to function.

5.7 **Flights when Carrying Out Agricultural Operations.** Safety harness for all occupants.

A.B 6 COMPASSES

6.1 The compass prescribed in 3.1.3 shall be installed so that after compensation the residual deviation does not exceed 5°. In addition, the change in deviation as a result of the movement of or interaction between other components (e.g. control movement) or the worst likely combination of electrical interference shall not exceed 5°.

6.2 A card shall be installed on or adjacent to the magnetic compass and shall:—

(a) Give the deviations (errors) of the installation in level cruising flight with all engines operating. The deviations shall be stated unambiguously and shall be related to standard headings at intervals not exceeding 45°.

(b) State whether the deviations were measured with the radio receivers on or off.

(c) Give the deviations which occur under all normal and emergency combinations of generator and equipment utilisation.

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APPENDIX TO CHAPTER G6—1

Revised in part, 17th December, 1980

FLIGHT PATH COMPUTING SYSTEMS

1 (See G6—1, 2.18) A satisfactory method of meeting the requirements of **G6—1,** 2.18, is to ensure that no single fault will affect both the flight path computing and indicating system and that system (or instruments) to which the pilot would turn to avoid danger. Additionally, where a fault analysis shows that the inherent characteristics of the flight path computing and indicating system are such that a fault liable to mislead the pilot dangerously could occur, then fault indicating devices (e.g. warning flags) should be incorporated.

2 WARNING DEVICES

2.1 **Rotor System Speed** (see **G6—1,** 3.2.1(r)). With the rotorcraft initially in steady unaccelerated cruising flight at Rotor Minimum RPM (Power On), it should be possible to prevent the rotor speed from falling below the Rotor Minimum RPM (Power Off) after any sudden loss of engine power. Pilot reaction will be considered critical if, with the rotorcraft initially in steady unaccelerated cruising flight at Rotor Minimum RPM (Power On), the time which elapses between the sudden loss of power and the rotor speed falling to the Rotor Minimum RPM (Power Off), assuming no pilot intervention, is less than 5 seconds.

2.2 **Engine Failure** (see **G6—1,** 3.2.3(e)).

2.2.1 A flashing warning light mounted in such a position that its operation is immediately obvious to the pilot would meet this requirement.

2.2.2 A master visual warning indicator, with individual engine indication on a central warning panel, is also acceptable.

2.3 **Visual and Aural—Independence** (see **G6—1,** 3.2.1(r), 3.2.3(e) and (f)). If both visual and audible warnings are activated by the same sensor, this sensor should be completely independent of the normal engine power and rotor speed indicating systems. If either of the visual or audible warnings are actuated by the normal engine power and rotor speed indicating systems, the other warning sensor should be completely independent.

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SUB-SECTION G6—EQUIPMENT INSTALLATIONS

CHAPTER G6—2 HYDRAULIC SYSTEMS

Issued, 7th November, 1975

A.B

1 APPLICABILITY

1.1 Hydraulic installations used for any Essential Service shall comply with the requirements of this Chapter.

1.2 Hydraulic installations used for any other services shall comply with the requirements of this Chapter only to the extent necessary for compliance with **G6—1, 2.**

NOTES: (1) Any part of a hydraulic system which is an engine accessory will also need to comply with the relevant requirements of **Section C.**
(2) See also **G4—9, 8.**
(3) See **G4—1, 6,** for reduction of normal acceleration.

2 GENERAL

2.1 **Output.** The output of the pumps and hydraulic accumulators together shall be sufficient to operate the most adverse combination of Essential Services and other services which may be operated at the same time, against the appropriate external loads, and within any minimum times prescribed. Where part of this output is from an accumulator, the required number of operations of the services, and the time intervals between operations, shall be such as to be adequate for safety in relation to the services operated.

2.2 **Duplication.** The need for duplication of any part of the system shall be decided on the basis of the requirements for the particular service (see **G4—1, 2**). Essential Services shall continue to operate after the failure of any source of power to the extent required by **G4—1, 3,** including any Power-unit failure, and provision shall be made to ensure that sufficient power is available for such services. Where pipe-lines are duplicated they shall be so installed that any cause of damage to one line is unlikely also to affect the other.

2.3 **Abnormally High Temperatures.** The system shall be designed to avoid hazard to the rotorcraft arising from the effects of abnormally high temperatures which may occur in certain parts of the system under fault conditions.

NOTE: It is recommended that, in achieving compliance with this requirement, reliance should not be placed upon a simple pressure relief device. Experience gained from hydraulic pumps which have failed to off-load and thereafter delivered maximum flow at maximum pressure, shows that the resultant temperature rise across the pressure relief valve can produce fluid degradation and a potentially serious fire hazard, depending upon the type of fluid being used. This may also affect the integrity of items such as joints, seals and flexible hoses.

2.4 **Filters.** Filters of appropriate rating and capacity shall be provided in the system where necessary to safeguard the rotorcraft against the effects of damage or malfunctioning of components as a result of contamination of the fluid.

NOTE: The capacity of filters should be such as to prevent the need for frequent filter inspections and cleaning.

A.B

2.5 **Hydraulic Fluid**

2.5.1 The fluid chosen for use in the system shall:—

(a) be established as suitable for use under the ranges of conditions in which the rotorcraft may be operated (see also 5.2),

(b) be to an Approved specification and

(c) be specified in the appropriate manual required by **Section A**, Chapter **A6—1**.

The word "hydraulic" or its equivalent in other languages and the specifications of the Approved fluids shall be marked on, or adjacent to, all system filling points and unit filling points.

2.5.2 If the fluid is noxious to human beings when liberated in any form, the installation shall be so arranged that the fluid cannot enter personnel compartments in the event of leakage or spillage.

2.5.3 If the fluid is not harmful to human beings when liberated in any form the installation shall be such that in the event of leakage the fluid, especially in the form of a spray or mist, will not interfere unduly with the flight crew when carrying out their normal duties.

3 POWER CONTROLS (see also G4—8, 2.3.7) On hydraulic systems associated with power-operated or power-assisted primary flight control systems, a means of indicating to the pilot the failure of each system, and, if appropriate, each power source, shall be provided.

4 PRESSURE

4.1 In each main system, indication of the pressure, or warning of inadequate pressure, or a means of positively checking for adequate pressure before operation of the system shall be given to the appropriate member of the flight crew. When the emergency operation of Essential Services is dependent on energy stored in accumulators, indication shall be provided in the flight-crew compartment of the available pressure in each source.

4.2 Means shall be provided for limiting, without loss of fluid, the maximum steady pressures achievable during operation (e.g. by one or more short-circuiting relief valves). These means shall ensure that the transient pressures realised in any possible condition of operation do not exceed 1·33 P_w, except that, if transient pressures greater than 1·33 P_w would arise from the system being suddenly arrested, these will be acceptable provided that the design of the system takes account of the stresses thereby imposed. (See 6.1.1).

4.3 Means shall be provided to safeguard all parts of the system against pressures which might be set up owing to any abnormal cause (e.g. by extremely rapid temperature changes or failure of a pressure reducing valve). Fluid released in meeting this requirement shall either be returned to the system or be discharged to some safe place. The system shall, however, be so designed as to ensure that fluid is not lost to an extent which might prejudice the operation of any Essential Service.

A.B

5 FIRE PRECAUTIONS

5.1 **General.** The hydraulic installation shall not introduce or increase any risk of explosion or fire. Hydraulic tanks and accumulators shall be mounted outside Designated Fire Zones. Parts of the hydraulic installation which are installed in Designated Fire Zones shall comply with the fire precaution requirements of **G5—8.**

NOTE: See also **G4—3, 9.**

5.2 **Low-flammability Fluid.** An Approved low-flammability fluid shall be used in a hydraulic system unless compliance is shown with 5.3.

5.3 **Segregation of Services.** A hydraulic system using Flammable fluid may be accepted (except in Designated Fire Zones, for which see 5.1) provided that the system is so separated from potential sources of ignition that the risk of fire as a result of leakage or bursting of the hydraulic system is reduced to an acceptable level.

NOTE: Potential sources of ignition of the fluid include surfaces at a temperature exceeding 200°C and electrical sparks which may ignite a mist of the fluid.

6 STRENGTH

6.1 General

6.1.1 The strength requirements are based on the following limit pressures:—

P_w The maximum steady pressure permitted by the limiting means required by 4.2 within their design tolerances, or any higher pressure that the designer may declare.

P_r The maximum steady pressure permitted by any pressure-relief means provided in compliance with 4.3 within their design tolerances.

6.1.2 Where any part of the system is subject to fluctuating or repeated external or internal loads, due allowance shall be made for fatigue (see also **G3—1, 5** and **G3—1** App. No. 2, **4**).

6.2 **Loads.** Hydraulic system parts shall be able to withstand:—

(a) without leakage or permanent deformation, the loads prescribed in this paragraph 6.2 for proof conditions, and

(b) without fracture or bursting, the loads prescribed in this paragraph 6.2 for ultimate conditions.

NOTE: Such deformation or leakage as might directly prevent the operation of any part, or would in the course of one flight be likely to render the system inoperative will be regarded as ultimate failure.

6.2.1 **Components**

(a) **Proof Loads.** Loads resulting from pressures of 1·5 P_w or 1·0 P_r, whichever is the greater.

(b) **Ultimate Loads.** Loads resulting from pressures of 2·0 P_w or 1·5 P_r, whichever is the greater.

6.2.2 **Pipes and Couplings**

(a) **Proof Loads.** Loads resulting from pressures of 1·5 P_w or 1·0 P_r, whichever is the greater.

(b) **Ultimate Loads.** Loads resulting from pressures of 3·0 P_w or 2·25 P_r, whichever is the greater.

A.B

6.2.3 **Parts Subjected to Externally Applied Loads.** Where loads may be applied to a part of a hydraulic system as a result of its being part of the rotorcraft structure or attachment to the rotorcraft (e.g. stress induced into a pipe by deflections of structure along which the pipe runs) the limit loads prescribed in 6.2.1 and 6.2.2 shall be taken as acting in conjunction with the most adverse of such externally applied limit loads.

6.2.4 Adequate flexibility shall be provided between points in a hydraulic system where, under normal and emergency conditions, relative motion or differential vibration could exist.

7 TESTS

7.1 All prototype components, pipes and couplings shall be tested to the proof pressure. The representation of external loads for fatigue testing and the extent of testing to the ultimate pressure shall be to the satisfaction of the Authority.

NOTE: It is recommended that all prototype flexible pipes, couplings and components containing compressed gas should be tested under hydraulic pressure to at least 100% of the ultimate design pressure.

7.2 Complete prototype systems shall be submitted to such tests as are necessary, in the light of previous experience, to prove them to be satisfactory. The tests required for each system, which shall give due regard to its characteristics and conditions of operation, shall be specified by the designer, and shall include proof pressure tests of each system at a pressure equal to at least P_r. During the proof tests there shall be no evidence of failure, malfunctioning or permanent deformation.

7.3 The designer shall specify the tests necessary for series components, pipes and couplings and these tests shall be to the satisfaction of the Authority.

NOTE: All pressure-regulating and relief devices will require testing at their functioning pressure. Also, unless shown to be unnecessary, all lengths of piping should be tested, in finally assembled condition, to their proof pressure.

7.4 All complete series systems shall be tested at the working pressure for leakage and correct functioning.

SUB-SECTION G6—EQUIPMENT INSTALLATIONS

CHAPTER G6—4 AUTOMATIC FLIGHT CONTROL AND STABILITY AUGMENTATION SYSTEMS

Issued, 16th August, 1982

A.B

1 APPLICABILITY

1.1 These requirements are applicable to limited authority and limited rate automatic flight control and stability augmentation systems used in conjunction with the primary flight control systems.

1.2 The term "system" in these requirements shall be taken to include all those actuators, sensors, power supplies, etc., which are necessary to the performance of the automatic system function.

2 GENERAL (See also G6—4 App. and G2—8,8)

2.1 A safety assessment of the system shall be made to establish the probability and consequence of Occurrences. In particular it shall be established that no Failure or Event involving the system which is not Extremely Remote will have any of the following consequences:—

(a) the imposition on any part of the rotorcraft structure of a load greater than its proof strength,

(b) an exceedance of V_{DF},

(c) a negative normal acceleration,

(d) an exceedance of bank angle limitations or excessive bank angle (see **G6—4** App., 2.3),

(e) hazardous degradation of the handling qualities of the rotorcraft.

2.2 Where, in order to comply with these requirements, it is necessary to assume pilot action, the action assumed shall include a reasonable time for the pilot to recognise the need to take action and shall not require him to use greater control forces or more skill than can reasonably be expected. (See **G6—4** App., 4.1.)

NOTE: In this context "reasonably" means what can be expected of virtually all pilots on all occasions.

2.3 Any part of the system which is not disengaged from the flying controls when the system is not in use shall be regarded as a part of the flying control system and shall meet the requirements for such systems (see **G4—8**).

2.4 Precautions shall be taken with the object of preventing the incorrect installation or connection of parts of the system if such errors could hazard the rotorcraft. (See also **G4–8** App., **2.**)

2.5 The design of the installation shall be such that, so far as is practicable, errors in maintenance cannot create a danger (e.g. limit switches etc., should not be provided with so great a range of adjustment that maladjustment could be catastrophic in either normal or failure conditions).

A.B

3 CONTROLS

3.1 The pilot shall be provided with a control mounted on the cyclic control which, when operated, frees the rotorcraft from the control of the automatic system, unless it can be shown that any Failure in the system which is Recurrent will only result in a Minor Effect.

3.2 Attitude controls (i.e. pitch, trim, etc.) shall operate in the plane and direction of the required rotorcraft response.

NOTE: The direction of motion, if not obvious, should be clearly indicated on or near the control.

3.3 The design of the controls shall be such as to minimise the risk of inadvertent mis-selection or other error by the pilot.

3.4 The system shall provide a positive indication that it is in operation and of the mode of operation in which it is functioning. A suitably compelling warning shall be given of the system ceasing to operate correctly if in such a situation crew action is necessary (if not readily apparent to the pilot due to the failure effects) to prevent a hazardous situation resulting.

4 STRENGTH System servo-motors, their mountings and their connections to the flying control shall have Proof and Ultimate Factors of not less than 1·0 and 1·5 respectively, with the maximum loads including the loads arising from fault conditions, which could be imposed by the automatic system or from the flying control system (up to its design load), whichever is the greater.

NOTE: When, in order to continue safe flight, a mechanical disconnect is required to isolate the system from the primary flight controls in the event of Failure, the strength of any such connection shall be agreed with the Authority.

APPENDIX TO CHAPTER G6—4

Issued, 16*th August,* 1982

AUTOMATIC FLIGHT CONTROL AND STABILITY AUGMENTATION SYSTEMS—SAFETY ASSESSMENT

1 INTRODUCTION (See G6—4, 2) This Appendix gives guidance on acceptable methods of making the safety assessment required by **G6—4, 2.**

NOTE: See Foreword, 3.3.7 for the use of capital letters for Defined Terms.

2 EVENTS

2.1 Occurrences may consist of Events, Failures, Errors or combinations of any or all of them (see **G1—2,** 7). Events, in the form of atmospheric disturbances, should be considered, and it should be shown that the response of the system will not be such as to hazard the rotorcraft. It should be shown that the rotorcraft is safely controllable if the system is disengaged or saturated in the presence of turbulence or gusts.

2.2 It will not normally be necessary to consider the combined effects of atmospheric disturbances and Failures, unless such Failures might be caused by the disturbance, (e.g. automatic disengagement of the system). It will be necessary to consider crew errors to show that foreseeable errors will not have hazardous consequences.

2.3 A bank angle of more than 60° en route, or more than 30° when in the configuration for the final approach would be regarded as excessive.

3 FAILURES The types of Failure to be considered should include those given in 3.1 to 3.4.

3.1 **Passive Failures.** Passive failures are defined as failures which do not, of themselves, cause a flight path disturbance but permit the rotorcraft to be disturbed by other influences without correction, e.g. turbulence. The effect of such failures occurring anywhere in the system should be examined. It will generally be sufficient to show that the pilot is given a clear indication of the failure before the rotorcraft can diverge dangerously from the intended flight path (see **G6—4,** 3.4).

3.2 **Runaways.** Runaways are defined as failures which force the rotorcraft to diverge from its intended flight path either slowly or rapidly. Such failures in the system should be examined and the most critical cases shown to be safe by in-flight demonstrations. It should be noted that the fastest runaway is not necessarily the most critical case. Slower runaways can continue undetected for longer periods and result in larger disturbances unless adequate provision is made for their detection.

3.3 **Oscillatory Failures.** In considering oscillatory failures it is preferable that, rather than an attempt to discover what amplitudes and frequencies of oscillation would be caused by failures, an analysis is made of the protection against such failure to show that no possible oscillation is hazardous.

3.4 **Non-disengagement.** It is anticipated that in the majority of cases the ability to fly and to land the rotorcraft with the system engaged will be demonstrated, to show compliance with **G6—4,** 2.1(e). However, as an alternative, it may be shown that non-disengagement of the system when required is Extremely Improbable.

3.5 **General**

3.5.1 Where a single Failure can affect more than one axis, or more than one system, the total Effects shall be considered.

3.5.2 Failures should be assumed to occur with the system as far off centre, and/or the rotorcraft as far out of trim, as is likely in normal operation.

3.5.3 Consideration should be given to the effect on the system of Failures in other parts of the rotorcraft (e.g. of the engine, or of power-operated or power-assisted primary flight controls) to ensure that these Failures do not induce dangerous characteristics in the system.

4 ASSUMPTIONS

4.1 **Failure Recognition.** Where the response of the rotorcraft to the Failure is immediate and rapidly detectable it may be assumed that the pilot recognises the need to take action 1 second after the occurrence of the Failure. If the response of the rotorcraft to the Failure is not immediate and rapidly detectable the Failure recognition time should be that at which a pilot may reasonably be expected to recognise the need to take action.

NOTE: Where the pilot is assumed to have his hands on the controls, a shorter time than 1 second may be accepted.

4.2 **Recovery.** At all speeds up to V_{NO}, the pilot should be assumed to take corrective action not less than 2·5 seconds after he has recognised the need to do so, except that during hover, take-off, initial climb, final approach, and at speeds between V_{NO} and V_{NE}, this delay may be reduced to not less than 1·5 seconds. For cases where the pilot is considered to have released the controls a delay time of 5 seconds should be assumed.

NOTE: Consideration of the case where the pilot has released the controls will be essential when certification is sought for single-pilot operation of rotorcraft having a maximum weight up to 5700 kg (12,500 lb).

5 LIMITATIONS Limitations may be applied to the use of the system in order to enable compliance with these requirements provided that they are of a type which a pilot can be expected to observe (e.g. minimum height) (see also **G8—2,** 5.4).

6 FLIGHT TESTS Flight tests to establish the consequences of the most critical Failures which are not Extremely Remote should be made to substantiate the safety assessment. The flight test programme to be completed should be agreed with the Authority beforehand.

SUB-SECTION G6—EQUIPMENT INSTALLATIONS

CHAPTER G6—6 LIFE RAFTS AND ESCAPE CHUTES/SLIDES

Issued, 17th December, 1980

A.B 1 APPLICABILITY Where the carriage of life rafts or escape chutes/slides is mandatory, the installation of such equipment shall comply with the requirements of this Chapter.

NOTE: See also **G6—1** for requirements covering the installations of mandatory equipment.

2 LIFE RAFTS

2.1 **General** (see **G6—6** App., 1). The location of life rafts and their method of release shall be suitably chosen in relation to the ditching and flotation characteristics of the rotorcraft, the escape facilities of the rotorcraft, and the disposition of the occupants. (See also **G4—3,** 5.2.4 and **G4—10, 2**).

2.2 **Installations**

2.2.1 Life-raft installations shall be designed so as to ensure that the life rafts, together with any equipment, provisions, etc., which are required to be carried, will be serviceable when needed and that, so far as is practical, the installations will not be damaged by any defect likely to necessitate an Emergency Alighting on water (e.g. engine fire or fuel leakage) or by any damage liable to occur during such an alighting.

2.2.2 The design of the installations shall be such that, in emergency conditions, the life rafts can be launched quickly, the right way up, and clear of any obstructions liable to foul or damage them during launching and during boarding.

2.3 **Stowage**

2.3.1 The stowage of all life rafts shall be such that the probability of unintentional inflation or release is not greater than Extremely Remote, unless it can be shown that such inflation or release will not hazard the rotorcraft.

2.3.2 The stowage of all life rafts (including valise-types) shall be such that the life rafts will not be disturbed except for inspection purposes and, under normal conditions, will not be liable to damage by passengers or by the loading or unloading of freight.

2.3.3 Internal life-raft stowages shall be so arranged that adequate space is available for access to and easy manipulation of the life-raft package prior to launching.

2.3.4 Stowages shall be such as to prevent damage to or deterioration of the life-raft package due to spillage of or contact with any likely contaminants, including deleterious quantities of water.

2.3.5 Stowage covers opening outside the rotorcraft shall be secured by mechanical locks adequate to prevent spontaneous opening of the stowage cover during any condition of flight, including Emergency Alighting on water. The security of stowage covers shall be readily ascertainable by visual inspection when the rotorcraft is on the ground.

2.3.6 Stowages, covers and locks shall comply with the strength requirements for the rotorcraft as a whole as prescribed in Sub-section G3. In addition, due allowance shall be made for the loads resulting from pre-loading, altitude effects due to residual gas in life rafts, aerodynamic forces and vibration.

A.B

2.3.7 External stowage compartments shall be substantially weathertight, and yet designed to drain completely both in flight and in ground attitudes.

2.3.8 All stowages shall be free from any sharp edges or projections liable to damage a life raft whilst stowed or during launching, and shall provide positive location for inflation cylinders and any other articles which might shift and damage or disarrange the life raft or the release and operating mechanism.

2.3.9 All equipment essential for the operation of the life raft after its release and such other equipment and provisions as may be prescribed shall either be attached to the life raft, or its stowage in relation to the life raft shall be such as to ensure that, so far as possible, each life raft will be launched with its required equipment.

2.4 **Release and Launching**

2.4.1 **General.** After launching it shall be possible to hold life rafts in such a position that the likelihood of the occupants of the rotorcraft being immersed while boarding them is reduced to a minimum.

2.4.2 **Manual Launching**

(a) Where launching is by hand, the necessary actions shall be within the capacity of an untrained person of average strength, and shall not require exceptional agility or skill (see also **G6—1,** 2.17).

NOTE: A suitable line which can be attached to the rotorcraft prior to launching is provided as part of the life raft.

(b) The overall dimensions of the life-raft package shall be such that it can be easily passed through any emergency exit likely to be used for launching (see also **G4—3,** 5.2.3 Note (2)).

2.4.3 **Remotely Controlled Release**

(a) Release systems shall be safeguarded against spontaneous or inadvertent operation in any condition of flight, and shall be so designed that it is impossible to operate the release partially and return the control to its normal position, without it being obvious that the release has been partially operated.

(b) A manual release shall be provided at the life-raft position for each life raft normally intended to be released by remote control. Jamming of the remote control shall not prevent functioning of the manual release.

(c) A life raft released by remote control shall be attached to the rotorcraft by its line. This line, however, shall be incapable of submerging or capsizing the life raft if the rotorcraft sinks with the line still attached.

NOTE: The effects of wind on the raft with any inflatable canopies erected should be taken into account when deciding the breaking strength and length of the line.

(d) The means of releasing life rafts shall be rapid and obvious and the location of such means shall be adequately marked.

(e) There shall be at least one convenient release means inside the rotorcraft by which all remotely controlled life rafts can be released.

NOTE: It is recommended that release means, on the outside of the rotorcraft and likely to be accessible to survivors in the water, be provided.

2.4.4 **Automatic Release.** Requirements for automatic release systems shall be decided in consultation with the Authority.

3 ESCAPE CHUTES/SLIDES When the carriage of an escape chute/slide is mandatory, the equipment, its installation and functioning shall comply with requirements prescribed by the Authority.

APPENDIX TO CHAPTER G6—6

Issued, 17th December, 1980

1 GENERAL (see G6—6, 2.1)

1.1 Where operating regulations require the carriage of two or more life rafts, each should have a nominal capacity not less than the appropriate proportion of the total number of occupants (e.g. half the total number of occupants in the case of two life rafts, a third in the case of three life rafts, etc.).

1.2 Single-seat life rafts which might be provided for crew should not be taken into consideration when passengers are carried.

1.3 Detailed life raft specifications are contained in CAA Airworthiness Division Specification No. 2, Dinghies, obtainable from the Civil Aviation Authority, Airworthiness Division, Brabazon House, Redhill, Surrey, RH1 1SQ.

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SUB-SECTION G6—EQUIPMENT INSTALLATIONS

CHAPTER G6—7 EXTERNAL LIGHTS

Issued, 20th January, 1975

A.B 1 APPLICABILITY The requirements of this Chapter are applicable to the external lights, i.e. navigation and anti-collision lights which are provided in order to comply with the Rules of the Air and Air Traffic Control Regulations, 1972, as amended.

2 DEFINITIONS For the purposes of this Chapter the following definitions apply.

2.1 **Longitudinal Axis.** The longitudinal axis of the rotorcraft is a selected axis parallel to the forward direction of flight at a normal cruising speed, and passing through the c.g. of the rotorcraft.

2.2 **Horizontal Plane.** The horizontal plane is the plane containing the longitudinal axis and perpendicular to the plane of symmetry of the rotorcraft fuselage.

2.3 **Vertical Planes.** Vertical planes are planes perpendicular to the horizontal plane defined in 2.2.

2.4 **Dihedral Angles.** The three dihedral angles referred to as Dihedral Angle L, Dihedral Angle R and Dihedral Angle A are formed by pairs of intersecting vertical planes, the intersections of which with the horizontal plane are as shown in plan in Fig. 1 (G6—7).

2.5 **Effective Flash Frequency.** The frequency at which the anti-collision light or lights are observed from a distance. The frequency applies to all sectors of light including the overlaps which might exist when the system consists of more than one light source.

2.6 **Candela.** The unit of luminous intensity as defined in BS 4727, Part 4, "Terms Particular to Lighting and Colour".*

3 GENERAL

3.1 **Determination of Intensity.** The intensities prescribed shall be those to be provided by new equipment with all filters and covers in place. Intensities shall be determined with the light source operating at a steady value equal to the average luminous output of the light source at the normal operating voltage of the rotorcraft.

3.2 **Location of Light Sources**

3.2.1 Light sources shall be located so that they will not cause glare objectionable to the pilot.

3.2.2 The white astern light shall be as far aft as practicable, and the red port and green starboard lights shall be spaced as far apart as practicable.

3.3 **Light Filters and Covers**

3.3.1 The prescribed colours shall be within the limits for Class A Red, Class A Green and Class A White as specified in BS 1376 "Colours of Light Signals".*

*Obtainable from the British Standards Institution.

A.B

3.3.2 The determination of the colour of a light shall be made with the light source operating at the average efficiency corresponding to the normal operating voltage of the rotorcraft.

3.3.3 Covers and filters shall be of material which is not Flammable, shall be constructed so that they will not change colour or shape, and shall be such that there is no appreciable loss of light transmission during normal use.

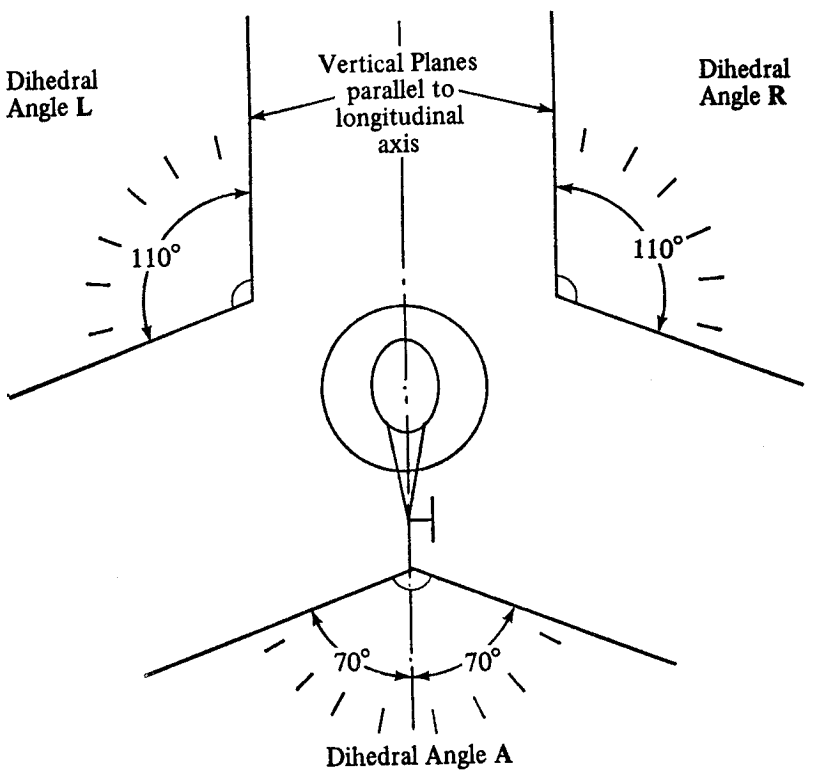
4 NAVIGATION LIGHTS

4.1 The following lights shall be emitted within the Dihedral Angles of Fig. 1 (G6—7)—

(a) **Starboard Signal.** A steady green light within Dihedral Angle R.

(b) **Port Signal.** A steady red light within Dihedral Angle L.

(c) **Astern Signal.** A steady white light within Dihedral Angle A.



NAVIGATION LIGHTS—DIHEDRAL ANGLES

Fig. 1 (G6—7)

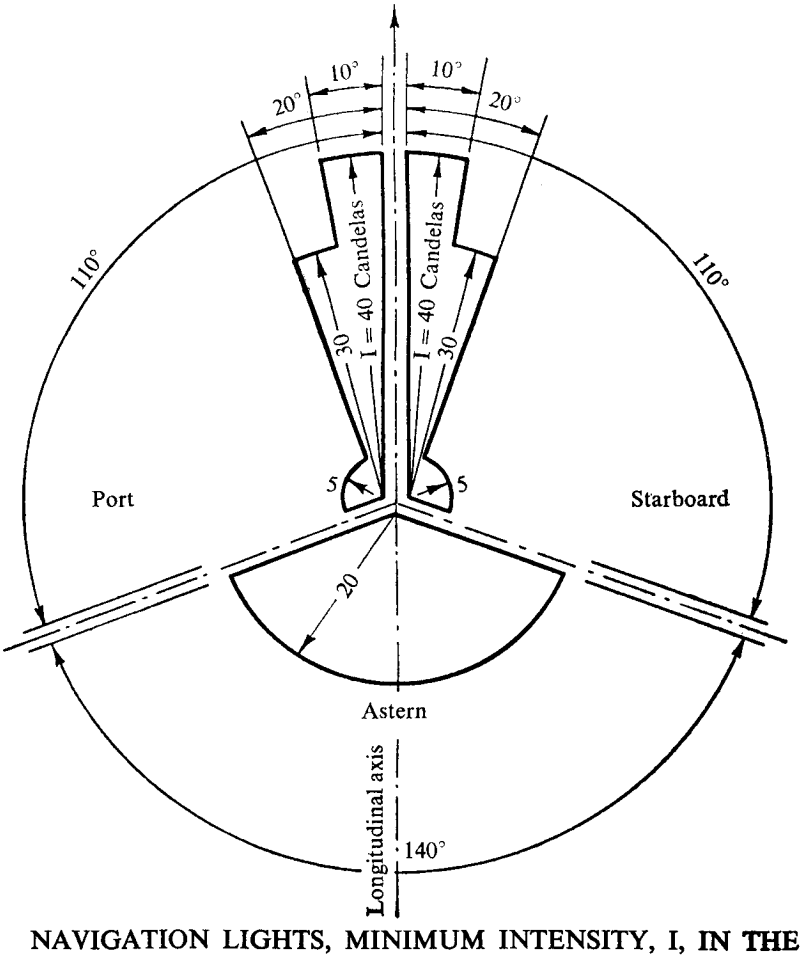
A.B

4.2 The intensity in any direction in the horizontal plane shall be not less than the values given in Table 1 (G6—7) (see also Fig. 2 (G6—7)).

TABLE 1 (G6—7)

MINIMUM INTENSITIES IN THE HORIZONTAL PLANE

Dihedral Angle	Angle from Right or Left of Longitudinal Axis measured from Dead Ahead (degrees)	Intensity (candelas)
L & R	0 to 10	40
	10 to 20	30
	20 to 110	5
A	110 to 180	20



NAVIGATION LIGHTS, MINIMUM INTENSITY, I, IN THE HORIZONTAL PLANE

Fig. 2 (G6—7)

A.B

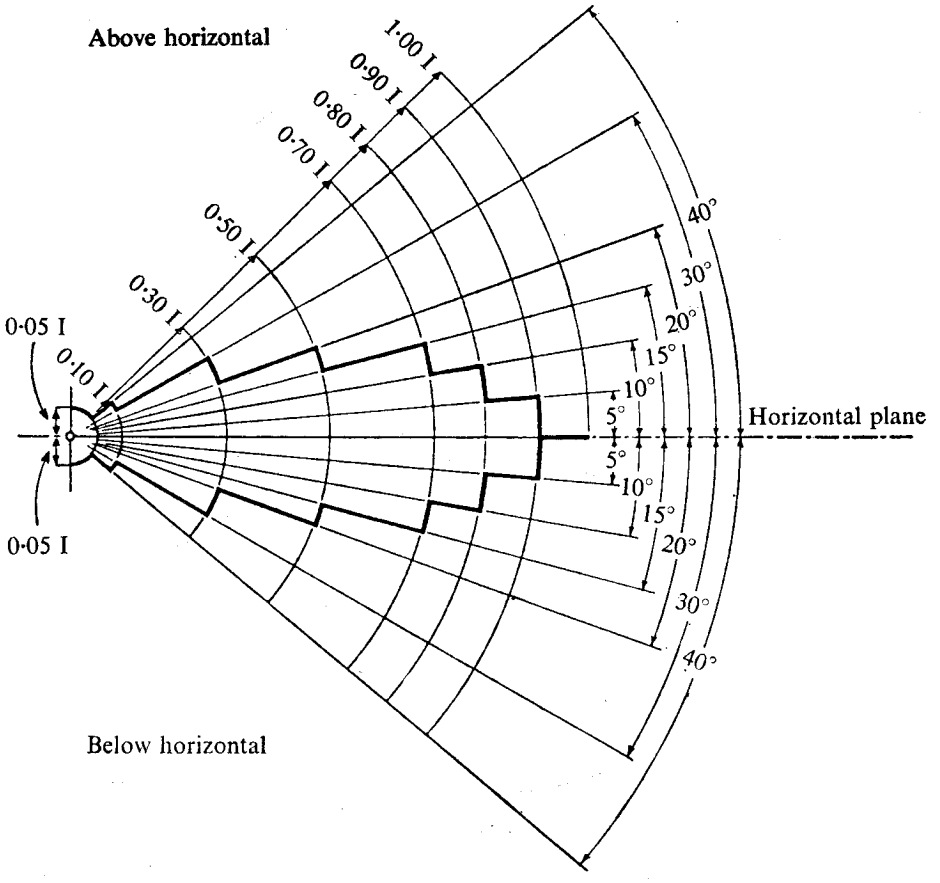
4.3 The intensity in any direction in any vertical plane shall be not less than the appropriate value given in Table 2 (G6—7) (see also Fig. 3 (G6—7)).

TABLE 2 (G6—7)
MINIMUM INTENSITIES IN ANY VERTICAL PLANE

Angle Above or Below Horizontal (degrees)	Intensity (candelas)
0	1·00
0 to 5	0·90
5 to 10	0·80
10 to 15	0·70
15 to 20	0·50
20 to 30	0·30
30 to 40	0·10
40 to 90	0·05

× I

where, "I" is the minimum intensity prescribed in Table 1 (G6—7).



NAVIGATION LIGHTS, MINIMUM INTENSITIES IN VERTICAL PLANES
Fig. 3 (G6—7)

A.B

4.4 The intensities in overlaps between adjacent signals shall not exceed the values given in Table 3 (G6—7).

TABLE 3 (G6—7)

MAXIMUM INTENSITIES IN OVERLAPS

Overlap	θ (degrees)	Maximum Intensity (candelas)
Green in Dihedral Angle L	10 to 20 beyond 20	10 1
Red in Dihedral Angle R	10 to 20 beyond 20	10 1
Green in Dihedral Angle A	10 to 20 beyond 20	5 1
Red in Dihedral Angle A	10 to 20 beyond 20	5 1
Rear white in Dihedral Angle L	10 to 20 beyond 20	5 1
Rear white in Dihedral Angle R	10 to 20 beyond 20	5 1

where θ is the vertical projection in the horizontal plane of the overlap angle.

5 ANTI-COLLISION LIGHTS

5.1 The anti-collision light (or lights) shall emit a flashing red light which shall comply with this paragraph **5**.

5.2 Within 30° above and 30° below the horizontal plane the anti-collision light(s) shall afford coverage in all directions, except that a solid angle or angles of obstructed visibility, totalling not more than 0·05 steradians, shall be permissible.

5.3 The effective flash frequency of the signals emitted by the anti-collision light(s) shall be not less than 40 and not more than 100 flashes per minute. In an overlap, flash frequencies of up to 180 flashes per minute will be permitted.

A.B

5.4 The minimum effective light intensity in all vertical planes shall be in accordance with Table 4 (G6—7). In the determination of minimum effective intensity the following relationship shall be assumed.

$$I_e = \frac{\int_{t_1}^{t_2} I_t \, dt}{0{\cdot}2 + (t_2 - t_1)}$$

where, I_e .. .. candelas .. is effective intensity;

I_t .. .. is instantaneous intensity as a function of time;

$(t_2—t_1)$ .. secs. .. is flash time interval.

TABLE 4 (G6—7)

MINIMUM EFFECTIVE INTENSITIES FOR ANTI-COLLISION LIGHT(S)

Angle Above or Below Horizontal Plane (degrees)	Effective Intensity (candelas)
0 to 5	100
5 to 10	60
10 to 20	20
20 to 30	10

SUB-SECTION G6—EQUIPMENT INSTALLATIONS

CHAPTER G6—10 ATTITUDE DISPLAY SYSTEMS

Issued, 16th August, 1982

A

1 INTRODUCTION

1.1 The requirements of this Chapter are applicable to the attitude display systems provided in order to comply with **G6—1, 5,** for flight in Instrument Meteorological Conditions.

1.2 Compliance with the requirements of this Chapter does not imply that the system is acceptable in its effects on other systems.

1.3 Rotorcraft fitted with attitude display systems which comply with the requirements of this Chapter will also comply with the relevant provisions of the Air Navigation Order (see **G6—1,** 5.1.3 and 5.3.2).

2 GENERAL (see G6—10 App., 1)

2.1 Each pilot's station shall be provided with a separate display in the form of a gyro stabilised artificial horizon line which indicates the position of the horizon relative to a rotorcraft reference symbol.

NOTE: This Chapter **G6—10** does not cover head-up display systems. Where it is intended to use such a system, reference should be made to the Authority.

2.2 The probability of total loss of attitude indication to the flight crew shall be in the lower part of the Extremely Remote range. (See **G6—10** App., 1.3).

2.3 The probability of the indication of incorrect information likely to lead to a hazardous attitude shall be Extremely Remote.

2.4 In the event of a total failure of the main generated electrical power supply the captain's station of the rotorcraft shall be provided with uninterrupted usable attitude information for a period of time sufficient for the rotorcraft to be landed safely assuming that any prescribed crew action necessary is taken (see 2.5). It is not acceptable to assume that this action is taken in less than 10 minutes after the appearance of the failure warning. (See also **G6—10** App., 1.3 and **G6—1,** 5.3.5.)

NOTES: (1) The usable attitude information should be displayed in a position such that it can also be used by the co-pilot.

(2) The provision of uninterrupted usable information implies that, when necessary, adequate illumination of the display is also maintained without interruption for the required period.

2.5 Precise drills covering crew action in the event of electrical generation system failures and malfunctions shall be included in the appropriate rotorcraft manual(s), together with a statement of the battery endurance under specified load conditions.

2.6 If the period of time for which attitude information is available after total failure of the main generated electrical power supply is less than the endurance of the rotorcraft, the time shall be declared in the Flight Manual. It shall not, in any event, be less than half the endurance of the rotorcraft.

NOTE: The Authority may limit the operation of the rotorcraft if adequate time is not provided.

A

3 DISPLAY CHARACTERISTICS (see G6—10 App., 2)

3.1 No misleading information shall be given during or after any exceedance of the range of attitudes for which the display is designed.

3.2 The artificial horizon line shall move in roll so as to remain parallel to the true horizon, i.e. when the rotorcraft rolls through an angle of 30°, the artificial horizon line will also rotate through 30° relative to the fixed index.

3.3 The artificial horizon line shall remain in view over a range of pitch attitudes sufficient to cover all normal operations of the rotorcraft plus a margin of not less than 2° in either direction. Additional 'ghost' horizon lines shall be provided parallel to the main horizon line so that beyond this range, at least one such line is in view at any attitude within the range of the display.

3.4 The pitch attitude scale shall be linear while the main horizon line is in view, but may become non-linear beyond this range, provided that indications continue to be given in the correct sense. The response and sensitivity of the display to changes in attitude shall be such as to permit accurate control of the rotorcraft.

3.5 Sufficient pitch and bank angle graduations and markings shall be provided to allow an acceptably accurate reading of attitude and to minimise the possibility of confusion at extreme attitudes. The graduation intervals on all the attitude displays in the rotorcraft shall be sufficiently similar for there to be no risk of confusion in transferring attention from one display to another.

3.6 A bank angle index and scale shall be provided. The index shall at all times be at 90° to the horizon lines, and shall be in the same position, i.e. either 90° above or 90° below, for all displays in the rotorcraft.

3.7 The 'earth' to 'sky' areas of the display shall be clearly distinguished by means of a distinctive colour or shade contrast. This differentiation shall not be lost at any pitch or roll attitude.

3.8 Any additional information (e.g. flight director commands) displayed on an attitude display shall not obscure or significantly degrade the attitude information.

3.9 The display shall be clearly visible under all conditions of daylight and artificial lighting.

APPENDIX TO CHAPTER G6—10

Issued, 16th August, 1982

ATTITUDE DISPLAY SYSTEMS

1 GENERAL (see G6—10, 2)

1.1 For main attitude displays the width of the perceived moveable horizon display should not be less than 76 mm (3 in), except that smaller displays may be accepted subject to a satisfactory flight evaluation.

1.2 Means may be provided to adjust the position of the rotorcraft reference symbol, or the horizon line, but in pitch only, to allow for variations in the rotorcraft attitude in flight, due to different centre of gravity positions, so that the symbol and line can be aligned during cruising flight. The range of adjustment should be such that hazardous misalignment is not possible.

1.3 An acceptable means of compliance with the requirements of **G6—10,** 2.2 to 2.5 inclusive, would be the provision of three displays, the reliability and independence of which was shown to be adequate by a suitable assessment, one for each of the two pilots' stations, and a third 'standby' display positioned so that both pilots can use it. Each display should have independent sensors and power supplies. The power supply to the standby display should be such that it will be maintained automatically, in the event of total failure of the main generated electrical power supply, for at least 90 minutes. However, a shorter period, but in no case less than 45 minutes, may be acceptable where it can be shown that the rotorcraft can be landed safely, in all circumstances, within this time. For the purposes of **G6—10,** 2.2, the lower part of the Extremely Remote range should be taken as not greater than 1×10^{-8}.

1.4 Where a third 'standby' display is fitted, the instrument should be provided with a failure warning device, e.g. a warning flag which should indicate loss of power supply or significant wheel speed deviation. For two pilot operation the warning should be visible to both pilots.

1.5 The standby display should be similar in presentation to the other displays except that it may be smaller, with a width of perceived moveable horizon display of not less than 50 mm (2 in).

1.6 When making the assessment required by **G6—10,** 2.3, it should be established that the provision of rotorcraft attitude retention by means of an automatic flight control system using the same attitude sensor information does not introduce any greater degree of hazard.

2 DISPLAY CHARACTERISTICS (see G6—10, 3)

2.1 Each display should function correctly over a range of $\pm 120°$ in roll and $\pm 80°$ in pitch.

2.2 The following graduation intervals are acceptable:—

Pitch: 20° nose up to 20° nose down: every 5°.

Beyond this range: at least one numbered graduation to be in view at any attitude but without unnecessary clutter.

Roll: 0° to 30° : every 10°
30° to 90° : every 30°.

Sufficient pitch graduation intervals should be numbered and in such a way as to ensure ready and correct identification.

2.3 Where it is considered necessary to add wording to displays the wording should be agreed with the Authority.

SUB-SECTION G6—EQUIPMENT INSTALLATIONS

CHAPTER G6—12 EMERGENCY FLOTATION GEAR

Revised in part, 17th December, 1980

A.B 1 APPLICABILITY Where the carriage of emergency flotation gear is essential for compliance with operating regulations, the equipment and its installation shall comply with the requirements of this Chapter.

2 GENERAL

2.1 The design and installation of the emergency flotation gear shall be such that, during and after an Emergency Alighting on water, the requirements of **G4—10, 2** are met.

2.2 **Buoyancy.** The buoyancy of each float shall be not less than 125% of that proportion of the Maximum Weight of the rotorcraft normally supported by the float in fresh water.

2.3 **Stability**

2.3.1 The arrangement of the floats shall be such as to provide a margin of positive stability for the rotorcraft in the conditions of **G4—10.**

NOTE: This may be demonstrated by means of model tests in representative sea conditions (see **G4—10** App.). Limitations on the range of sea states regarded as acceptable may need to be included in the Flight Manual.

2.3.2 The number of separate watertight compartments shall be such that a margin of positive stability in conditions up to Sea State 2 (as defined in **G4—10** App.), is provided with any single compartment flooded.

NOTE: For subsequent salvage purposes consideration should be given to providing continued stability of the rotorcraft with the weight and c.g. combination which would exist after evacuation of the occupants.

3 STRENGTH The strength of the emergency flotation gear and its attachment shall comply with **G3—5,** 7.3.

4 INSTALLATION

4.1 **General.** This paragraph 4.1 applies both to floats which are normally inflated and to those which are normally deflated. Additional requirements for normally deflated floats are given in 4.2.

4.1.1 Installations shall be so designed that, so far as practical, the installation will not be damaged by any defect likely to necessitate ditching (e.g. engine fire or fuel leakage) or by any damage likely to occur to the rotorcraft during an Emergency Alighting.

4.1.2 The location of floats and, where applicable, their means of inflation shall be suitably chosen in relation to the ditching characteristics of the rotorcraft, the escape facilities, and the location of personnel inside the rotorcraft.

A.B 4.1.3 Any limitations on the permitted speed, altitude, temperature range, or fitment of other equipment to the rotorcraft, imposed by the design of floats shall be established and included in the Flight Manual. (See **G8—5**).

4.2 **Normally Deflated Floats**

4.2.1 **Attachments.** Attachments of stowages and protective covers shall have Proof and Ultimate Factors of at least 1·0 and 1·5 respectively under the most adverse practical combination of loads of Sub-section G3. In addition, due allowance shall be made for the loads resulting from pre-loading, inertia, aerodynamic pressures and altitude effects resulting from residual gas in stowed floats.

4.2.2 **Security.** The security of protective covers shall be readily ascertainable by visual inspection when the rotorcraft is on the ground.

4.2.3 **Inflation**

(a) The probability that floats will not inflate correctly when required, or inflate asymmetrically, shall not be more than Remote.

NOTE: This will normally require two separate and independent systems for initiating inflation and the interconnection of all inflation systems. For example, if initiation is by water contact, a pilot-operated back-up system will be required.

(b) Inflation systems shall be safe-guarded against spontaneous or inadvertent operation in all conditions of flight.

NOTE: For automatically-inflating systems a disarming system, if used only above a certain air speed or height, could satisfy this requirement.

(c) The probability of hazard to the rotorcraft in the event of inadvertent inflation in any normal condition of flight shall not be more than Remote.

(d) Where flotation gear is intended to be inflated in flight, an envelope of flight conditions shall be established as safe for the inflation.

(e) The time of inflation, i.e. that time from initiation to full inflation, shall be sufficiently small to prevent the rotorcraft becoming more than partially submerged, and shall be such that occupants may be expected to remain dry.

B NOTE: It is recommended that, for Group B rotorcraft, the time of inflation, from initiation to neutral buoyancy, should not be more than 2·5 seconds.

A.B (f) Suitable means shall be provided for checking the pressure in gas storage cylinders.

(g) A means shall be provided to guard against the possibility of over-inflation.

5 TESTS

5.1 **Flight Tests.** Compliance with the requirements of 4.2.3(c) and (d) shall be demonstrated by flight tests, and those of 4.2.3(e) by suitable tests, on prototype installations.

SUB-SECTION G7—TRANSMISSION AND ROTOR SYSTEM TESTS

CHAPTER G7—1 GENERAL

Revised, 15th June, 1966

A.B 1 APPLICABILITY The requirements prescribed in this Sub-section G7 are applicable to helicopters of conventional design fitted with turbine engines of conventional design driving one or two shaft-driven main rotors. The requirements of **G7-1** and **G7-2** are also applicable to helicopters of conventional design fitted with piston engines of conventional design driving one or two shaft-driven main rotors.

NOTE: The ground and flight test requirements for piston-engined installations will be decided in consultation with the Board.

2 ENGINE FAILURE Should an engine failure occur during the prototype tests prescribed in this Sub-section, the cause of the failure shall be established. If the failure of the engine resulted from incompatibility of the engine/helicopter combination, appropriate modification and approval testing of the engine and helicopter shall be carried out.

SUB-SECTION G7—TRANSMISSION AND ROTOR SYSTEMS TESTS

CHAPTER G7—2 TEST CONDITIONS—PISTON AND TURBINE ENGINE INSTALLATIONS

Revised, 15th June, 1966

A.B 1 GENERAL The requirements of this Chapter are of a general nature and are applicable to Sub-section G7 as a whole. There may be cases where a general requirement given in this Chapter has to be overriden by a detailed requirement in a particular chapter; the text used in the particular chapter will make this clear.

NOTES : (1) Before commencing the tests the Applicant should obtain an assurance from the appropriate engine constructor that the conditions of the tests are acceptable to him.

(2) Where, because of transmission limitations of r.p.m. or torque, the declared ratings of the helicopter are less than the declared ratings of the engine (Maximum One-hour Power, Maximum Continuous Power, etc.) the tests will be run to the limitations applicable to the helicopter.

2 OBSERVATIONS

2.1 **General**

2.1.1 Throughout the tests of this Sub-section observations shall be made as prescribed in the stage or test. The observation reference numbers shall be interpreted in accordance with 2.2 or 2.3, as appropriate, and 2.4.

2.1.2 Operating conditions shall be allowed to stabilise as far as practical before observations are taken.

2.2 **Piston-engined Helicopters.** The Observation Reference Numbers shall be those detailed in **Section C,** Chapter **C2—3,** 2.3 except that, for the purpose of these tests, Observation Reference Number 26 shall be interpreted as ambient barometric pressure.

2.3 **Turbine-engined Helicopters.** The Observation Reference Numbers shall be those detailed in **Section C,** Chapter **C3—3,** 2.3 except that, for the purpose of these tests, Observation Reference Number 17 shall be interpreted as ambient barometric pressure.

2.4 **All Helicopters.** The following Observation Reference Numbers, in addition to any further Observations required to establish compliance with any intended operating limitation, are applicable to all helicopters.

Ref. No.	Observation	Standard Units
50	Main Rotor rotational speed	R.P.M.
51	Pressure of each pressure lubrication system in the Transmission System	lb/sq. in.
52	Oil temperature in each lubrication system in the Transmission System. In addition, if there is more than one gearbox in any lubrication system, the temperature of the oil at the outlet from each gearbox	°C
53	Transmission System driving shaft torque (if available directly) or such other engine conditions as will enable this to be established	—

A.B 3 TRANSMISSION AND ROTOR SYSTEMS TO BE USED DURING TESTS A single Transmission and Rotor System shall complete satisfactorily the Ground Endurance Test. If desired, other Transmission and Rotor Systems and components of the same type may be used for the other tests.

4 STOPS In the event of an unscheduled stop occurring during the Endurance Tests, the whole of the scheduled period in which the stop occurs shall be repeated unless the Board considers this to be unnecessary. The complete test shall be repeated if an excessive number of unscheduled stops occurs such as to cast doubt on the validity of the test.

5 ENGINE AIR INTAKES AND EXHAUST PIPES All tests of the complete helicopter shall be made, unless otherwise agreed by the Board, using engine air intakes and exhaust pipes representative of the design for which approval is sought.

6 CONDITIONS APPLICABLE TO ALL TESTS

6.1 **Lubricants.** The lubricants specified in the manufacturer's declaration shall be used for all tests. Representative samples of the used lubricants shall be analysed at the end of the Endurance Tests and the data shall be included in the test reports. The results of the analysis shall be satisfactory to the Board.

6.2 **Controls and Adjustable Devices**

6.2.1 All the automatic controls which are normally in use shall be in operation whenever possible. Automatic controls which operate only in an emergency or under special conditions shall also be exercised to an agreed schedule.

6.2.2 Controls (i.e. variable devices which are intended for use during flight or ground handling) shall be operated in accordance with the manufacturer's instructions. Any exceptions necessary to obtain the required test conditions shall be agreed by the Board.

6.2.3 Adjustable devices (i.e. variable devices not intended to be varied in flight or ground handling) shall be set prior to each test in accordance with the manufacturer's instructions, and shall not be altered until after the test is completed and any information required by 6.2.4 has been obtained. Any exceptions necessary to obtain the required test conditions shall be agreed by the Board.

6.2.4 Adjustable devices shall be checked and unintended variations from the original settings recorded:—

(a) at each strip examination,

(b) when they are re-set where the nature of a test demands it,

(c) as required by requirements relating to specific tests.

6.2.5 The manufacturer's instructions referred to in 6.2.2 and 6.2.3 shall be those which it is proposed to incorporate in the appropriate manuals.

6.3 **Transmission Adjustments, and Parts Replaced during Tests.** During all tests, only servicing and minor repairs shall be permitted, and details of all the work done shall be included in the report. Where considered acceptable to the Board, major repairs or replacement of parts may be resorted to, provided that the parts in question are subjected to such additional tests as are necessary to prove their reliability. These additional tests will be dependent both upon the nature and extent of the repairs or replacements involved, and when they occur in the test programme.

A.B

6.4 **Engine Intake Pressure and Temperature.** The intake air pressure and temperature shall be measured at an agreed point relative to the engine.

6.5 **Accessory Drives.** Throughout all ground tests all transmission accessory drives shall be loaded with the accessories listed in the constructor's declaration, in accordance with a schedule agreed with the Board.

SUB-SECTION G7—TRANSMISSION AND ROTOR SYSTEM TESTS

CHAPTER G7—3 GROUND AND FLIGHT TESTS—SINGLE TURBINE-ENGINE INSTALLATIONS

Issued, 15th June, 1966

B 1 INTRODUCTION This Chapter prescribes requirements and tests for helicopters with one turbine-engined power-unit. See also **G7—1** and **G7—2** for the general requirements and conditions applicable to this Chapter **G7—3**.

NOTES : (1) When reviewing the results of these tests the Board will also take into consideration the development history of the Transmission and Rotor System.

(2) Where modifications are introduced as a result of any of these tests, or if modifications are incorporated in the helicopter which could affect the conditions of operation of the Transmission or Rotor System, all the tests already completed will need to be repeated with the modifications embodied in the helicopter unless otherwise agreed by the Board.

2 GENERAL

2.1 **Oil System Pressure Tests**

2.1.1 All parts of the oil system of a representative Transmission and Rotor System, including oil pipes and integral oil passages and tanks, but excluding separate oil tanks, shall be pressure tested in accordance with this paragraph 2.1 and during the tests no unacceptable leaks shall occur from joints required to be liquid tight. The parts shall be capable of supporting the loads imposed during the tests.

2.1.2 The parts shall be tested at the temperature associated with the most critical stressing case unless it is agreed by the Board that the test pressure differential may be increased to simulate the loss of strength as a result of the temperature and account is taken of any thermal stresses that would occur.

2.1.3 All parts, excluding integral oil tanks, shall be pressure tested to at least 1·5 times the maximum operating pressure of the particular part, or 2·0 times the normal operating pressure, whichever is the greater. Oil tanks which are an integral part of the Transmission and Rotor System shall be pressure tested to a pressure of 1·5 times the maximum operating differential pressure or 5 lb/sq. in. more than the maximum operating differential pressure, whichever is the greater.

NOTE : Equivalent pressure tests carried out in the approval of components such as pumps, filters, etc., may be accepted as demonstrating compliance with this requirement.

2.2 **Vibration Survey and Tests**

2.2.1 A vibration survey of the Transmission and Rotor System shall be made over the full range of both ground and flight conditions (see also **G3—1, 5**). An investigation of the effects of engine malfunctioning shall be carried out. If the effects of engine malfunctioning are found to be significant they shall be included in the demonstration of 2.2.4.

2.2.2 The vibration survey shall cover likely combinations of such conditions as:—

(a) starting and stopping the engine and rotors, at any permissible control setting, on the ground or as applicable in flight,

(b) the most critical cases of clutch, free wheel and rotor brake operation,

(c) rotor out of balance to a value to be agreed with the Board.

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2.2.3 It shall be established that the resulting stresses are within satisfactory limits for the materials and particular designs involved.

2.2.4 It shall be demonstrated that no dangerous torsional or flexural vibration or whirling of shafting can occur in the helicopter at any possible torque and at any rotation speed up to,

(a) in the case of the Rotor System
  (i) 115% of the Rotor Maximum R.P.M. (Power On),
  (ii) 105% of the Rotor Never Exceed R.P.M.,
  whichever is the greater,

(b) in the case of the remaining parts of the transmission
  (i) 105% of the Rotor Maximum R.P.M. (Power On),
  (ii) the Rotor Never Exceed R.P.M.,
  whichever is the greater.

2.2.5 Tests involving speeds exceeding the declared operating limitations may be conducted on the ground.

2.2.6 At specific reference stations on the helicopter, the Applicant shall establish the levels of vibration which are acceptable, and with which the vibration levels of series helicopters when new, in service, and after overhaul, can be compared.

3 ENDURANCE TESTS

3.1 **Ground and Flight Tests.** The requirements of this paragraph 3.1 are applicable to the Ground and Flight Endurance Tests.

3.1.1 **Test Helicopters.** The tests shall be made on helicopters which are representative of the helicopter for which certification is sought in respect of the engine, transmission, rotor blades, control systems, supporting structure, landing gear, and any other feature which may influence the vibration characteristics.

3.1.2 **Detail Inspections.** Prior to assembly of the Transmission and Rotor System for both the Ground and the Flight Endurance Test they shall be subjected to a complete detail inspection and a record shall be made of those dimensions liable to change by reason of wear, and/or distortion. This process shall be repeated on completion of each test.

3.1.3 **Torque Calibration.** The torque measuring systems, or if no torque measuring system is fitted, the engines used, shall be suitably calibrated before and after the completion of the Ground Endurance Test and before and after the Flight Endurance Test so that an accurate assessment of the power developed during the test may be made. The Board may require the complete test to be repeated or additional periods run if the power deteriorates by an excessive amount. The point at which the torque is to be measured shall be defined and any limitations presented to the flight crew shall be derived from this datum point.

3.2 **Ground Endurance Test.** The requirements of this paragraph 3.2 are applicable to the Ground Endurance Test.

3.2.1 **Restraint During Test.** The method of restraint for the test shall be to the satisfaction of the Board.

3.2.2 **Oil Pressure.** Twenty-four Stages of the test shall be run with the transmission oil pressure(s) set to give the declared normal operating pressure at Maximum Continuous conditions. One stage shall be run with the pressure set to give the declared minimum operating pressure at Maximum Continuous conditions. Alternatively, evidence in respect of minimum operating pressure from equivalent rig tests would be acceptable.

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3.2.3 **Oil Temperature.** All of Parts 1, 4 and 7 of the test shall be run at the appropriate declared maximum transmission oil temperatures, unless adequate rig tests are completed of the same duration and of at least equal severity in respect of speeds and steady and fluctuating loads with the oil at the declared maximum transmission oil temperatures.

3.2.4 **Rotor Balance.** The degree of out of balance before, during and at the conclusion of the test shall be recorded.

NOTE: The maintenance instructions regarding rotor balancing should take into account the experience gained during the Ground Endurance Test.

3.2.5 **Change of Power Settings.** The time taken in changing power settings during the test shall not be deducted from the prescribed periods at higher settings.

3.2.6 **Critical Loads.** Any components which can be subjected to critical loading conditions not adequately covered by the standard test conditions, e.g. bearings which can be off-loaded by gear reaction or preloading, shall be tested by suitable variations of the Ground Endurance Test or by additional tests acceptable to the Board.

3.2.7 **Transmission Operating Limitations.** The transmission operating limitations of torque, r.p.m., etc., associated with permitted periods of use, will be based on the mean values recorded during the appropriate tests. The operating limitations of temperature will be based on the mean values recorded during the appropriate periods of the Ground Endurance Test or equivalent rig tests (see 3.2.3). Any short period temperature limitations may be substantiated by variation of the Endurance Test or by supplementary rig tests acceptable to the Board.

3.2.8 **Rotor Starts, Accelerations, Clutch Engagements, Decelerations and Brake Tests.**

(a) In the accelerations prescribed in 3.2.13 the rotors shall be accelerated from the minimum ground idling speed to conditions producing Rotor Maximum One-hour Torque and the maximum rotor r.p.m. associated with that torque in the most rapid manner permitted. If a clutch is fitted, it shall be engaged using the technique recommended by the helicopter manufacturer. Each engine deceleration shall be made as quickly as possible. If necessary the engine shall be stopped in order to bring the Rotor System to rest. If a rotor brake is fitted it shall be applied on each occasion the rotor is stopped at the speed and using the technique recommended by the manufacturer. If, however, the vibration survey shows that the free run down is more severe, an agreed number of stops shall be made without using the rotor brake. During the accelerations the rotor pitch shall be set or controlled to give accelerating conditions at least as severe as those which will occur during the operation of the helicopter.

(b) Ten of the accelerations shall be carried out with the transmission lubricating system at the declared minimum temperature for exceeding Rotor Ground Idling conditions, or the minimum obtainable temperature, whichever is higher. If a lower temperature for starting the rotors is declared, 10 additional rotor starts shall be made at this temperature. The transmission will be approved for use at the mean of the temperatures at which the tests were made. If, because the prevailing ambient conditions are unsuitable, a low enough clearance cannot be obtained by this method, suitable rig tests on the critical components may be accepted as an alternative.

3.2.9 **Rotor Controls.** Nine hundred complete cycles of control movements, each cycle being as prescribed in (a) and (b), shall be made at agreed intervals during the periods at Maximum Continuous conditions prescribed in 3.2.13. Each control position shall be held at maximum for at least ten seconds and the rate of change of control position shall be at least as rapid as for normal operation.

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(a) The controls shall be operated up to the positions of full vertical thrust, maximum forward thrust component, maximum aft thrust component, maximum left thrust component, and maximum right thrust component, except that the control movements need not produce loads or blade flapping motion exceeding the maximum loads or motions encountered in flight.

(b) The directional controls shall be operated up to the control extreme of maximum right turning torque and maximum left turning torque, through neutral turning torque, except that the control movements need not produce loads exceeding the maximum loads encountered in flight.

3.2.10 **Rotor Thrust and Turning Torque.** The periods of 3.2.13 specified in (a) to (f) shall be run with the rotor controls set to produce the maximum thrust in each of the directions indicated, except that the control positions need not produce loads or blade flapping motion exceeding those encountered in flight. Except where prescribed at (f) the specified periods shall be run at neutral turning torque.

(a) Part 1 of four Stages	— Right thrust component.
(b) Part 1 of four Stages	— Left thrust component.
(c) Part 1 of four Stages	— Aft thrust component.
(d) Part 4 of every even numbered Stage	— Vertical thrust.
(e) All remaining Parts 1 & 4	— Forward thrust component as appropriate to the maximum forward speed associated with the prescribed operating conditions.
(f) Part 5 of all Stages	— Periods of running at maximum left and right turning torques so that a total of 12 hours each left and right turning torque is achieved, the remainder being at neutral turning torque.

3.2.11 **Safety and Warning Devices.** All safety devices, including warning devices, shall be fitted throughout the test. Additional functional tests shall then be made which, together with the type endurance test, will be adequate to demonstrate the reliability of the devices. Any limitations on the use of the devices shall be established.

3.2.12 **Test Running.** The test shall be run as detailed in 3.2.13. Each stage shall be run as far as possible in non-stop periods of not less than two hours. Those of the Observations referred to in **G7—2,** 2.1 to be made during each part of the test, and the frequency at which they are made, shall be agreed with the Board.

3.2.13 **Ground Endurance Test.** The Ground Endurance Test shall be as prescribed in this paragraph 3.2.13 and, except as may be chosen for Parts 7 and 8, shall consist of twenty-five 6-hour stages, each stage comprising:—

Part	Duration	Operating Conditions
1	1 Hr. 25 Min.	Rotor Maximum Continuous Torque and Rotor Maximum R.P.M. (Power On)*
2	15 Min.	Three 5-minute cycles, each cycle comprising:— (a) 2½ min. at rotor ground idling conditions. (b) Acceleration. (c) 2½ min. at Rotor Maximum One-hour Torque and Rotor Maximum R.P.M. (Power On)*. (d) Deceleration. (e) Stop the rotor, applying brake at maximum speed permitted.

*If because of governor "droop" characteristics the rotor maximum r.p.m. varies with the torque applied, the speeds of these tests shall be the maximum associated with the prescribed torque as defined by the manufacturer in a curve of limiting speed against torque.

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Part	Duration	Operating Conditions
3	5 Min.	Three cycles comprising:— (a) (1st cycle) 2½ min. at rotor ground idling conditions. (2nd) and (3rd) ½ min. at rotor ground idling conditions. (b) Acceleration. (c) ½ min. at Rotor Maximum One-hour Torque and Rotor Maximum R.P.M. (Power On)*. (d) Deceleration. (e) Stop the rotor, applying brake at maximum speed permitted.
4	1 Hr. 30 Min.	Rotor Maximum One-hour Torque and Rotor Maximum R.P.M. (Power On)*.
5	2 Hr.	During the Ground Endurance Test at least 12 equal periods shall be run at approximately equal speed and torque increments so as to cover the envelope of conditions between Rotor Maximum and Minimum R.P.M. (Power On) and between Rotor Maximum One-hour Torque and rotor ground idling conditions, excluding Rotor Maximum Continuous Torque. These periods shall be appropriately adjusted to include any particular conditions which are likely to be used for considerable periods in service.
6	30 Min.	Ten 3-minute cycles, each cycle comprising:— (a) 1½ min. at rotor ground idling conditions. (b) Acceleration. (c) 1½ min. at Rotor Maximum One-hour Torque and Rotor Maximum R.P.M. (Power On)*. (d) Deceleration. (e) Stop the rotor, applying brake at maximum speed permitted.
7†	7½ Min.	3% in excess of Rotor Maximum R.P.M. (Power On) at not less than Rotor Maximum Continuous Torque.
8†	7½ Min.	Rotor Maximum R.P.M. (Power On) and the minimum power necessary to obtain this R.P.M.

3.3 **Flight Endurance Test.** 100 hours flying shall be completed in accordance with a schedule to be agreed by the Board. The schedule shall include all manoeuvres, and shall include suitable periods of operation at all conditions liable to occur during use of the helicopter in each of the declared roles for which certification is sought. If the power input to the transmission falls significantly with altitude, a proportion of the flying shall be carried out at low altitude conditions so that the appropriate maximum powers can be developed. Details of the observations to be taken and the frequency thereof shall be included in the schedule.

NOTE : Where practical, other work, e.g. performance testing, may be included in this period of flying.

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*If because of governor "droop" characteristics the rotor maximum r.p.m. varies with the torque applied, the speeds of these tests shall be the maximum associated with the prescribed torque as defined by the manufacturer in a curve of limiting speed against torque.

†If desired Parts 7 and 8 may be omitted from these 25 stages and run in the prescribed sequence as a separate 6¼ hour stage.

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4 FREE-WHEEL TESTS The mechanical reliability of the free-wheel mechanism shall be demonstrated by suitable tests acceptable to the Board. The tests will normally take the form of repeated engagement and overrunning tests, which may be carried out in the helicopter or on a suitable rig. If any particularly severe engagement conditions can occur as a result of engine malfunctioning, mishandling or carelessly applied techniques, etc., tests shall be carried out to show that there is no detrimental effect on the continued satisfactory operation of the mechanism.

5 OVER-TORQUE TEST The Transmission and Rotor System shall be subjected to a 15 minute test at the declared Rotor Maximum Over-Torque at the associated maximum rotor r.p.m. with power on appropriate to that torque. The test shall be run at the most critical lubrication conditions either in the helicopter or using rigs if they are sufficiently representative.

6 ROTOR BRAKE ABUSE TESTS If the rotors can be started with the rotor brake applied or if the brake can be applied inadvertently in spite of warning devices or through a fault developing, suitable ground tests shall be made to establish that no unacceptable hazard would be introduced under these conditions.

7 ROTOR BLADE "SAILING" If blade "sailing" can occur, the Board will require either a demonstration that no hazardous damage to the transmission or rotor can be caused, or the promulgation of an adequate inspection procedure in the appropriate manual.

8 PROOF SPEED TEST The test of this paragraph **8** shall be carried out on the Transmission and Rotor System in a representative helicopter.

8.1 The test shall comprise twenty cycles, each cycle being of one minute duration involving:—

(a) half minute at Rotor Maximum R.P.M. (Power On) and Rotor Maximum One-hour Torque,

(b) half minute at

(i) 5% in excess of the declared Rotor Never Exceed R.P.M., or

(ii) 15% in excess of Rotor Maximum R.P.M. (Power On),

whichever is the greater, and at the minimum power necessary.

8.2 Before assembly for this test and after dismantling following the completion of the test the Transmission and Rotor System shall be inspected and a record shall be made of those dimensions liable to change by reason of wear and/or distortion. After the completion of this test, the Transmission and Rotor Systems shall still be in a serviceable condition.

9 FAULT DETECTION DEVICES TESTS It shall be demonstrated by tests, acceptable to the Board, that those fault detection devices which give an early warning of the impending failure of a part the failure of which could lead to catastrophe (see **G4—9, 3**) give adequate and reliable warning of the fault before it has progressed to a dangerous extent.

10 FATIGUE STRENGTH The fatigue strength of the Transmission and Rotor Systems is determined by requirements contained in other Chapters in Section G, e.g. **G3—1** for general fatigue requirements and **G3—4,** App., **1** for fatigue testing of gear boxes.

SUB-SECTION G7—TRANSMISSION AND ROTOR SYSTEM TESTS

CHAPTER G7—4 GROUND AND FLIGHT TESTS—TWIN TURBINE-ENGINE INSTALLATIONS

Issued, 15th June, 1966

A.B

1 INTRODUCTION This Chapter prescribes requirements and tests for helicopters with twin turbine-engined power-units. See also **G7—1** and **G7—2** for the general requirements and conditions applicable to this Chapter **G7—4**.

NOTES : (1) When reviewing the results of these tests the Board will also take into consideration the development history of the Transmission and Rotor System.

(2) Where modifications are introduced as a result of any of these tests, or if modifications are incorporated in the helicopter which could affect the conditions of operation of the Transmission or Rotor System, all the tests already completed will need to be repeated with the modifications embodied in the helicopter unless otherwise agreed by the Board.

(3) This Chapter G7—4 has been written for helicopters that do not have a Maximum Take-off Power rating. Where such a rating is employed the variation of the requirements will have to be decided in consultation with the Board.

2 GENERAL

2.1 **Oil System Pressure Tests**

2.1.1 All parts of the oil system of a representative Transmission and Rotor System, including oil pipes and integral oil passages and tanks, but excluding separate oil tanks, shall be pressure tested in accordance with this paragraph 2.1 and during the tests no unacceptable leaks shall occur from joints required to be liquid tight. The parts shall be capable of supporting the loads imposed during the tests.

2.1.2 The parts shall be tested at the temperature associated with the most critical stressing case unless it is agreed by the Board that the test pressure differential may be increased to simulate the loss of strength as a result of the temperature and account is taken of any thermal stresses that would occur.

2.1.3 All parts, excluding integral oil tanks, shall be pressure tested to at least 1·5 times the maximum operating pressure of the particular part, or 2·0 times the normal operating pressure, whichever is the greater. Oil tanks which are an integral part of the Transmission and Rotor System shall be pressure tested to a pressure of 1·5 times the maximum operating differential pressure or 5 lb/sq. in. more than the maximum operating differential pressure, whichever is the greater.

NOTE : Equivalent pressure tests carried out in the approval of components such as pumps, filters, etc., may be accepted as demonstrating compliance with this requirement.

2.2 **Vibration Survey and Tests**

2.2.1 A vibration survey of the Transmission and Rotor System shall be made over the full range of both ground and flight conditions (see also **G3—1, 5**). The survey shall include an investigation of the effects of operating with each engine stopped under all conditions up to Rotor Maximum Contingency Torque and up to 105% of the highest rotor r.p.m. declared in accordance with **G1—2**, 3.2.1, together with the effects of engine malfunctioning.

2.2.2 The vibration survey shall cover likely combinations of such conditions as :—

(a) starting and stopping the engine(s) and rotors, at any permissible control setting, on the ground or as applicable in flight,

(b) the most critical cases of clutch, free wheel and rotor brake operation,

(c) rotor out of balance to a value to be agreed with the Board.

2.2.3 It shall be established that the resulting stresses are within satisfactory limits for the materials and particular designs involved.

A.B

2.2.4 It shall be demonstrated that no dangerous torsional or flexural vibration or whirling of shafting can occur in the helicopter at any possible torque and at any rotational speed up to,

(a) in the case of the Rotor System :—
(i) 115% of the Rotor Maximum R.P.M. (Power On),
(ii) 105% of the Rotor Never Exceed R.P.M.,
whichever is the greater,

(b) in the case of the remaining parts of the transmission :—
(i) 105% of the Rotor Maximum R.P.M. (Power On),
(ii) the Rotor Never Exceed R.P.M.,
whichever is the greater.

2.2.5 Tests involving speeds exceeding the declared operating limitations may be conducted on the ground.

2.2.6 At specific reference stations on the helicopter, the Applicant shall establish the levels of vibration which are acceptable, and with which the vibration levels of series helicopters when new, in service, and after overhaul, can be compared.

3 ENDURANCE TESTS

3.1 **Ground and Flight Tests.** The requirements of this paragraph 3.1 are applicable to the Ground and Flight Endurance Tests.

3.1.1 **Test Helicopters.** The tests shall be made on helicopters which are representative of the helicopter for which certification is sought in respect of the engines, transmission, rotor blades, control systems, supporting structure, landing gear, and any other feature which may influence the vibration characteristics.

3.1.2 **Detail Inspections.** Prior to assembly of the Transmission and Rotor System for both the Ground and the Flight Endurance Tests they shall be subjected to a complete detail inspection and a record shall be made of those dimensions liable to change by reason of wear, and/or distortion. This process shall be repeated on completion of each test.

3.1.3 **Torque Calibration.** The torque measuring systems, or if no torque measuring system is fitted, the engines used, shall be suitably calibrated before and after the completion of the Ground Endurance Test and before and after the Flight Endurance Test so that an accurate assessment of the power developed during the test may be made. The Board may require the complete test to be repeated or additional periods run if the power deteriorates by an excessive amount. Points at which the torque is to be measured shall be defined and any limitations presented to the flight crew shall be derived from these points.

3.2 **Ground Endurance Test.** The requirements of this paragraph 3.2 are applicable to the Ground Endurance Test.

3.2.1 **Restraint During Test.** The method of restraint for the test shall be to the satisfaction of the Board.

3.2.2 **Oil Pressure.** Twenty-four Stages of the test shall be run with the transmission oil pressure(s) set to give the declared normal operating pressure at Maximum Continuous conditions. One stage shall be run with the pressure set to give the declared minimum operating pressure at Maximum Continuous conditions. Alternatively, evidence in respect of minimum operating pressure from equivalent rig tests would be acceptable.

A.B

3.2.3 **Oil Temperature.** All of Parts 1, 4(a), 6 and 9 of the test shall be run at the appropriate declared maximum transmission oil temperatures, unless adequate rig tests are completed of the same duration and of at least equal severity in respect of speeds and steady and fluctuating loads with the oil at the declared maximum transmission oil temperatures.

3.2.4 **Rotor Balance.** The degree of out of balance before, during and at the conclusion of the test shall be recorded.

NOTE : The maintenance instructions regarding rotor balancing should take into account the experience gained during the Ground Endurance Test.

3.2.5 **Change of Power Settings.** The time taken in changing power settings during the test shall not be deducted from the prescribed periods at higher settings.

3.2.6 **Critical Loads.** Any components which can be subjected to critical loading conditions not adequately covered by the standard test conditions, e.g. bearings which can be off-loaded by gear reaction or preloading, shall be tested by suitable variations of the Ground Endurance Test or by additional tests acceptable to the Board.

3.2.7 **Transmission Operating Limitations.** The transmission operating limitations of torque, r.p.m., etc., associated with permitted periods of use, will be based on the mean values recorded during the appropriate tests. The operating limitations of temperature will be based on the mean values recorded during the appropriate periods of the Ground Endurance Test or equivalent rig tests (see 3.2.3). Any short period temperature limitations may be substantiated by variation of the Endurance Test or by supplementary rig tests acceptable to the Board.

3.2.8 **Rotor Starts, Accelerations, Clutch Engagements, Decelerations and Brake Tests.**

(a) In the accelerations prescribed in 3.2.13, the rotors shall be accelerated from the minimum ground idling speed to conditions producing the prescribed rotor system torque and the maximum rotor r.p.m. associated with that torque in the most rapid manner permitted. If clutches are fitted, they shall be engaged using the technique recommended by the helicopter manufacturer. Each engine deceleration shall be made as quickly as possible. If necessary the engine(s) shall be stopped in order to bring the Rotor System to rest. If a rotor brake is fitted it shall be applied on each occasion the rotor is stopped at the speed and using the technique recommended by the manufacturer. If, however, the vibration survey shows that the free run down is more severe, an agreed number of stops shall be made without using the rotor brake. During the accelerations, the rotor pitch shall be set or controlled to give accelerating conditions at least as severe as those which will occur during the operation of the helicopter.

(b) Ten of the accelerations in Part 2 shall be carried out with the transmission lubricating system at the declared minimum temperature for exceeding rotor ground idling conditions, or the minimum obtainable temperatures, whichever is higher. If a lower temperature for starting the rotors is declared, 10 additional rotor starts shall be made at this temperature. The transmission will be approved for use at the mean of the temperatures at which the tests were made. If, because the prevailing ambient conditions are unsuitable, a low enough clearance cannot be obtained by this method, suitable rig tests on the critical components may be accepted as an alternative.

A.B

3.2.9 **Rotor Controls.** Nine hundred complete cycles of control movements, each cycle being as prescribed in (a) and (b), shall be made at agreed intervals during the periods at Maximum Continuous conditions prescribed in 3.2.13. Two hundred of these control movements shall be made with one engine only operating, divided equally between the engines. Each control position shall be held at maximum for at least ten seconds and the rate of change of control position shall be at least as rapid as for normal operation.

(a) The controls shall be operated up to the position of full vertical thrust maximum forward thrust component, maximum aft thrust component, maximum left thrust component and maximum right thrust component, except that the control movements need not produce loads or blade flapping motion exceeding the maximum loads or motions encountered in flight.

(b) The directional controls shall be operated up to the extreme of maximum right turning torque and maximum left turning torque, through neutral turning torque, except that the control movements need not produce loads exceeding the maximum loads encountered in flight.

3.2.10 **Rotor Thrust and Turning Torque.** The periods of 3.2.13 specified in (a) to (f) shall be run with the rotor controls set to produce the maximum thrust in each of the directions indicated, except that the control positions need not produce loads or blade flapping motion exceeding those encountered in flight. Except where prescribed at (f) the specified periods shall be run at neutral turning torque.

(a) Part 1 of three Stages	— Right thrust component.
(b) Part 1 of three Stages	— Left thrust component.
(c) Part 1 of three Stages	— Aft thrust component.
(d) Part 1 of six Stages	— Vertical thrust.
(e) All remaining Parts 1	— Forward thrust component as appropriate to the maximum forward speed associated with the prescribed operating conditions.
(f) Part 3 of all Stages	— Periods of running at maximum left and right turning torques so that a total of 12 hours each left and right turning torque is achieved, the remainder being at neutral turning torque.

3.2.11 **Safety and Warning Devices.** All safety devices, including warning devices and devices for opening up one engine if the other fails, shall be fitted throughout the test. Additional functional tests shall then be made which, together with the type endurance test, will be adequate to demonstrate the reliability of the devices. Any limitations on the use of the devices shall be established.

3.2.12 **Test Running.** The test shall be run as detailed in 3.2.13. Each stage shall be run as far as possible in non-stop periods of not less than two hours. Those of the Observations referred to in **G7—2,** 2.1 to be made during each part of the test, and the frequency at which they are made, shall be agreed with the Board.

A.B

3.2.13 **Ground Endurance Test.** The Ground Endurance Test shall be as prescribed in this paragraph and, except as may be chosen for Parts 4a and 4b, shall consist of twenty-five 8-hour stages, each stage comprising:—

Part	Engine	Duration	Operating Conditions
1	Both	2 Hr.	(a) Accelerate rotor(s) from rest (releasing brake if applicable at the speed recommended by the constructor), to (b) Rotor Maximum R.P.M. (Power On)* and Rotor Maximum Continuous Torque. Maintain for 2 hours. (c) Decelerate to rotor ground idling conditions. (d) Stop the rotors (applying the brake at the maximum speed permitted by the constructor).
2	Both	20 Min.	Ten cycles each comprising:— (a) Accelerate rotors from rest (releasing brake at the speed recommended by the constructor). (b) 1 minute at rotor ground idling conditions. (c) Accelerate to Rotor Maximum R.P.M. (Power On)* and Rotor Maximum Continuous Torque and maintain for 1 minute. (d) Decelerate to rotor ground idling conditions. (e) Stop the rotors (applying the brake at the maximum speed permitted by the constructor).
3	Both	2 Hr. 5 Min.	During the 200 hour test, approximately 20 hours covering the range of recommended cruise conditions, the remainder being divided into at least 10 equal periods at approximately equal speed and torque increments between Rotor Maximum and Minimum R.P.M. (Power On) and between Rotor Maximum Continuous Torque and rotor ground idling conditions.
4a.‡	Both	7½ Min.	3% in excess of Rotor Maximum R.P.M. (Power On)*† at not less than Rotor Maximum Continuous Torque.
4b.‡	Both	7½ Min.	Rotor Maximum R.P.M. (Power On) and the minimum power necessary to obtain this r.p.m.
5	Both then No. 1	15 Min.	(a) Accelerate rotor(s) from rest (releasing brake at the speed recommended by the constructor), to (b) Rotor Maximum R.P.M. (Power On)* and Rotor Maximum Continuous Torque. Maintain for 5 minutes.

*If, because of governor "droop" characteristics the rotor maximum r.p.m. varies with the torque applied, the speeds of these tests shall be the maximum associated with the prescribed torque as defined by the manufacturer in a curve of limiting speed against torque.

†If a speed different from Rotor Maximum R.P.M. (Power On) is declared for use in the event of a single engine failure, these tests shall be run at the appropriate Intermediate or Maximum Contingency speeds declared. (See G1—2, 3.2.1.)

‡If desired, the combined period at these conditions may be run together as a separate stage at any convenient point in the Ground Endurance Test.

A.B

Part	Engine	Duration	Operating Conditions
			(c) Simulate (by an agreed method) failure of No. 2 engine.
			(d) Accelerate No. 1 engine to Rotor Maximum R.P.M. (Power On)† and Rotor Maximum Contingency Torque. Maintain for 2½ minutes.
			(e) Decelerate No. 1 engine to flight idling conditions and restore No. 2 engine to flight idling conditions. Maintain for 1 minute.
			(f) Simulate (by an agreed method) failure of No. 2 engine.
			(g) Accelerate No. 1 engine to Rotor Maximum R.P.M. (Power On)† and Rotor Maximum Contingency Torque. Maintain for 1 minute.
			(h) Decelerate No. 1 engine, and restore No. 2 engine, to Rotor Maximum R.P.M. (Power On) and a recommended twin engine cruise torque. Maintain for 2 minutes.
			(i) Simulate (by an agreed method) failure of No. 2 engine.
			(j) Acclerate No. 1 engine to Rotor Maximum R.P.M. (Power On)† and Rotor Intermediate Contingency Torque. Maintain for 1½ minutes.
			(k) Decelerate No. 1 engine to flight idling conditions and restore No. 2 engine to flight idling conditions. Maintain for 1 minute.
			(l) Simulate (by an agreed method) failure of No. 2 engine.
			(m) Accelerate No. 1 engine to Rotor Maximum R.P.M. (Power On)† and Rotor Intermediate Contingency Torque. Maintain for 1 minute.
			(n) Decelerate No. 1 engine and stop the rotor(s) (applying rotor brake at the maximum speed permitted by the constructor).
6	No 1	1 Hr.	(a) Accelerate rotor(s) from rest (releasing brake at the speed recommended by the constructor), to
			(b) Rotor Maximum R.P.M. (Power On)† and Rotor Intermediate Contingency Torque. Maintain for 1 hour.
			(c) Decelerate to rotor ground idling conditions.
			(d) Stop the rotors (applying the brake at the maximum speed permitted by the constructor).

†If a speed different from Rotor Maximum R.P.M. (Power On) is declared for use in the event of a single engine failure, these tests shall be run at the appropriate Intermediate or Maximum Contingency speeds declared (See G1—2, 3.2.1.)

A.B

Part	Engine	Duration	Operating Conditions
7	No. 1	25 Min.	(a) Accelerate rotor(s) from rest (releasing brake at the speed recommended by the constructor) to, (b) At least 5 equal periods during the 200 hour test at Rotor Maximum R.P.M. (Power On)* and at equal torque increments between the engine torque associated with Maximum Continuous conditions under twin engine operation and Rotor Intermediate Contingency Torque. (c) Decelerate to rotor ground idling conditions. (d) Stop the rotors (applying the brake at the maximum speed permitted by the constructor).
8	Both then No. 2	15 Min.	As Part 5 (reading No. 1 engine for No. 2 engine and vice versa).
9	No. 2	1 Hr.	As Part 6.
10	No. 2	25 Min.	As Part 7.

3.3 **Flight Endurance Test.** 150 hours flying, including 25 hours on each engine separately, shall be completed in accordance with a schedule to be agreed with the Board. The schedule shall include all manoeuvres, and shall include suitable periods of operation at all conditions liable to occur during the use of the helicopter in each of the declared roles for which certification is sought. If the power input to the transmission falls significantly with altitude, a proportion of the flying shall be carried out at low altitude conditions so that the appropriate maximum powers are developed. Details of the observations to be taken and the frequency thereof shall be included in the schedule.

NOTE : Where practical, other work, e.g. performance testing, may be included in this period of flying.

4 FREE WHEEL TESTS The mechanical reliability of the free-wheel mechanisms shall be demonstrated by suitable tests acceptable to the Board. The tests will normally take the form of repeated engagement and overrunning tests, which may be carried out in the helicopter or on a suitable rig. If any particularly severe engagement conditions can occur as a result of engine malfunctioning, mishandling or carelessly applied techniques, etc., tests shall be carried out to show that there is no detrimental effect on the continued satisfactory operation of the mechanism.

5 OVER-TORQUE TEST The Transmission and Rotor System shall be subjected to a 15 minute test at the declared Rotor Maximum Over-Torque at the associated maximum rotor r.p.m. with power on appropriate to that torque. More than one test may be involved in order to cover all parts of the Transmission System, e.g. synchronising shaft. The tests shall be run at the most critical lubrication conditions either in the helicopter or using rigs if they are sufficiently representative.

6 ROTOR BRAKE ABUSE TESTS If the rotors can be started with the rotor brake applied or if the brake can be applied inadvertently in spite of warning devices or through a fault developing, suitable ground tests shall be made to establish that no unacceptable hazard would be introduced under these conditions.

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*If a speed different from Rotor Maximum R.P.M. (Power On) is declared for use in the event of single engine failure, this test shall be run at the speeds associated with the prescribed torque increments.

A.B

7 ROTOR BLADE "SAILING" If blade "sailing" can occur, the Board will require either a demonstration that no hazardous damage to the transmission or rotor can be caused, or the promulgation of an adequate inspection procedure in the appropriate manual.

8 PROOF SPEED TEST The test of this paragraph **8** shall be carried out on the Transmission and Rotor System in a representative helicopter.

8.1 The test shall comprise twenty cycles, each cycle being of one minute duration involving:—

(a) half minute at Rotor Maximum R.P.M. (Power On) and Rotor Maximum Continuous Torque,

(b) half minute at

(i) 5% in excess of the declared Rotor Never Exceed R.P.M., or,

(ii) 15% in excess of Rotor Maximum R.P.M. (Power On)*

whichever is the greater, and at the minimum power necessary.

8.2 Before assembly for this test and after dismantling following completion of the test the Transmission and Rotor System shall be inspected and a record shall be made of those dimensions liable to change by reason of wear and/or distortion. After completion of this test, the Transmission and Rotor Systems shall still be in a serviceable condition.

9 FAULT DETECTION DEVICES TESTS It shall be demonstrated by tests, acceptable to the Board, that those fault detection devices which give an early warning of the impending failure of a part the failure of which could lead to catastrophe (see **G4—9, 3**) give adequate and reliable warning of the fault before it has progressed to a dangerous extent.

10 FATIGUE STRENGTH The fatigue strength of the Transmission and Rotor Systems is determined by requirements contained in other Chapters in Section G, e.g. **G3—1** for general fatigue requirements and **G3—4, App., 1** for fatigue testing of gear boxes.

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*If a speed higher than Rotor Maximum R.P.M. (Power On) is declared for use in the event of single engine failure, substitute the Intermediate or Maximum Contingency speed declared, whichever is the higher for the Rotor Maximum R.P.M. (Power On). See **G1—2**, 3.2.1.)

APPENDIX TO CHAPTER G7—4

Issued, 15th June, 1966

GROUND ENDURANCE TEST

1 INTRODUCTION Table 1 (G7—4 App.) is reproduced for information only and should not be taken as amending **G7—4,** 3.2.13.

TABLE 1 (G7—4 App.)
ROTORCRAFT GROUND ENDURANCE TEST

Part	Engine	Max. Ctgy.	Int. Ctgy.	Incremental	Max. Cont.	Incremental	Idling	Overspeed	Transmission Acceleration From Rest
1	Both	..	..	..	2 h.	..	..	..	1
2	Both	..	..	..	10 m.	..	10 m.	..	10
3	Both	..	..	..	..	2 h. 5 m.	..	..	—
4	Both	..	..	..	..	7½ m.	..	7½ m.	—
5	No. 1	3½ m.	2½ m.	..	5 m. (both)	4 m. (both)	..	..	1 (both)
6	No. 1	..	1 h.	..	..	..	..	..	1 (both)
7	No. 1	..	..	25 m.	..	..	..	..	1 (both)
8	No. 2	3½ m.	2½ m.	..	5 m. (both)	4 m. (both)	..	..	1 (both)
9	No. 2	..	1 h.	..	..	..	..	..	1 (both)
10	No. 2	..	..	25 m.	..	..	..	..	1 (both)
Each Engine									
Per Stage		3½ m.	1 h. 2½ m.	25 m.	2 h. 20 m.	2 h. 20½ m.	10 m.	7½ m.=6 h. 29 m.	17
Per Test		1 h. 27½ m.	26 h. 2½ m.	10 h. 25 m.	58 h. 20 m.	58 h. 32½ m.	4 h. 10 m.	3 h. 7½ m.=162 h. 5 m.	425
Transmission									
Per Stage		7 m.	2 h. 5 m.	50 m.	2 h. 20 m.	2 h. 20½ m.	10 m.	7½ m.=8 h.	17
Per Test		2 h. 55 m.	52 h. 5 m.	20 h. 50 m.	58 h. 20 m.	58 h. 32½ m.	4 h. 10 m.	3 h. 7½ m.=200 h.	425

NOTE : Times are shown in hours (h) and minutes (m).

SUB-SECTION G8—OPERATING LIMITATIONS AND INFORMATION

CHAPTER G8—1 GENERAL

Revised, 30th September, 1977

A.B

1 INTRODUCTION A certain amount of information is derived in the course of showing compliance with the Requirements. The establishment of this and other information and its presentation to the flight crew in the form of markings, placards and the Flight Manual is the subject of this Sub-section G8.

NOTES: (1) The operating limitations prescribed in **G8—2** are those which are within the competence of the flight crew to observe, and there is a legal obligation on the flight crew to observe them.

(2) There are operating limitations, however, which are not within the competence of the flight crew to observe, the observance of which is the responsibility of the operator of the rotorcraft. Such limitations are usually those relating to the maintenance of the rotorcraft (e.g. a limitation, in terms of total flying hours, placed on the life of a component for fatigue reasons) and are either contained in the Approved Maintenance Schedule for the rotorcraft or are promulgated by the CAA as Mandatory Modifications or Inspections.

2 GENERAL In addition to the information prescribed in this Sub-section, the Applicant shall provide such additional information as is considered necessary; in particular that associated with unconventional design, operating or handling features.

NOTES: (1) Details of information which has to be established are contained in **G8—2.**

(2) General requirements applicable to markings and placards (e.g. warning notices) are prescribed in **G8—3,** which also prescribes markings not necessarily covered elsewhere in the requirements, and for convenience, lists and cross-references all mandatory rotorcraft markings other than those necessary for compliance with the Air Navigation Order.

(3) Details of the information which normally has to be included in the Flight Manual or appropriate document are contained in **G8—5.**

(4) Administrative procedures for the publication of manuals are prescribed in **Section A,** Subsection A6.

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SUB-SECTION G8—OPERATING LIMITATIONS AND INFORMATION

CHAPTER G8—2 OPERATING INFORMATION

Issued, 30th September,* 1977

A.B

1 INTRODUCTION This Chapter contains requirements for the establishment of information, mostly in the form of operating limitations and procedures.

NOTE: The method of presentation of this information is the subject of the requirements of **G8—3** and **G8—5.**

2 AIR SPEED

2.1 **Operating Speed Limitations.** Operating speed limitations shall be selected in accordance with this paragraph **2,** and shall be established.

2.2 **Never Exceed Speed,** V_{NE}. This speed shall be such that the probability of inadvertently exceeding the Maximum Demonstrated Flight Speed, V_{DF}, is Remote. This speed shall be chosen to provide the required margin for all possible rotorcraft characteristics in all likely flight conditions. In the absence of an investigation substantiating another value, V_{NE} shall not exceed 0·9 times V_{DF}.

2.3 **Normal Operating Limit Speed,** V_{NO}. This speed shall be established for all rotorcraft with V_H exceeding 0·9 V_{NE} and shall be sufficiently below V_{NE} to ensure that the probability of exceeding V_{NE} in a moderate upset occurring at V_{NO} is not more than Reasonably Probable. In the absence of an investigation substantiating another value, V_{NO} shall not exceed 0·9 V_{NE}.

2.4 **Maximum Demonstrated Flight Speed,** V_{DF}. This speed shall not be greater than V_D.

2.5 **Landing Gear Operating Speed,** V_{LO}. This speed shall not be greater than the maximum speed at which compliance with **G4—5** is established.

2.6 **Minimum Speeds Related to Control.** Information shall be given of any minimum air speeds for the control of the rotorcraft, the observance of which is found as the result of flight tests to be necessary in particular circumstances. (See **G2—3** and **G2—5**).

3 WEIGHT AND BALANCE The weight and balance limitations prescribed in this paragraph **3** shall be established and shall be so chosen as to comply with 3.1 to 3.3 as appropriate. Any other weight and balance limitations which are necessary shall also be established.

3.1 **Maximum Take-off and Landing Weights.** The Maximum Take-off Weight and the Maximum Landing Weight shall be those weights established in accordance with **G1—1, 6.**

*Chapter **G8—2** previously contained information on Markings, Placards and Cards; this information is now contained in Chapter **G8—3.**

A.B

3.2 **Cargo and Baggage Compartment Loading.** The maximum total load and the maximum load per unit area of cargo and baggage compartments shall not exceed those at which compliance with **G4—3, 3** has been established.

3.3 **C.G. Range.** The c.g. range shall be a range no greater than that at which compliance with the Requirements has been established.

4 POWER-PLANT The Power-plant limitations and data prescribed in this paragraph **4** shall be established. Any other Power-plant limitations which are necessary shall also be established. The Power-plant limitations shall be such that any limitations declared as a condition of the type certification of the engine, propeller or Power-plant accessories will not be exceeded.

4.1 **Specifications.** The established information shall include the following:—

(a) The approved fuel specifications and, if applicable, the minimum fuel grades, together with any associated temperature limitations.

(b) The approved oil specifications, brands and types, together with any associated temperature limitations.

4.2 **Starting.** The established information shall include the following:—

(a) Limitations (e.g. minimum temperature, oil pressure) to be observed in the starting of an engine or transmission system on the ground or restarting an engine in flight.

(b) Limitations to be observed following an unsuccessful attempt to start an engine on the ground or to restart an engine in flight.

4.3 **Fuel System.** The established information shall include the following limitations:—

(a) The minimum fuel temperature.

(b) The minimum fuel pressure.

4.4 **Oil Systems.** The established information shall include the following limitations for engine and transmission oil systems:—

(a) The maximum permissible oil temperatures.

(b) The minimum permissible oil pressures and the conditions of rotational speed and oil temperature with which it is associated.

(c) The maximum rates of oil consumption (if applicable).

4.5 **Engine Power.** The established information shall include the following which shall be expressed in the appropriate terms of 4.5.1:—

(a) Maximum Take-off Power limitations together with any restricted period for use.

(b) Maximum Continuous Power limitations.

(c) Contingency Power limitations.

4.5.1 (a) Engine rotational speeds;

(b) Induction manifold pressure (piston engines);

(c) Exhaust gas temperature or equivalent (turbine engines);

(d) Cylinder head temperature (piston engines);

(e) Oil temperature;

(f) Oil pressure;

(g) Torque or equivalent.

A.B

4.6 **Miscellaneous Power-plant Limitations.** The established information shall include the following:—

(a) For piston engines, the maximum cylinder head temperature before commencing a take-off.

(b) Limitations associated with the use of the fuel/air mixture control system and fuel injection system and, for piston engines, limitations associated with weak mixture operation.

(c) Limitations on, and procedures for the use of Power-plant ice-protection systems.

(d) For turbine engines, limitations on the use of turbine bleeds.

5 MISCELLANEOUS The information prescribed in this paragraph **5** shall be established. Any other information which is necessary shall also be established, in particular that associated with unconventional design, operating or handling features.

5.1 **Operating Information.** Whether or not the rotorcraft can be used for the types of operation described in (a) to (c),

(a) Instrument Flight by day or by night,

(b) at altitudes greater than 10,000 feet,

(c) in icing conditions.

5.2 **Maximum Operating Altitude.** This shall not be greater than the maximum altitude at which compliance with the Requirements has been established.

5.3 **Air Temperatures.** The maximum and, if appropriate, the minimum air temperature in which operation is permissible, together with information on any special features necessary for operation in any particular temperature range.

5.4 **Automatic Control System** (see **G8—2** App., **1**). The minimum height above terrain for the operation of any automatic control system, together with any other limitations on its use.

5.5 **Minimum Flight Crew.** The minimum flight crew for safe operation under visual or instrument flight conditions, taking into account the fields of view obtained, and the accessibility and ease of operation of the essential controls, by the appropriate member of the flight crew.

5.6 **Rotational Speeds**

5.6.1 **Maximum Rotor Rotational Speed.** A maximum rotor rotational speed limitation shall be established. This speed shall not exceed a percentage agreed by the Authority of the maximum rotational speed at which it has been demonstrated in flight that no dangerous characteristics exist.

5.6.2 **Minimum Rotor Rotational Speed.** A minimum rotor rotational speed limitation, applicable to conditions where the rotor is supplying lift, shall be established. This speed shall exceed the Design Minimum Rotor Rotational Speed by a suitable margin.

NOTE: Where maximum and minimum rotor rotational speeds may be different in power-on or power-off conditions, appropriate limitations should be established.

A.B

5.7 **Rotor Torques**

5.7.1 **Single-engined Helicopters (where applicable)**

(a) A Rotor Maximum One-Hour Torque approved for the Rotor System shall be established, limited in use to a maximum continuous period of one hour.

(b) A Rotor Maximum Continuous Torque approved for the Rotor System shall be established, for use with unrestricted duration.

(c) A Rotor Maximum Over-torque for the Rotor System shall be established which has been determined to have no detrimental effect on the transmission when used for a period of 20 seconds.

5.7.2 **Twin-engined Helicopters (where applicable)**

(a) A Rotor Maximum Contingency Torque approved for the Rotor System shall be established for use in the event of failure of one Power-unit, limited in use to a maximum continuous period of 2½ minutes.

(b) A Rotor Intermediate Contingency Torque approved for the Rotor System, shall be established, for use in the event of failure of one Power-unit during en-route operation.

(c) A Rotor Maximum Continuous Torque approved for the Rotor System shall be established for use with unrestricted duration.

(d) A Rotor Maximum Over-torque for the Rotor System shall be established which has been determined to have no detrimental effect on the transmission when used for a period of 20 seconds.

5.8 **Interrelated Limitations.** The limitations which are specified in 2.2, 4.6, 5.6 and 5.7 may, on the basis of their being unique and independent, have more than one value and be interrelated (so far as this is necessary to permit efficient operation of the rotorcraft) provided that the combined limitations are readily remembered and complied with.

NOTE: In deciding whether a proposed set of such limitations is acceptable, account should be taken of the presence of any characteristics or devices giving reliable, clear and sufficiently early warning that dangerous conditions are being approached. Account should also be taken of the safety margin allowed by the limitations and the nature of the hazard involved.

5.9 **Miscellaneous.** If, as a result of flight tests, it is found that certain conditions in respect to the following items must not be exceeded if hazardous conditions are to be avoided, limitations shall be established to control these conditions. Where no limitation is established for an item, information shall be given on the most adverse conditions encountered during tests.

NOTE: Flight trials covering reasonable ranges of conditions in respect of these items will be required: provided, however, that reasonable ranges of conditions are covered the choice of the exact ranges will be left to the Applicant.

5.9.1 **Maximum Speed on the Surface of the Ground or Water.** This speed, for take-off, landing and taxying, shall be related to specific ground or water conditions.

5.9.2 **Most Adverse Cross-wind for Take-off and Landing.** This shall include Emergency Landing.

5.9.3 **Maximum Sideways Speed and Maximum Backward Speed.**

5.9.4 **Maximum Wind Speed for Rotor Starting and Stopping.**

A.B 5.9.5 **Maximum Speeds on Tow with the Engine(s) Stopped (if applicable).**

5.9.6 **Most Adverse Water Conditions (if applicable).** These limitations shall be established for take-off, landing and taxying.

5.9.7 **Maximum and Minimum Air Speeds for Agricultural Operations (if applicable).** The maximum air speed shall not exceed, and the minimum air speed shall not be less than, the speeds selected by the Applicant as being safe for the discharge of the hopper contents.

5.9.8 **Emergency Alighting on Water.** The limitations prescribed in **G4—10,** 5.2.

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APPENDIX TO CHAPTER G8—2

Issued, 30th September, 1977

OPERATING INFORMATION

1 AUTOMATIC FLIGHT CONTROL AND STABILITY AUGMENTATION SYSTEM LIMITATIONS (See G8—2, 5.4)

1.1 Automatic flight control and stability augmentation system limitations should be based on the automatic-pilot requirements of **Section D,** Chapter **D6—4** and the recommendations of its Appendix.

1.2 Except for the case specified in 1.3, the minimum permissible height above terrain for use of the automatic system should be equal to twice the height lost as a result of the most critical malfunction of the automatic system.

1.3 When approval is required for an automatic approach system or an automatic system coupled to ground radio installations, the minimum height for operation of the automatic system should be related to the approach aiming point elevation. This minimum height should be such that, following the most critical malfunction of the automatic system to be considered, the height above terrain remaining after recovery from the malfunction would not be less than half the minimum permitted height.

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SUB-SECTION G8—OPERATING LIMITATIONS AND INFORMATION

CHAPTER G8—3 MARKINGS AND PLACARDS

Issued, 30th September,* 1977

A.B

1 GENERAL

1.1 The markings and placards prescribed in this Chapter shall be provided, together with any other markings and placards which are necessary; in particular those associated with unconventional design, operating or handling features, or required by the Air Navigation Order.

1.2 Markings and placards shall be such that that they are not easily removed, disfigured or erased.

NOTE: It is recommended that, wherever possible, markings and placards should be in the form of engraved metal or plastic labels.

1.3 Markings and placards shall be displayed in a conspicuous place, as close to the related feature as is practical. No placard shall be positioned such that it will reduce the capability of the instrument to be read.

1.4 Information conveyed by markings and placards shall be presented as briefly as possible and with maximum clarity. Terminology shall, as far as is possible, be standardized.

2 INSTRUMENT MARKINGS

2.1 **General**

2.1.1 Where markings are placed on the transparent cover of the dial of an instrument, provision shall be made to maintain the correct alignment of the markings with the instrument dial.

2.1.2 Each marking shall be of sufficient boldness to be clearly visible to the flight crew.

NOTE: When the limitations to be presented are of such complexity that the significance of markings is unlikely to be quickly apparent to the flight crew, the limitations may, with the agreement of the Authority, be presented in the form of placards.

2.2 **Air Speed Indicators.** Each air speed indicator shall be marked in accordance with (a) to (c) in terms of I.A.S. If any limiting speed varies with altitude, the marking shall correspond to the value appropriate to sea-level.

(a) A red radial line at V_{NE}.

(b) A green arc for the normal operating range, from zero extending to an upper limit at V_{NO}.

(c) A yellow arc to indicate a cautionary range, extending from the radial line specified in (a) to the upper limit of the arc specified in (b).

NOTE: Other speed limitations established in accordance with G8—2, 2, will be placarded (see e.g. 5.1) or provided in a suitable form.

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*Chapter G8—3 previously contained information on Flight Manuals; that information is now contained in Chapter G8—5.

A.B

2.3 **Power-plant Instruments**

2.3.1 Each mandatory Power-plant instrument shall be marked in accordance with this paragraph 2.3.1. The markings to be applied are:—

(a) A red radial line at the maximum, and if applicable, the minimum limitation.

(b) A yellow arc for each cautionary or take-off range, which shall not extend beyond any radial line provided in accordance with (a).

(c) A green arc for each normal operating range, which shall not extend beyond any radial line provided in accordance with (a) nor overlap any arc provided in accordance with (b).

2.3.2 **Fuel Quantity Indicators.** If the unusable fuel quantity, established in accordance with **G5—2**, 3.4, for the tank to which an indicator relates is greater than 5% of the tank capacity and not less than 4·5 litres (1 gal), a red arc shall be marked on the indicator extending from the calibrated zero reading to the lowest reading obtainable in level flight.

2.4 **Rotor Speed Indicators.** Each rotor speed indicator shall be marked in accordance with (a) to (c).

(a) A green arc extending from the radial line marking the Rotor Maximum r.p.m. (Power On) to the radial line marking the Rotor Minimum r.p.m. (Power On).

(b) A yellow arc extending from the radial line marking the Rotor Maximum r.p.m. (Power On) to the radial line marking the Rotor Maximum r.p.m. (Power Off), and from the radial line marking the Rotor Minimum r.p.m. (Power On) to the Rotor Minimum r.p.m. (Power Off).

(c) A red radial line at the Rotor Never Exceed r.p.m.

(d) A yellow arc for any cautionary r.p.m. range.

3 CONTROL MARKINGS

3.1 **General.** Except for primary flight controls, a marking shall be provided for each normal and emergency operating control which is intended for use by the flight crew so as to indicate its function and, except for simple push-button switches, its method of operation. Emergency operating controls shall be coloured red.

3.2 **Power-plant Fuel Controls**

3.2.1 A marking shall be provided for operating controls for fuel tank selection to indicate the position corresponding with each tank and any cross-feed positions.

3.2.2 Where more than one fuel tank is provided, and if safe operation depends upon the use of tanks in a specific sequence, a marking shall be provided for the operating controls for fuel tank selection to indicate to the flight crew the order in which the tanks are to be used.

3.2.3 For multi-engined rotorcraft, a marking shall be provided for operating controls for engine selection to indicate the position corresponding to each engine.

3.2.4 The usable capacity of each fuel tank shall be indicated adjacent to the operating control for fuel tank selection.

A.B

4 MISCELLANEOUS MARKINGS

4.1 A marking shall be provided to identify the datum to which the c.g. range, established in accordance with **G8—2,** 3.3 is related, unless some well-defined feature of the rotorcraft (e.g. rotor mast) is used.

4.2 Markings shall be provided to enable the rotorcraft to be levelled on the ground.

4.3 Operating controls for normal and emergency exits shall be marked to indicate their function. The markings for emergency exits shall be in red. (See also 5.4 and **G4—3,** 5.2.7).

4.4 The fuel system markings specified by **G5—1,** 2.4.

4.5 The oil system markings specified by **G5—1,** 2.4.

4.6 Safety equipment shall be marked as to its method of operation and suitable markings, visible to the occupants of the rotorcraft, shall indicate the places where any such equipment is stowed.

4.7 Maximum weight of hopper contents (see **G4—11,** 1.4).

4.8 Flammable fluid emergency controls shall be clearly marked to indicate their functions and methods of use.

4.9 Jettison controls shall be clearly marked to indicate their functions and methods of use.

5 PLACARDS

5.1 Air Speeds

5.1.1 Where the Landing Gear Operating Speed, V_{LO}, or the Landing Gear Extended Speed, V_{LE}, is lower than V_{NO}, a placard shall be installed as close as practicable to each airspeed indicator or landing gear operating control, stating in terms of I.A.S. V_{LO} and, if different, V_{LE}.

5.1.2 A placard shall be installed as close as practicable to each airspeed indicator, or a suitable indicating means shall be provided, stating in terms of I.A.S.:—

(a) any permitted variations with altitude, temperature and weight limitations which have been marked on the airspeed indicator in accordance with 2.2, and

(b) any speed limitation which is not marked on the airspeed indicator in accordance with 2.2.

5.2 Loading

5.2.1 Placards shall be provided for each baggage and cargo compartment stating the loading limitations established in accordance with **G8—2,** 3.2.

5.2.2 Placards shall be provided stating the loading limitations for each ballast location.

5.2.3 Where the maximum weight which may be carried in a seat is less than 77 kg (170 lb), a placard stating this lesser weight shall be attached to the seat structure.

5.2.4 The Maximum Weight shall be placarded, together with a caution that this does not necessarily ensure a safe performance, for which the Flight Manual should be consulted. This placard need not be readily visible in flight, but shall be readily visible when entering the cockpit.

A.B

5.3 **Operation of the Rotorcraft**

5.3.1 A placard shall be provided stating that the rotorcraft is to be operated in accordance with the Approved Flight Manual.

5.3.2 A placard shall be provided stating:—

(a) the type of operation (e.g. Day or Night) for which the rotorcraft is approved to be used, drawing attention, where necessary, to the need for the required equipment to be installed for such operations, and

(b) the type of operation (e.g. flight in icing conditions) for which the rotorcraft may not be used.

5.4 **Emergency Exits.** A placard shall be provided near each emergency exit indicating its purpose and method of operation. The lettering of the placard shall be red. (See also 4.3.).

5.5 **Magnetic Compass.** The card required in accordance with **G6—1, 6,** shall be installed on or near the magnetic compass.

5.6 **Automatic Control System Operation.** A placard shall be provided stating all the limitations regarding the use of the automatic control system established in accordance with **G8—2,** 5.4.

5.7 **Smoking.** If required by **G4—3,** 9.2.6 a placard stating that smoking in the compartment is not permitted.

5.8 **Use of Rotor Brake and Clutch.** Any necessary limitations or information regarding the use of the rotor brake and clutch shall be placarded where it is visible to the pilot in flight.

5.9 **Maximum Weight of External Load.** For rotorcraft approved for carrying external loads, the maximum weight of the external load shall be placarded beside the external load attaching means so as to be readable by the person attaching the load.

5.10 **Minimum Safe Weight of External Load.** For rotorcraft approved for carrying external loads which incorporate an automatic device for releasing the loads, the minimum safe weight of the external load shall be placarded beside the external load attaching means.

SUB-SECTION G8—OPERATING LIMITATIONS AND INFORMATION

CHAPTER G8—5 FLIGHT MANUALS

Revised in part, 16th August, 1982

A.B 1 INTRODUCTION This Chapter prescribes requirements for the layout and contents of Flight Manuals. **Section A,** Chapter **A6—1** prescribes the division of responsibility between the Authority and the Applicant for the production of Flight Manuals and details appropriate administrative procedures.

2 GENERAL (see G8—5 App. No. 1, 1)

2.1 A Flight Manual hereinafter referred to in this Chapter as "the Manual", shall be supplied with each rotorcraft and shall comply with the requirements of this Chapter. Where unusual design features, operating procedures or handling characteristics so warrant, the Authority may require data, additional to that prescribed by this Chapter, to be included in the Manual.

2.2 The Manual shall be approved by the Authority and each page of the Manual shall indicate this fact together with the date of issue of the page. A means shall be provided for checking the completeness of the Flight Manual, e.g. by a log of pages (see also 2.9).

2.3 The Manual may be included as part of the Crew Manual required by **Section A,** Chapter **A6—7** (which contains material not prescribed by this Chapter and which is not approved by the Authority). In such a case, those portions which are provided in accordance with this Chapter **G8—5** and approved by the Authority shall be separated and clearly distinguished from those which are not.

2.4 Normally no material need be included in the Manual if, beyond reasonable doubt, it can be assumed to be knowledge common to the flight crew who will be entitled by their licences to operate the rotorcraft.

2.5 The Manual shall be provided with a protective cover, except when it forms part of another manual (see 2.8.2). The binding shall be such that pages are unlikely to be inadvertently detached, and such that amended pages can be inserted (but see 2.9).

2.6 The Manual shall be identified by a reference number which will be appropriate only to that particular Manual; this reference number shall appear on every page.

2.7 The method of reproduction adopted shall be such as to provide good quality text and graphs, with minimum distortion of graphs and minimum variability in legibility and contrast between pages.

2.8 **Contents**

2.8.1 Except as permitted by 2.8.2, the Manual shall be divided into Sections as follows:—

Section 1	General
Section 2	Limitations
Section 3	Emergency Procedures
Section 4	Normal Procedures
Section 5	Performance
Section 6	Supplements.

A.B 2.8.2 Where the Manual forms part of another Manual, or where the Manual includes unapproved material, the Section numbering in 2.8.1 need not be adopted, but the Manual shall at least include the Sections prescribed in 2.8.1, and these Sections shall be in the prescribed sequence.

2.9 **Amendments.** Provision shall be made for the incorporation of amendments. Amendments shall be effected by the provision of revised or additional approved pages. The amendment number shall be shown on each page affected by the amendment. Where the Manual consists of less than ten pages amendment may be made by a complete re-issue of the Manual.

2.10 **Units**

2.10.1 The following units shall be used in the Manual.

(a) Horizontal distance—large	n miles.
(b) Horizontal distance—small	metres (m).
(c) Speed	knots.
(d) Temperature	degrees Celsius (°C).
(e) Vertical distance	feet (ft).
(f) Weight	kilograms (kg).

NOTES: (1) It is acceptable for additional units to be given (e.g. 100 m (328 ft)) (see also 3(f)).
(2) See also **G8—5** App. No. 1, 1.4.4.

2.10.2 In the cases of all parameters, including any additional to those detailed in 2.10.1, the units referred to in the Manual shall be the same as those marked on the appropriate rotorcraft instruments.

3 SECTION 1—GENERAL This Section shall contain the items prescribed in (a) to (g), except for any item that is incorporated in another manual of which the Flight Manual is part (see **G8—5** App. No. 1, 1.1).

(a) A front page which includes, or incorporates provision for, the following:—

(i) The official designation of the rotorcraft.

NOTE: A type name will only be acceptable if this has also been used consistently in other official documents such as the Certificate of Airworthiness and Certificate of Registration.

(ii) Registration marks.

(iii) The constructor's serial number.

(iv) The name of the designing company, and (if different) the name of the constructor.

(v) The number and date of issue of the associated Certificate of Airworthiness.

(vi) The date of the initial approval of the Manual and the name of the Authority which approved it.

(vii) A statement as follows:—
"This rotorcraft shall be operated in accordance with the limitations in Section 2 and any additional limitations in the Supplements contained in Section 6."

NOTE: In the case of a Manual produced in accordance with 2.3, the references to the Sections will have to be altered accordingly.

(b) A Table of Contents.

(c) A description of the amendment system, together with amendment record sheets.

A.B

(d) A general arrangement drawing to a stated scale giving three views of the outline of the rotorcraft, together with the principal dimensions relevant to handling in flight and on the ground.

(e) A graph showing the relationship of air temperature to pressure altitude in the ICAO International Standard Atmosphere, if reference is made in the Manual to this atmosphere.

(f) Conversion of graphs or tables where additional units are given in accordance with 2.10.

(g) Definitions, as appropriate, of the following terms:—

(i) Air Temperature.
(ii) Altitude.
(iii) Gradient.
(iv) Gross Performance.
(v) Height.
(vi) Decision Point (Group A).
(vii) Net Performance.
(viii) Air speeds, EAS and IAS.
(ix) Take-off Safety Speed, V_2.
(x) Any other term or abbreviation used in the Manual which may not be generally understood.

NOTE: The definitions should, where possible, be based on those contained in **G1—2** and **G2—2**, as appropriate.

4 SECTION 2—LIMITATIONS (see G8—5 App. No. 2) This Section shall contain those items prescribed in (a) to (h) in the order given together with any other item which has been established as being a limitation in accordance with **G8—2.** Quantitative limitations over which the flight crew have control shall be expressed in such terms as to enable the flight crew to check these limitations using the available instrumentation. If any unusual limitation is imposed, the reason for it shall be concisely stated.

NOTE: Legislation places a legal obligation on the flight crew to observe the limitations in the Manual.

(a) **Weights.** A statement of the following:—

(i) Maximum Take-off Weight.
(ii) Maximum Landing Weight.

(b) **Baggage and Freight Loading.** A statement of the maximum loads and intensity of load of all cargo and baggage compartments. If necessary the limitations may be shown on a diagram or graph.

NOTE: For these limitations only structural considerations need be taken into account. Balance considerations will be the subject of loading instructions provided in accordance with **Section A,** Chapter **A5—1.**

(c) **Centre of Gravity**

(i) A statement of the c.g. limits longitudinally, laterally and, where appropriate, vertically, in terms of distance from a datum, together with a definition of that datum.
(ii) Where any of the limits vary with weight, a graph showing the variations.

A.B

(d) **Power-plant**

(i) A statement of the engines and, if appropriate, propellers to which the Manual relates.

(ii) A statement of all the limitations for the Power-plant which have been established in accordance with **G8—2.**

(iii) An explanation of the significance of any instrument colour markings provided in accordance with **G8—3.**

(iv) A statement of any limitations on the loading of the fuel tanks, and on their use in flight.

(v) Where the unusable fuel supply in any tank exceeds 5% of the tank capacity, or 4·5 litres (1 gal) whichever is the greater, a statement to the effect that the fuel remaining in the tank, when the quantity indicator reads zero, cannot be safely used in flight.

(vi) A statement of the effect on the unusable fuel quantity resulting from the failure of any pump.

(vii) A statement giving the conditions (e.g. flight attitudes) corresponding to the unusable fuel quantity.

(e) **Air Speed.** A statement of the following:—

(i) Operating speed limitations in terms of indicated airspeed (IAS);
—the limitations which have been established in accordance with **G8—2** together with an explanation of the significance of each limitation;
—in the case of retractable landing gear, the maximum air speed with the landing gear extended, if this is different from the Landing Gear Operating Speed, V_{LO}. If these air speeds are the same, an indication to this effect.

NOTE: Requirements affecting the choice of operating speed limitations are contained in **G8—2.**

(ii) An explanation of the significance of any instrument colour markings provided in accordance with **G8—3.**

(f) **Rotor Speed**

(i) A statement of rotor rotational speed limitations, in terms of rpm, established in accordance with **G8—2.**

(ii) An explanation of the significance of instrument colour markings provided in accordance with **G8—3.**

(g) **Carriage of External Loads.** The information required by **G4—12, 7.**

(h) **Miscellaneous**

(i) A statement of the Category or Categories in which the rotorcraft is certificated.

(ii) A statement relating to the types of operation, including VFR, IFR or IMC day and night, flight in icing conditions and flights at a Flight Level greater than 100*, and which indicates either that flight in such conditions is prohibited or that the rotorcraft may be so used. In the latter case, the statement shall specify any equipment which must then be fitted and which is not required by the Air Navigation legislation.

NOTE: It is not necessary to list any items of equipment the need for which is obvious.

(iii) A statement of any restrictions on smoking in the rotorcraft.

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*Defined in the ANO as one of a series of levels of equal atmospheric pressure, separated by notified intervals and each expressed as the number of hundreds of feet which would be indicated at that level on a pressure altimeter calibrated in accordance with the International Standard Atmosphere and set to 1013·2 mbar.

A.B

(iv) A statement of the maximum air temperature in which operation is permissible;
—a statement of any minimum air temperature limitation which has been established;
—where the fitting of any device (such as a radiator blanking piece) is necessary for operation below certain air temperatures, a statement to that effect.

(v) A statement of the number and composition of the minimum flight crew.

(vi) (See **G8—5** App. No. 2, **1**). A statement of the maximum permissible number of occupants, together with a statement that children under the age of three years when carried in the arms of an adult need not be taken into account.

(vii) A statement of the maximum permissible operating altitude.

(viii) A statement of the inscription on, and location of, each placard which is required to be displayed, together with an explanation of the significance of any instrument colour markings not covered by 4 (d) (iii) or 4 (e) (ii).

(ix) A statement of any limitation on the use of agricultural equipment, established in accordance with **G4—11.**

(x) A statement of any limitations on the use of the systems in the rotorcraft with particular reference to the electrical system and equipment.

5 SECTION 3—EMERGENCY PROCEDURES (see G8—5 App. No. 3, 2) This Section shall contain those operating procedures for flight and system emergency conditions which are essential for the continued safe operation of the rotorcraft. An emergency in this context is defined as a foreseeable but unusual situation in which the risk of a disaster can be substantially reduced by crew action. The procedures shall be presented as briefly as possible and with maximum clarity. References to air speed shall be made in terms of IAS. At least the items prescribed in (a) to (h) shall be included.

(a) Fire on the ground (engine, cabin, electric, or other possible types).

(b) Fire in the air (engine, cabin, electric, or other possible types including smoke clearance).

(c) Partial and complete power failure, at various conditions of height and airspeed, during take-off, approach, and other flight conditions.

(d) Actual or suspected damage or malfunctioning of rotor systems and auxilliary systems (fuel, electrical, power-operated controls, automatic flight control or stability augmentation system, etc.).

(e) Emergency alighting, including ditching.

(f) Severe static or lightning strikes.

(g) Procedure for restarting an engine in flight.

(h) The information required by **G4—12, 7.**

(j) Fuel jettisoning procedure (see **G5—2, 9).**

6 SECTION 4—NORMAL PROCEDURES (see also G8—5 App. No. 3, 2) This Section shall contain recommended procedures and information which are necessary for safety in relation to the handling of the rotorcraft, its engines and its equipment. References to air speed shall be made in terms of IAS. At least the items prescribed in (a) to (x) shall be included.

A.B

(a) Preparing the rotorcraft for flight (including unfolding of rotor blades, removing of covers, locks, etc.).

(b) Engine starting procedure.

(c) Rotor starting procedures.

(d) Engine run-up, control functioning and related checks.

(e) Ground taxying procedure.

(f) Pre-take-off cockpit check.

(g) Take-off procedure.

(h) Significance of limitations—warning characteristics.

(j) In-flight procedures.

(k) Use of special equipment.

(l) Flight in ice forming conditions, where applicable.

(m) Use of fuel system; control of c.g. in flight.

(n) Flight in turbulence.

(o) Use of automatic flight control or stability augmentation system.

(p) Pre-landing cockpit check.

(q) Approach and landing procedures for varying visibilities, with and without power.

(r) Balked landing procedure.

(s) Stopping the rotor.

(t) Stopping the engine(s).

(u) Towing.

(v) Parking.

(w) Picketing.

(x) The information required by **G4—12, 7.**

7 SECTION 5—PERFORMANCE

7.1 **General.** The requirements of this paragraph 7.1 are applicable to the Performance Section of the Manuals for Group A and B rotorcraft.

7.1.1 This Section shall contain the performance information derived in accordance with Sub-section G2. The information shall cover the ranges of weight, altitude, temperature and wind conditions selected in accordance with **G2—2, 3.** The ranges of these conditions shall be not less than those prescribed in **G2—2, 3.**

7.1.2 References to air speed shall, unless otherwise stated, be made in terms of IAS.

7.1.3 **Presentation of Graphs**

(a) Graphs shall be drawn in a clear and unambiguous manner.

(b) The scales used in the graphs shall be the largest permitted by the size of the paper remaining after suitable allowance has been made for margins, consistent with ease of interpolation.

A.B

(c) Except where the interpretation is obvious, the manner in which each graph is to be used shall be illustrated by means of an example shown on the graph with broken lines. An explanation shall also be given when two or more graphs are to be used in a calculation.

(d) The configurations and conditions which are associated with each graph shall be stated either on the graph or on the left hand facing page.

A 7.2 **Group A Rotorcraft** (see **G8—5** App. No. 4, **2**). The Performance Section of the Manual for Group A rotorcraft shall be presented in accordance with the general requirements of 7.1 and the detailed requirements of this paragraph 7.2.

7.2.1 **Method of Scheduling Data**

(a) The information shall be presented in graphical form with supporting text which should include an explanation of the use of the graphs and examples of typical calculations.

(b) Each Sub-section shall contain information appropriate to all the alternative powers and configurations which are approved for the rotorcraft.

7.2.2 **Sub-division of the Section.** The Section shall be divided into Sub-sections as follows:—

Number	*Title*
5.1	General
5.2	Take-off Procedures and Speeds
5.3	Take-off and Landing WAT Curves
5.4	Take-off and Landing Climb Gradients
5.5	Take-off Spaces and Areas
5.6	Take-off Net Flight Paths
5.7	En route
5.8	Landing Procedures and Speeds
5.9	Landing Spaces
5.10	Gross Performance Data.

7.2.3 **Sub-section 5.1—General** (see **G8—5** App. No. 4, **1**). This Sub-section shall include the items prescribed in (a) to (d).

(a) A statement that the rotorcraft is classified in Performance Group A1 or A2.

(b) Representative cruising true air speeds derived in accordance with **G2—2,** 4.1.1 and 4.1.2.

(c) The type of engines and, if appropriate, the type of propellers for which the performance is valid.

(d) A statement indicating whether the performance information in the Manual may be extrapolated or not and the extent, if any, of the extrapolation permitted.

(e) Graphs to enable speeds when expressed in IAS to be corrected to EAS. These shall take into account the effects of rotorcraft attitude and flight condition, if significant.

(f) A statement of the maximum value of the static error correction to be applied to the altimeter reading, or a graph showing variations.

7.2.4 **Sub-section 5.2—Take-off Procedures and Speeds.** This Sub-section shall include the items prescribed in (a) to (c).

A

(a) The recommended procedures and speeds required to enable the take-off performance to be achieved.

(b) A statement of the Critical Power-unit, if any.

(c) A statement of the maximum cross-wind component for take-off. This component shall be appropriate to a wind speed measured at a height of 10 m.

7.2.5 **Sub-section 5.3—Take-off and Landing WAT Curves** (see **G8—5** App. No. 4, 2.1). This Sub-section shall include the Take-off and Landing WAT Curve for each take-off configuration derived in accordance with **G2—4, 3.**

7.2.6 **Sub-section 5.4—Take-off and Landing Climb Gradients** (see **G8—5** App. No. 4, 2.2). This Sub-section shall include the gradients of climb for the conditions prescribed in **G2—4.**

7.2.7 **Sub-section 5.5—Take-off Spaces and Areas** (see **G8—5** App. No. 4, 2.3 and 2.4). This Sub-section shall include the Take-off Spaces and Areas derived in accordance with **G2—3.** Any factor required by operational performance rules shall be included in the scheduled data and a statement that the factors are included shall be given in the Flight Manual.

7.2.8 **Sub-section 5.6—Take-off Net Flight Paths** (see **G8—5** App. No. 4, 2.5). This Sub-section shall include the Take-off Net Flight Paths derived in accordance with **G2—3.**

(a) The presentation shall be in the form of a series of graphs such that the position of the end of each sector can be determined in terms of co-ordinates from a defined datum and thus enable the flight path profile to be drawn by joining these points by straight lines.

(b) Where the effect of a significant banked turn is scheduled in accordance with **G2—3,** 6.4, the value of the radius of such a turn appropriate to the maximum altitude and air temperature for which take-off data are scheduled shall be given.

7.2.9 **Sub-section 5.7—En Route** (see **G8—5** App. No. 4, 2.6). This Sub-section shall include:—

(a) the all-engines-operating pressure rates of climb and corresponding gradient of climb

(b) the net rate and gradient of climb with one engine inoperative, derived in accordance with **G2—4, 6.**

7.2.10 **Sub-section 5.8—Landing Procedures and Speeds.** This Sub-section shall include the items prescribed in (a) to (c).

(a) The recommended procedures and speeds for the achievement of the landing performance.

(b) A statement of the Critical Power-unit, if any.

(c) A statement of the maximum cross-wind component for landing. This component shall be appropriate to a wind speed measured at a height of 10 m.

7.2.11 **Sub-section 5.9—Landing Spaces** (see **G8—5** App. No. 4, 2.7). This Sub-section shall include the Landing Distance Required derived in accordance with **G2—5, 3.** The data shall include the effect of the factors required by operational performance rules and a statement that the factors are included shall be given in the Flight Manual.

A 7.2.12 **Sub-section 5.10—Gross Performance Data.** This Sub-section shall include the Gross Performance necessary for the evaluation of the airworthiness flight test climb performance results as prescribed in **G2—2,** 4.2, and shall be presented in terms of rate of change of pressure altitude.

B 7.3 **Group B Rotorcraft** (see **G8—5** App. No. 4, **3**). The Performance Section of the Manual for Group B rotorcraft shall be presented in accordance with the general requirements of 7.1 and the detailed requirements of this paragraph 7.3.

7.3.1 **Method of Scheduling Data**

(a) The information shall be presented in graphical form with supporting text which should include an explanation of the use of the graphs and examples of typical calculations.

(b) Each Sub-section shall contain information appropriate to all the alternative powers and configurations which are approved for the rotorcraft.

7.3.2 **Sub-division of the Section.** The Section shall be divided into Sub-sections as follows:—

General;

Take-off and Landing Procedures;

Take-off and Landing WAT Curves;

Take-off Spaces and Areas;

Take-off Flight Paths;

En Route, Climb and Autorotative Glide Curves;

Landing Spaces;

Climb Performance Data.

7.3.3 **General** (see **G8—5** App. No. 4, **1**). The general items prescribed in (a) to (g) shall be included.

(a) A statement that the rotorcraft is classified in Performance Group B.

(b) A representative cruising true air speed derived in accordance with **G2—2,** 4.1.1.

(c) The type of engine(s) for which the performance is valid and, if appropriate, the type of propellers.

(d) A statement indicating whether the performance information in the Manual may be extrapolated or not, and the extent, if any, of the extrapolation permitted.

(e) If any of the scheduled performance information has been derived from calculations which took advantage of the test extrapolations permitted by **G2—2,** a statement indicating the ranges covered by such extrapolation.

(f) Graphs or tables to enable speeds when expressed in IAS to be corrected to EAS. These shall take into account the effect of rotorcraft attitude and flight condition, if significant.

(g) A statement of the maximum value of the static error correction to be applied to the altimeter reading or a graph showing variations.

B

7.3.4 **Take-off and Landing Procedures.** The items prescribed in (a) to (d) shall be included.

(a) A graph showing the envelope of forward speed and height within which, in zero wind, a landing can be made without hazard to the occupants after loss of power. (See **G2—8, 5).**

(b) The recommended procedures and speeds required to enable the take-off and landing performance to be achieved.

(c) A statement of the Critical Power-unit (if applicable).

(d) A statement of the maximum cross-wind component for take-off and for landing. This component shall be appropriate to a wind speed measured at a height of 10 m.

7.3.5 **Take-off and Landing WAT Curves.** The Take-off and Landing WAT Curves derived in accordance with **G2—4, 4** shall be included.

7.3.6 **Take-off Spaces and Areas.** The Take-off Spaces and Areas derived in accordance with **G2—3,** shall be included. Any factor required by operational performance rules shall be included in the scheduled data, and a statement that the factors are included shall be given in the Flight Manual.

7.3.7 **Take-off Flight Paths.** The Take-off Flight Paths derived in accordance with **G2—3** shall be included.

(a) Where the presentation is in graphical form it shall consist of a series of graphs such that the position of the end of each sector can be determined in terms of co-ordinates from a defined datum and thus enable the flight path profile to be drawn by joining these points by straight lines.

(b) Where the effect of a banked turn is scheduled in accordance with **G2—3,** 6.4, the value of the radius of such a turn appropriate to the maximum altitude and air temperature for which take-off data are scheduled shall be given.

7.3.8 **En Route.** The en-route climb detailed in (a) and (b) and derived in accordance with **G2—4, 6** shall be included.

(a) The all-engines-operating pressure rates of climb and the performance ceiling.

(b) The gradient of climb or descent with one engine inoperative, and the gradient of descent with total loss of power.

NOTE: In the case of single-engined rotorcraft this should be expressed as the autorotational gliding distance covered during descent through a given altitude at Maximum Take-off Weight in zero wind and in standard air temperature.

7.3.9 **Landing Spaces.** The Landing Space Required derived in accordance with **G2—5, 3** shall be included. Any factor required by operational performance rules shall be included in the scheduled data and a statement that the factors are included shall be given in the Flight Manual.

7.3.10 **Climb Performance Data.** The performance necessary for the evaluation of the Airworthiness Flight Test climb performance results as prescribed in **G2—2,** 4.2 shall be included and shall be presented in terms of rate of change of pressure altitude.

A.B **8** SECTION 6—SUPPLEMENTS (see G8—5 App. No. 5, 1) This Section shall contain, in the form of Supplements, information applicable to any particular feature or use of the rotorcraft which is not covered by the information and data included in the Manual, (e.g. carriage of external loads (see **G4—12**); flotation equipment (see **G6—12**).)

NOTES: (1) It is the intention that the Manual of each particular rotorcraft should include only those supplements which apply to it.

(2) When weight and balance data are required to be included in the Manual (see **Section A**, Chapter **A5—1**) they shall be included in Section 6 as a Supplement.

8.1 Each Supplement shall describe the specific feature or use of the rotorcraft to which it is related and shall list any additions to, or revision of, the scheduled information and data which have to be observed in the particular circumstances.

8.2 The material contained in a Supplement shall comply with the relevant requirements of this Chapter **G8—5.**

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APPENDIX No. 1 TO CHAPTER G8—5

Issued, 30th September, 1977

FLIGHT MANUALS—GENERAL

1 GENERAL (see G8—5, 2)

1.1 **Inclusion of Flight Manual in Another Manual.** When this alternative is adopted and the Maximum Weight of the rotorcraft does not exceed 2730 kg it is recommended that such a manual be called the "Owners Manual". This title should appear on the front page followed by a note to the effect that it incorporates the approved Flight Manual and stating which parts comprise the Flight Manual. When the Maximum Weight exceeds 2730 kg it is recommended that the title "Flight Manual" be retained and that a note be put on the front page that the Manual includes certain unapproved information and instructions.

1.2 **Size.** For standardization with other manuals, A4 size paper should be used (210 mm x 297 mm). For small rotorcraft in which stowage space for documents is limited, a size more convenient to the pocket may be selected.

1.3 **Reproduction.** Graphs should be printed on a right hand page; text associated with a graph should, where practical, appear on the left hand facing page. Where a number of graphs form a series and are likely to be used successively in a calculation, the same scales should be used.

NOTE: It is recommended that an offset-lithographic process be used.

1.4 **Contents**

1.4.1 When the contents of the Manual consists of more than ten pages, each Section of the Manual should commence on a right hand page, and Sections should be separated from one another by divider cards. These cards should each be identified by a tab with the name of the Section printed on it. The card and tab for the Emergency Procedures should be coloured red.

1.4.2 When the Manual forms part of another manual or when it includes unapproved portions not prescribed by this Chapter, other Sections may be included but the following order should be used:—

Section 1—General

Section 2—Design Features

Section 3—Limitations

Section 4—Emergency Procedures

Section 5—Normal Procedures

Section 6—Performance

Section 7—Supplements.

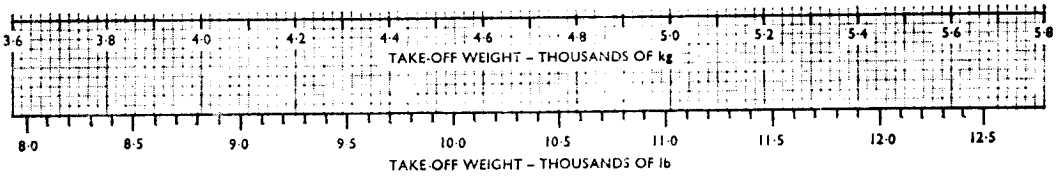
1.4.3 **Amendments.** When it is likely that the Manual will require frequent amendment an explanation should be given of the system that will be used e.g. temporary revisions or advance amendment bulletins. Divider Cards etc., should also be included.

1.4.4 **Conversion Graphs and Tables**

(a) In addition to the system of units prescribed in **G8—5,** 2.10.1 it is recommended that unless dual scales are used throughout, the following conversions be supplied either in graphical or in tabular form:—

kilograms	to pounds
knots	to miles per hour, to kilometres per hour
degrees Celsius	to degrees Fahrenheit
feet	to metres
nautical miles	to kilometres.

(b) The method in Fig. 1 (G8—5 App. No. 1) should be used for showing more than one scale on a graph.



METHOD OF SHOWING MORE THAN ONE SCALE ON A GRAPH

Fig. 1 (G8—5 App. No. 1)

APPENDIX No. 2 TO CHAPTER G8—5

Issued, 30th September, 1977

FLIGHT MANUALS—LIMITATIONS

1 MAXIMUM NUMBER OF OCCUPANTS (see G8—5, 4 (h) (vi)) This limitation should be expressed as follows:—

"The total number of persons carried including crew shall not exceed X or the number of seats which are approved for use during take-off and landing. Children under the age of three years carried in the arms of passengers need not be included in the total".

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APPENDIX No. 3 TO CHAPTER G8—5

Issued, 30th September, 1977

FLIGHT MANUALS—PROCEDURES

1 GENERAL In order to assist the flight crew to follow the procedures contained in the Manual, capital letters should be used to correspond with the marked position of the switch or control in question. The names by which switches or controls are identified should be the same as the marking in the rotorcraft. For example the procedure:— "HP fuel valve: START" means that the control marked "HP" should be moved to the position marked "START".

2 NORMAL PROCEDURES (see G8—5, 6) In addition to the procedures described in **G8—5, 6** this Section of the Manual should include any procedure which is recommended in the event of malfunctioning of any part of the rotorcraft which is not considered to be serious enough to be classified as an Emergency as defined in **G8—5, 5.**

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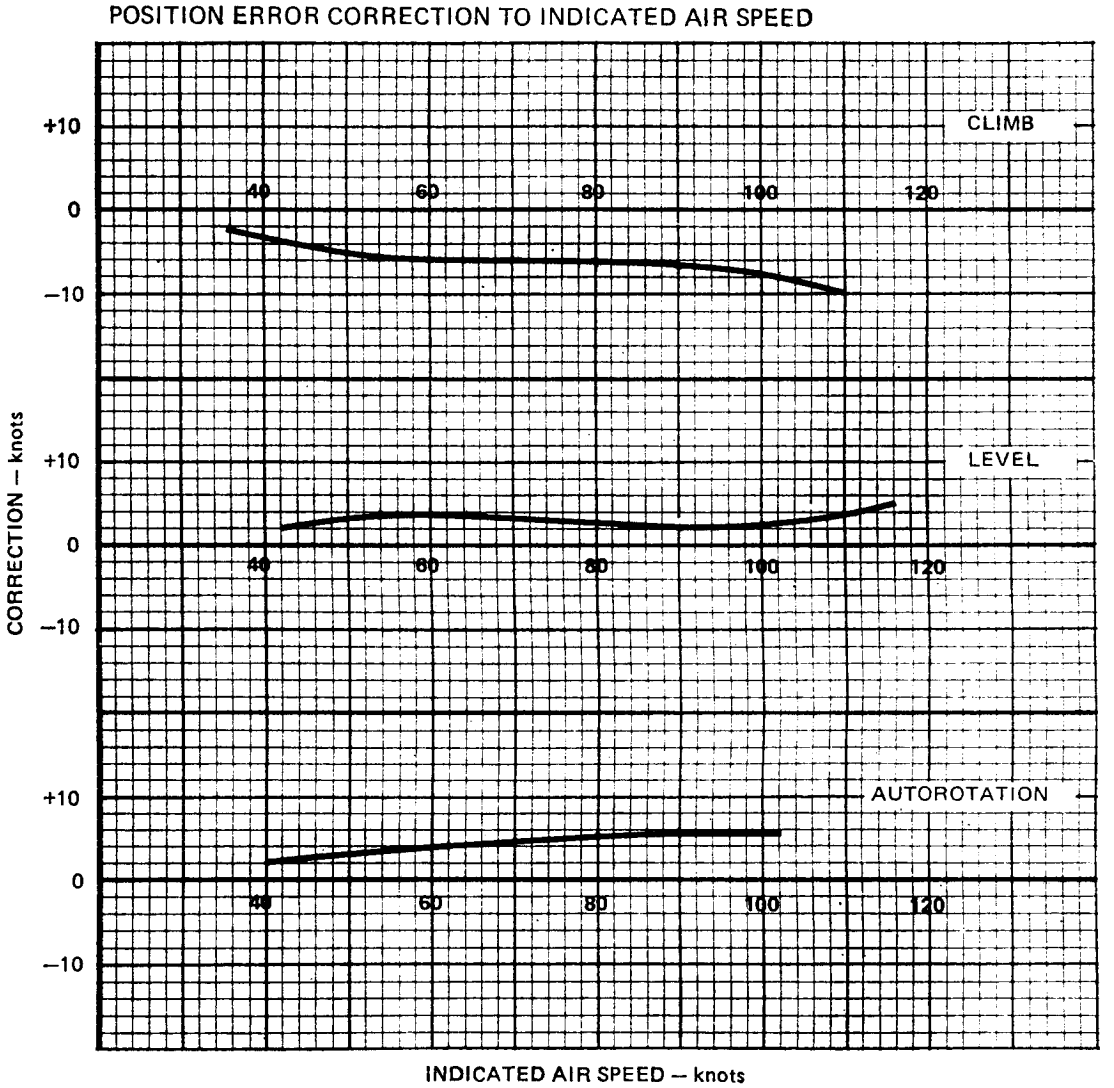
APPENDIX No. 4 TO CHAPTER G8—5

Issued, 30th September, 1977

FLIGHT MANUALS—PERFORMANCE

I GENERAL—ALL ROTORCRAFT (see G8—5, 7.2.3 and 7.3.3)

1.1 **Correction of I.A.S.** Graphs for the correction of I.A.S. to obtain E.A.S. should be as shown in Fig. 1 (G8—5 App. No. 4). This figure illustrates a case where the differing effects resulting from climb, level flight and autorotation have been taken into account.

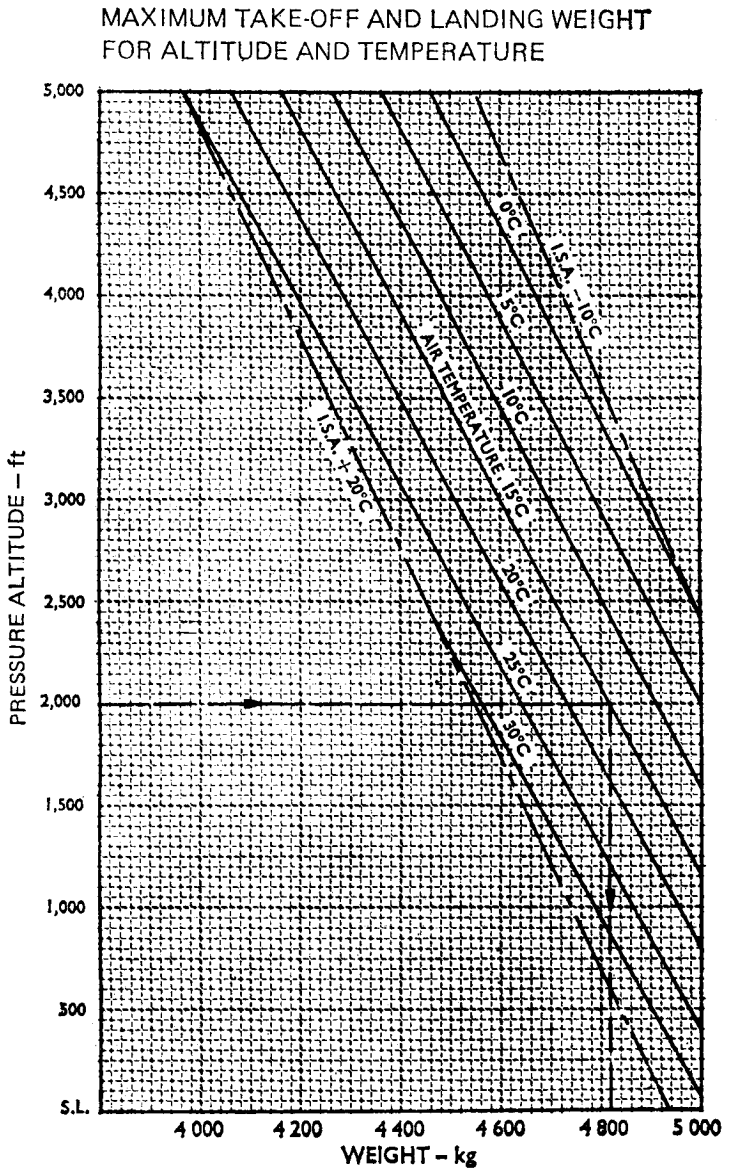


CORRECTION OF I.A.S. TO OBTAIN E.A.S.

Fig. 1 (G8—5 App. No. 4)

2 GROUP A ROTORCRAFT (see G8—5, 7.2) Performance data for Group A should be presented in accordance with the examples given in this paragraph **2.**

2.1 **Take-off and Landing WAT Curves** (see **G8—5,** 7.2.5). An example of the graphical presentation of the Take-off and Landing WAT Curve is shown in Fig. 2 (G8—5 App. No. 4).



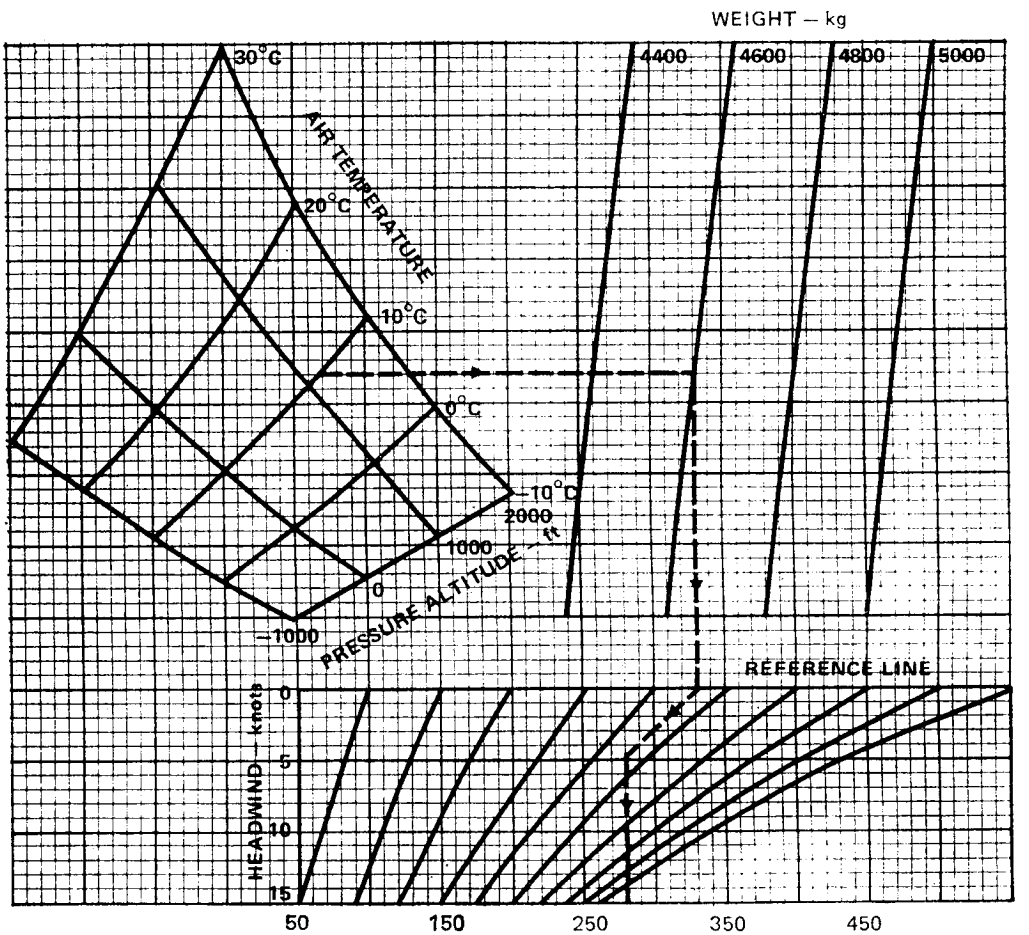
TAKE-OFF AND LANDING WAT CURVES

Fig. 2 (G8—5 App. No. 4)

2.2 **Take-off and Landing Climb Gradients** (see **G8—5,** 7.2.6). An example of a graph suitable for the presentation of gross gradients of climb is shown in Fig. 7 (G8—5 App. No. 4), which illustrates the En-route Gradient of Climb—One Engine Inoperative.

2.3 **Take-off Spaces** (see **G8—5,** 7.2.7). An example of a graph suitable for the presentation of the Take-off Space Required is shown in Fig. 3 (G8—5 App. No. 4).

TAKE-OFF SPACE REQUIRED



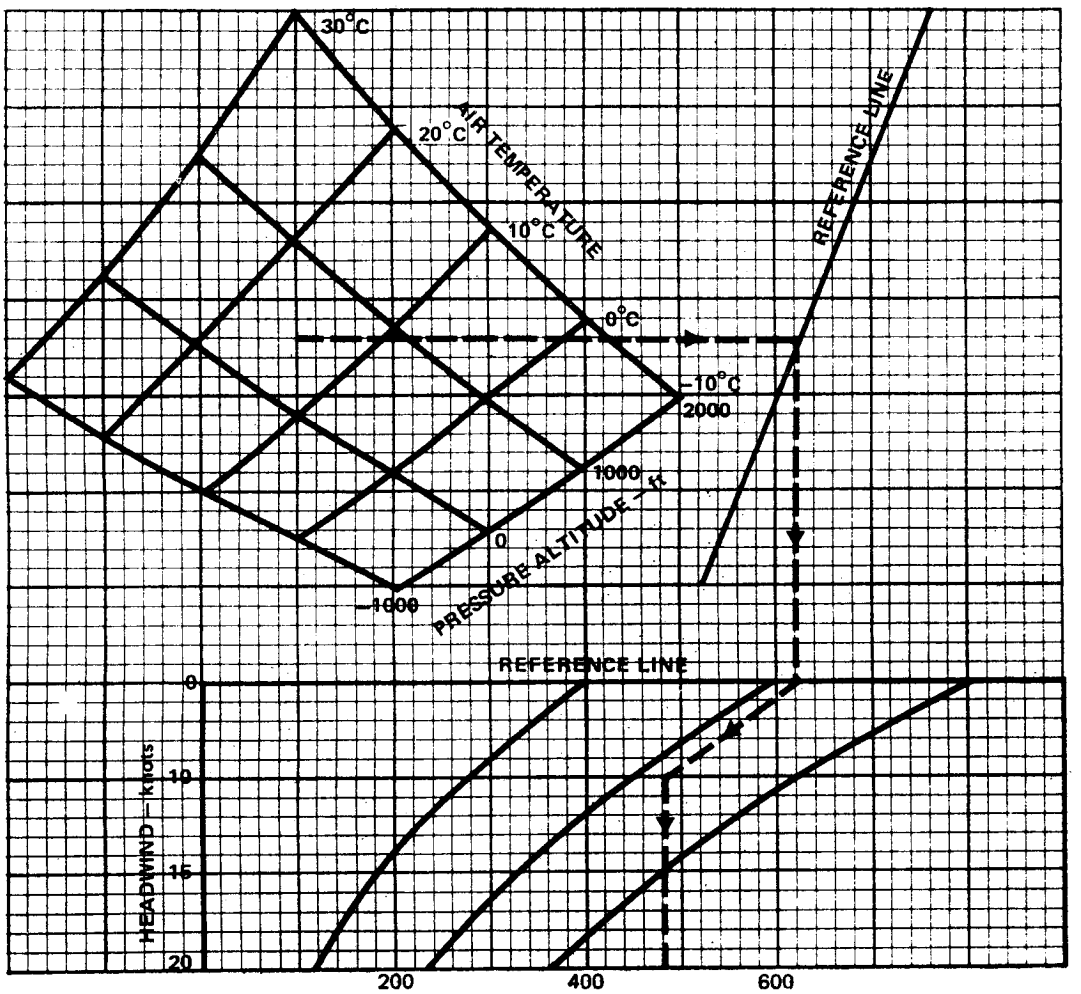
NOTE: Minimum width of Take-off Space Required shall be 30 m.

TAKE-OFF SPACE REQUIRED

Fig. 3 (G8—5 App. No. 4)

2.4 **Rejected Take-off Areas** (see **G8—5,** 7.2.7). An example of a graph suitable for the presentation of the Rejected Take-off Area Required is shown in Fig. 4 (G8—5, App. No. 4).

REJECTED TAKE-OFF AREA

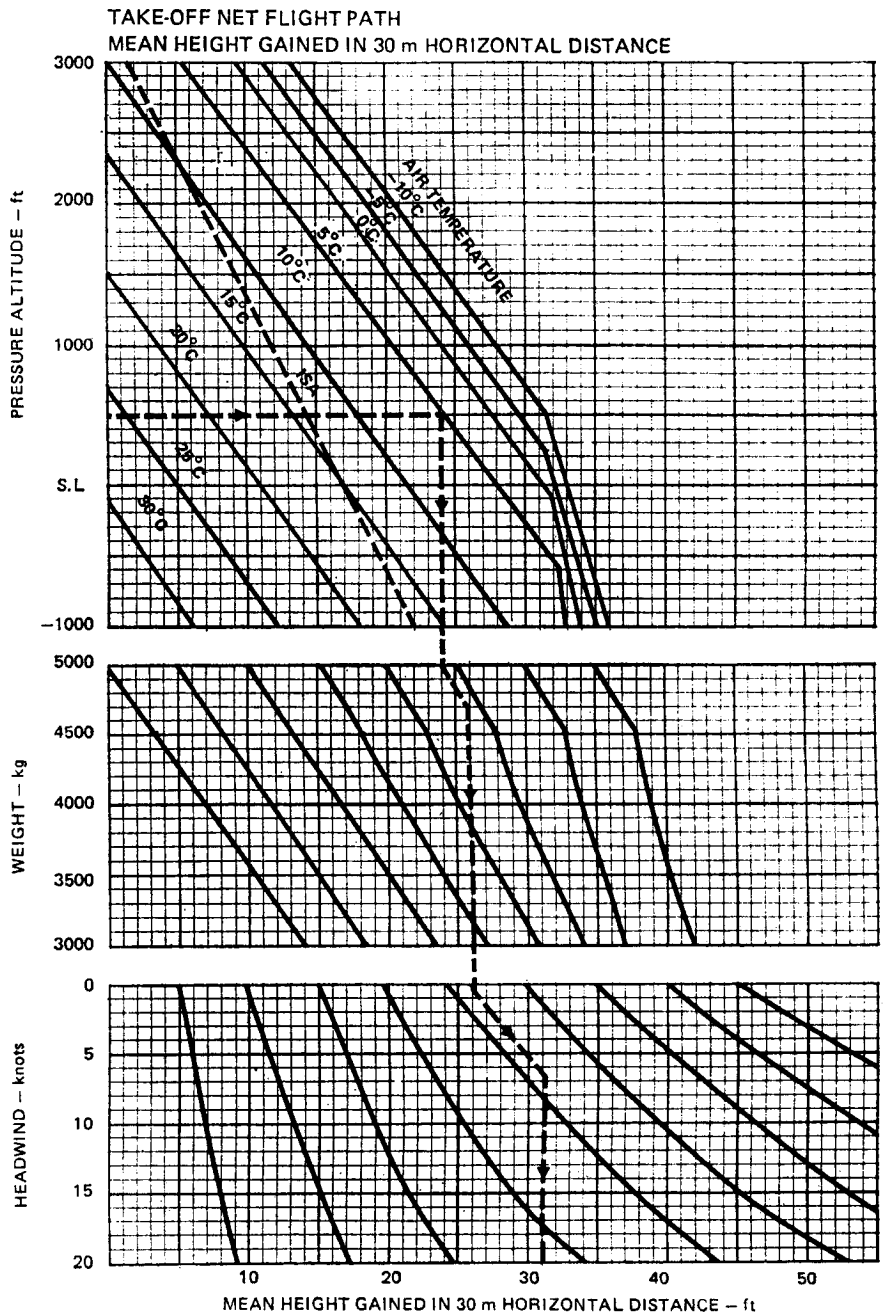


NOTE: The minimum width of the Rejected Take-off Area Required shall be 30 m.

REJECTED TAKE-OFF AREA REQUIRED

Fig. 4 (G8—5 App. No. 4)

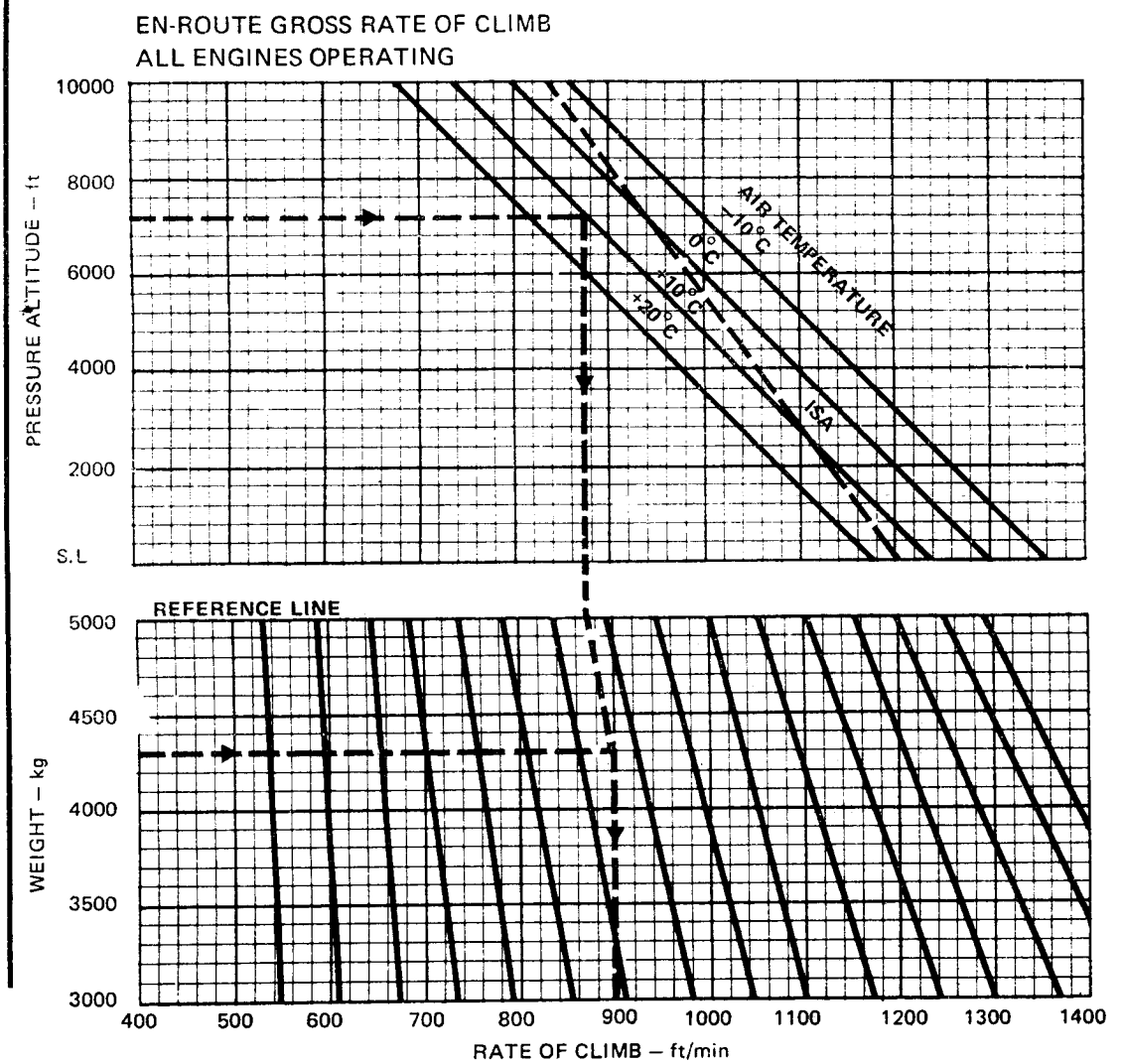
2.5 **Take-off Net Flight Paths** (see **G8—5,** 7.2.8). An example of a graph suitable for the presentation of Take-off Net Flight Paths is shown in Fig. 5 (G8—5 App. No. 4). Additional graphs giving corrections for the use of anti-icing devices, etc., should be included where necessary.



TAKE-OFF NET FLIGHT PATH

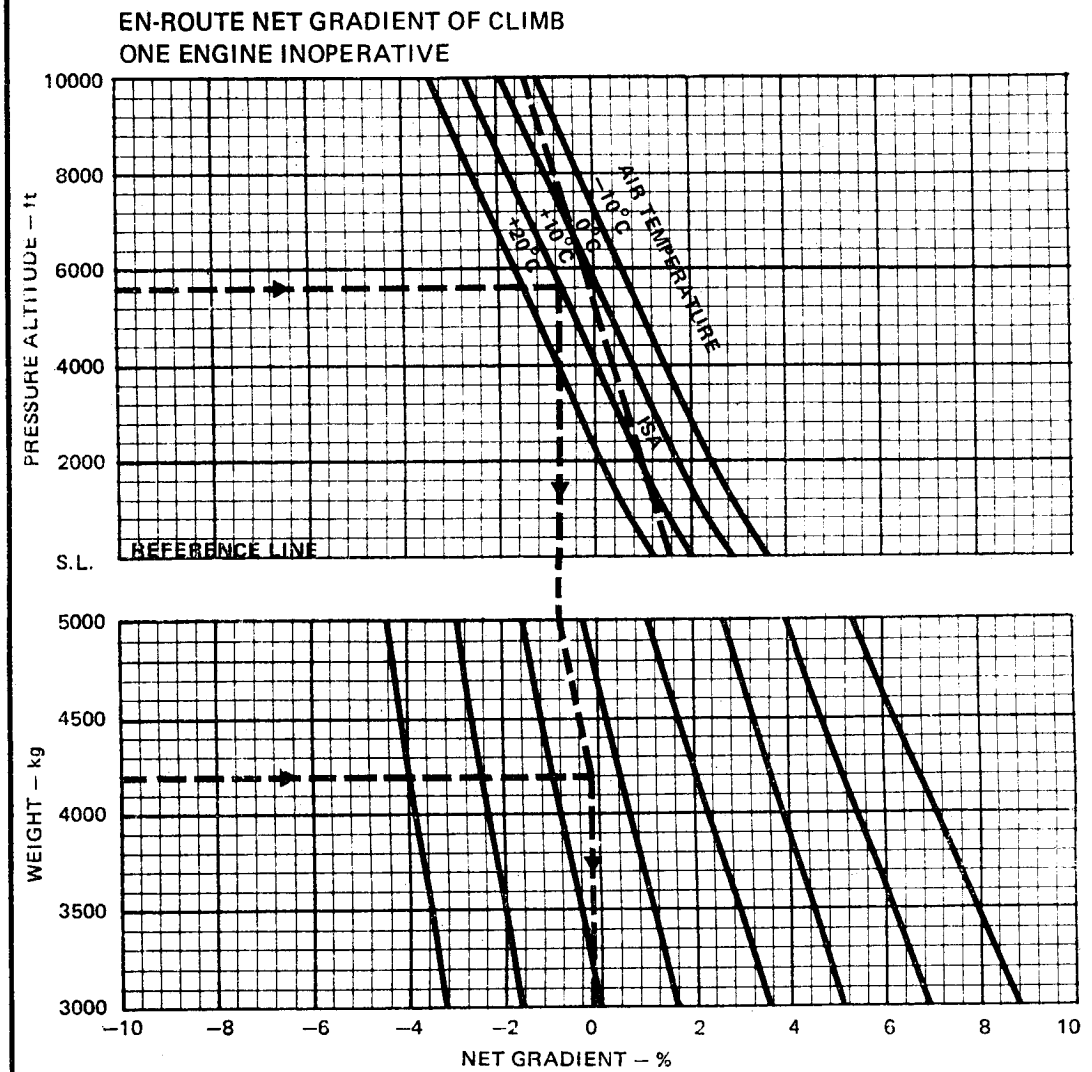
Fig. 5 (G8—5 App. No. 4)

2.6 **En Route** (see **G8—5,** 7.2.9). An example of the graphical presentation of the all-engines-operating gross rate of climb is shown in Fig. 6 (G8—5 App. No. 4). An example for the one-engine-inoperative en-route net gradient of climb is shown in Fig. 7 (G8—5 App. No. 4). Additional graphs giving corrections for the use of anti-icing devices etc. should be included where necessary.



EN-ROUTE CLIMB—ALL ENGINES OPERATING

Fig. 6 (G8—5 App. No. 4)



EN-ROUTE GRADIENT OF CLIMB—ONE ENGINE INOPERATIVE

Fig. 7 (G8—5 App. No. 4)

2.7 **Landing Spaces** (see **G8—5,** 7.2.11). The graphical presentation of Landing Spaces should be similar to that for the Take-off Space Required as shown in Fig. 4 (G8—5 App. No. 4), including a note giving the minimum width of the Landing Space.

3 GROUP B ROTORCRAFT (see G8—5, 7.3) Where graphical presentation is used for Group B the example given in **2** for Group A rotorcraft should, where appropriate, be followed.

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APPENDIX No. 5 TO CHAPTER G8—5

Issued, 30th September, 1977

FLIGHT MANUALS—SUPPLEMENTS

1 GENERAL (see G8—5, 8) An illustration of an acceptable method of complying with the requirement of G8—5, 8 is shown in this Appendix.

NOTE: It is recommended that amendments to Supplements be usually effected by a re-issue of the complete Supplement.

SPECIMEN SUPPLEMENT

Flight Manual Ref. No. 1234 **CAA approved 1.4.74**

AERIAL CRANES LTD.

Supplement No. 3

EXTERNAL FREIGHT LIFTING EQUIPMENT

INTRODUCTION

When A.C.L. Modification No. XY99 is installed on Bordair Model 67 helicopters, this supplement must be included in the Flight Manual. The freight lifting equipment consists of a frame and hook assembly, electrical and manual release systems, and attachments. An elastic shock cord is attached to the freight hook, which provides automatic stowing when the hook is not in use.

SECTION 2 LIMITATIONS

TYPES OF OPERATION

1 The helicopter shall be flown solely for aerial work when loads are carried on the freight hook, and no passengers shall be carried unless directly concerned with the freight-carrying operation.

2 The load carried on the hook shall not exceed 600 kg.

3 The load carried shall not touch any part of the helicopter structure.

4 For those types of load which may cause significant changes in the flight characteristics of the helicopter/load combination from those which have been demonstrated previously as being satisfactory, the operator must conduct flight checks in order to determine the conditions within which such loads may be carried safely.

Such flight checks, which should take place in an environment free from third party hazard, are required to ensure that the following manoeuvres can be performed safely.

(a) The picking up of an external load.

(b) Turns in the hover to ensure that adequate directional control is available.

(c) Transition from the hover.

(d) Level flight and turns at an airspeed not less than that required during the proposed operation.

(e) Return to the hover and release of the load.

PLACARDS

The following placard must be placed in a prominent position near to the freight hook—

"THE MAXIMUM LOAD APPROVED ON THIS HOOK IS 600 kg."

SECTION 3 EMERGENCIES

In the event of failure of the electrical release device, pull the mechanical release handle, marked "EMERGENCY CARGO RELEASE", fully backwards to release the load.

In the event of engine failure, the load must be jettisoned before an autorotative landing is made.

SECTION 4 NORMAL PROCEDURES

BEFORE PICKING UP LOAD

1 Cargo Hook Release circuit breaker—IN

2 Cargo Release Switch—ON

RELEASING LOAD

Depress cargo release push button located on the pilot's cyclic control grip.

NOTE: The mechanical release will function regardless of the Cargo Release switch or circuit breaker position.

GROUND CREW INSTRUCTIONS

Instruct the ground crew member to discharge helicopter static electricity, before attaching a load in the hover, by touching the airframe with a ground wire, or the hook up ring if a metal sling is used.

SECTION 5 PERFORMANCE

See Section 5 of basic Flight Manual.

SECTION G

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Revised, 16th August, 1982

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ABBREVIATIONS

SEH, Single-engined helicopters; TEH, Twin-engined helicopters.

A—*continued*

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ABBREVIATIONS

SEH, Single-engined helicopters; TEH, Twin-engined helicopters.

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SEH, Single-engined helicopters; TEH, Twin-engined helicopters.

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SEH, Single-engined helicopters; TEH, Twin-engined helicopters.

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ABBREVIATIONS

SEH, Single-engined helicopters; TEH, Twin-engined helicopters.

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ABBREVIATIONS

SEH, Single-engined helicopters; TEH, Twin-engined helicopters.

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	Chapter	para.
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	Chapter	para.
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ABBREVIATIONS

SEH, Single-engined helicopters; TEH, Twin-engined helicopters.

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ABBREVIATIONS

SEH, Single-engined helicopters; TEH, Twin-engined helicopters.

I—*continued*

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ABBREVIATIONS

SEH, Single-engined helicopters; TEH, Twin-engined helicopters.

L—*continued*

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ABBREVIATIONS

SEH, Single-engined helicopters; TEH, Twin-engined helicopters.

M—*continued*

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ABBREVIATIONS

SEH, Single-engined helicopters; TEH, Twin-engined helicopters.

O—*continued*

	Chapter	para.
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ABBREVIATIONS

SEH, Single-engined helicopters; TEH, Twin-engined helicopters.

P—*continued*

	Chapter	para.
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Functioning	G5—1	3
General requirements	G5—1	
Heat exchangers	G5—1	7.6
Incorrect assembly	G5—1	2.2
Instruments	G6—1	3.2;
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Oil systems	G5—3	
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Safety assessment	G5—1	3
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Interpretation	Foreword	2

ABBREVIATIONS

SEH, Single-engined helicopters; TEH, Twin-engined helicopters.

R—*continued*

	Chapter	para.
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ABBREVIATIONS

SEH, Single-engined helicopters; TEH, Twin-engined helicopters.

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ABBREVIATIONS

SEH, Single-engined helicopters; TEH, Twin-engined helicopters.

T—*continued*

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ABBREVIATIONS

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BCAR 29 ROTORCRAFT

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FOREWORD

1 GENERAL

1.1 British Civil Airworthiness Requirements, of which Part 29 is a constituent part, are published by the Civil Aviation Authority (hereinafter referred to as the "Authority"). They comprise minimum requirements and constitute the basis of approvals and certificates required by the Air Navigation Order 1985 as amended.

1.2 This BCAR 29 for rotorcraft has been based on Part 29 of the Federal Aviation Regulations, issued by the Federal Aviation Administration, amended where appropriate to align with the United Kingdom legislation and essential features of BCAR Section G — Rotorcraft.

2 INTERPRETATION

2.1 These requirements, with or without explanatory material, should not be regarded as constituting a text-book of current aeronautical knowledge; interpretation of the requirements against a background of such knowledge is essential.

2.2 Where necessary, the mandatory requirements of Section 1 are supplemented by advisory material (ACB — Advisory Circulars — British) in Section 2, which gives acceptable interpretation of requirements, states recommended practices, or gives supplementary information.

2.3 It is implicit in requirements expressed qualitatively (e.g. "readily visible", "adequately tested") that the Authority will adjudicate in cases where doubt exists.

3 PRESENTATION

3.1 The requirements of BCAR 29 are presented in two columns on loose pages, each page being identified by a page number and the Change number under which it is amended or re-issued.

3.2 Mandatory requirements are contained in Section 1 and ACB material in Section 2, with the same numbers as the requirements to which they relate. Appendices adopted unchanged from FAR 29 are included at the end of Section 1.

3.3 Where variations and additions to FAR Part 29 have been found necessary for BCAR 29, they are indicated in Section 1 by underlining.

3.4 Where sections or paragraphs have been reserved or deleted for BCAR 29 they have been marked accordingly.

3.5 In general, BCAR 29 sections carry the same number as the corresponding FAR section. In cases where new BCAR material is introduced and there is no corresponding section in FAR, a number is chosen for it which attempts to place the new material in the right context within the FAR numbering system.

3.6 Where for the purpose of the requirements, terms must carry a particular meaning, definitions are either given in appropriate places in BCAR 29 or, where the defined term applies throughout BCAR 29, the definitions appear in BCAR 29-1. Use of these defined terms within the text is indicated by initial capital letters, e.g. Maximum Weight.

4 AMENDMENT AND ISSUE

4.1 This printed version of the Part, which is identified by an Issue No. and date, will be deemed to be amended by each BCAR Blue Paper appropriate to the Part, which is issued subsequent to the date of Issue of the printed version. The effective date of each BCAR Blue Paper is marked on the first page of the Paper.

4.2 The BCAR Blue Papers will, at convenient intervals, be consolidated into the printed version of the Part, whereupon the Issue No. of the Section will be raised and the date will be changed. Advice of this consolidation will be given in the Explanatory Note associated with the new issue of the Part.

4.3 In both printed version and BCAR Blue Papers alike, material differences from the previous issue are indicated with a marginal line.

5 EFFECTIVE DATE New requirements and amendments promulgated in BCAR Blue Papers are effective from the date printed on them. Thus for any application made on or after the date of issue of a printed version of the Part, the effective requirements will be made up of those in the printed version of the Part together with those in any appropriate BCAR Blue Papers which are current at the time the application is made.

6 APPLICATIONS AND ENQUIRIES Applications for further copies of this Part and for details of the amendment service should be addressed to the Civil Aviation Authority, Printing and Publication Services, Greville House, 37 Gratton Road, Cheltenham, Glos., GL50 2BN. Applications for permission to reproduce any part of the Requirements and any enquiries regarding their technical content should be addressed to the Civil Aviation Authority, Airworthiness Division, Brabazon House, Redhill, Surrey, RH1 1SQ.

PREAMBLES

BCAR 29

17.12.86

BCAR 29 is the basis for the certification of new types of rotorcraft, application for certification of which is received after the above date. BCAR Section G, which will continue to be amended, remains current for derivatives of existing rotorcraft.

BCAR 29 consists of seven sub-parts, as does the basic code FAR-29, together with a separate sub-part designated BCAR 29-1 and entitled Definitions and Abbreviations.

Issue 1 of BCAR 29 presents the technical intent of BCAR Section G at Issue 9 (plus Blue Paper Nos. 235, 774, 778, 779, 780, 785 and 786) in the FAR format using FAR-29 at Change 17 as the basic document. Where possible, as much of the original FAR-29 text has been retained in BCAR 29.

The following BCAR Papers have been included in this Issue 1:—

29A—1
29B—2
29B—3
29C—4
29D—5
29E—6
29F—7
29G—8
29X—9

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BCAR 29-1 DEFINITIONS AND ABBREVIATIONS

1 GENERAL (See ACB 29-1, 1)

1.1 **Applicant.** A person applying for approval of a Rotorcraft or any part thereof.

1.2 **Approved.** Accepted by the Authority as suitable for a particular purpose.

1.3 **Atmosphere, International Standard.** An atmosphere defined as follows:—

(a) the air is a perfect dry gas;

(b) the temperature at sea-level is 15°C;

(c) the pressure at sea-level is $1{\cdot}013250 \times 10^5$ N/m² (29·92 in Hg) (1013·2 mbar);

(d) the temperature gradient from sea-level to the altitude at which the temperature becomes −56·5°C is 3·25°C per 500 m (1·98°C/1000 ft);

(e) the density at sea-level, ρo, under the above conditions is 1·2250 kg/m³ (0·002378 slugs/ft³); for the density at altitudes up to 15 000 m (50,000 ft) see Table 1.

NOTE: ρ is the density appropriate to the altitude and $\rho/\rho o$ the relative density is indicated by σ.

1.4 **Climates, Standard** (see ACB 29-1, 1.4)

NOTE: This paragraph defines three Standard Climates — Temperate, Tropical and Arctic — by stating the envelope conditions applicable to each. They are drawn up on the basis of conditions unlikely to be exceeded more often than on one day per year except that they do not cover the extremes of temperature occasionally reached in tropical deserts or in Siberia in winter.

The Temperate, Tropical and Arctic climates are defined by:—

(a) the temperature envelopes enclosed by the appropriate maximum and minimum temperature lines of Fig. 1 from zero metres (feet) to the selected height (e.g. the temperatures appropriate to 0—10 000 m (0—30,000 ft) in the Standard Temperate Climate are those within the envelope A, B, C, D, in Figure 1;

(b) every point included in these envelopes being associated with a relative humidity range of 20% to 100%; except that in the conditions represented by the area E, F, G in Fig. 1 the relative humidities shall be assumed to vary from 100% maximum and 20% minimum respectively at the line EF to the value appropriate to the height at the line GF. The value of relative humidity on the line GF shall be taken to vary linearly from 100% maximum and 20% minimum at F to some lower values at G (given here as 10% maximum and 2% minimum);

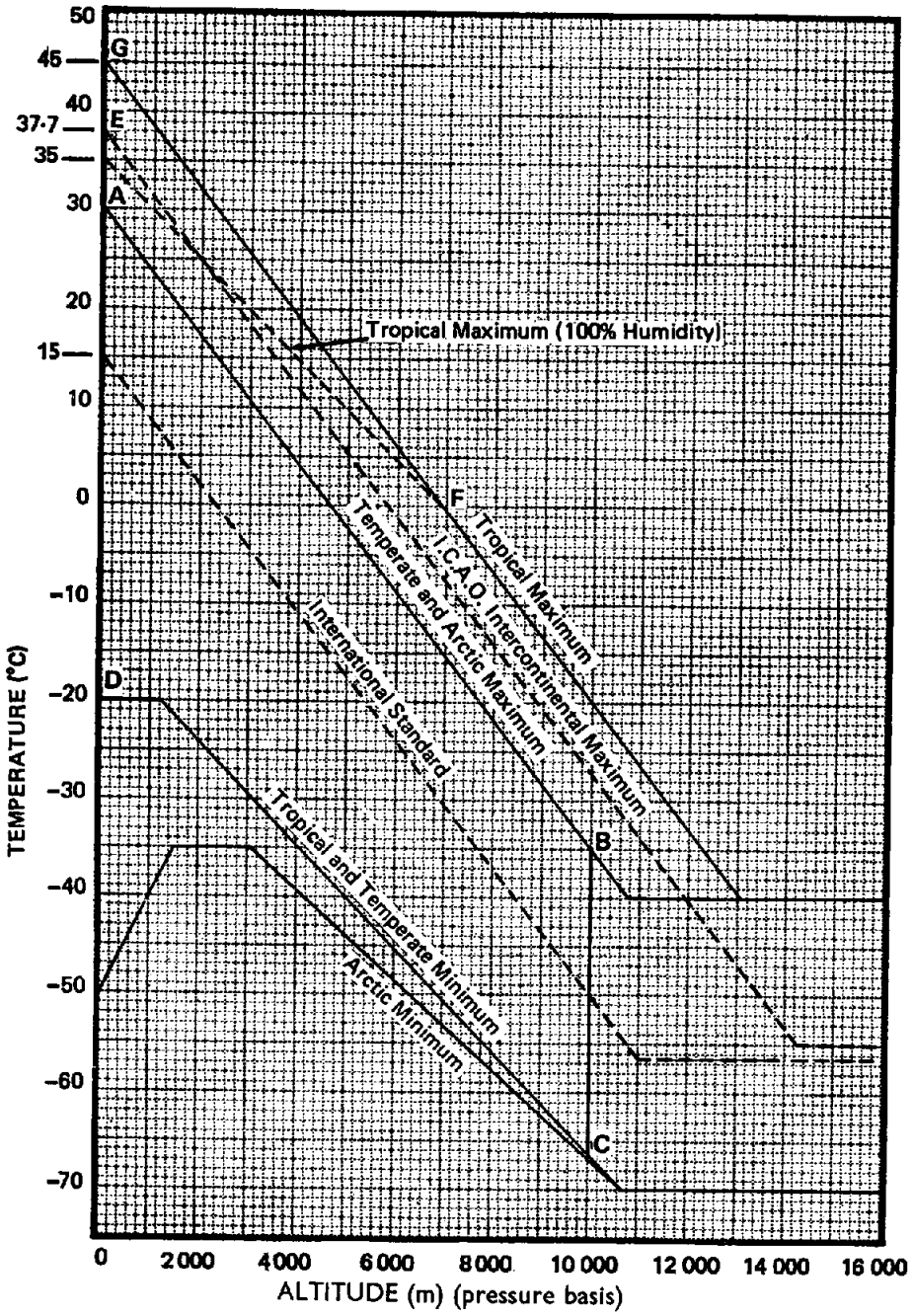
(c) every point included in these envelopes being associated with the International standard pressure (ICAO) appropriate to the height, as shown in Table 1;

(d) every point included in these envelopes being associated with the density corresponding to the temperature, pressure and humidity; extreme values are given in Table 1.

These conditions do not cover variation of pressure from the International standard. This shall be allowed for by assuming a variation of pressure 5% above and below the International standard pressure (ICAO) associated with the International standard temperature (ICAO).

1.5 **Essential Equipment, Services, etc.** A term indicating that the item under consideration is essential to the airworthiness of the rotorcraft or the safety of its occupants.

1.6 **Extended and Retracted.** Except where specifically stated to the contrary, the words 'extended' and 'retracted' when used in connection with such items as landing gear, mean 'fully extended' and 'fully retracted' respectively.

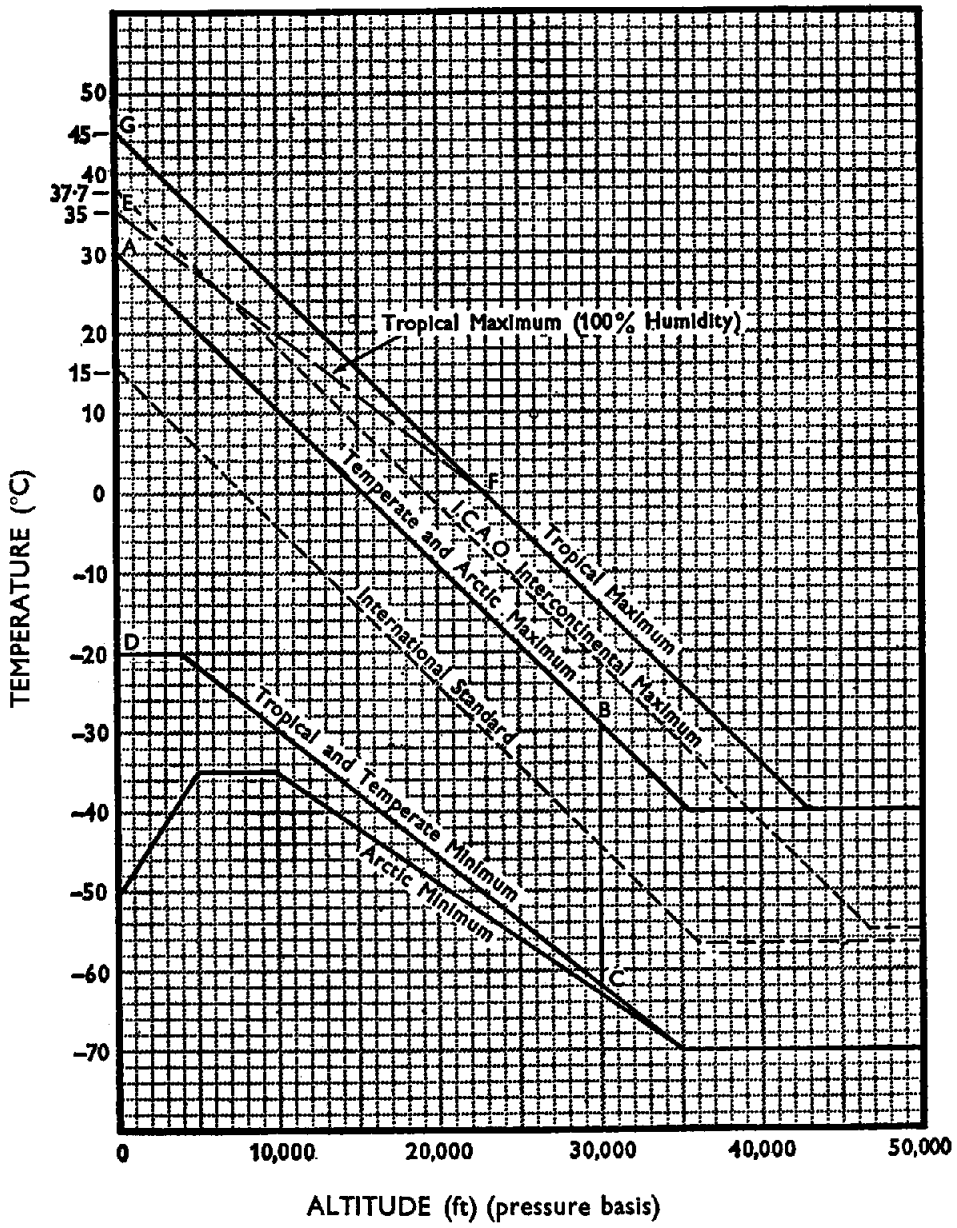


STANDARD CLIMATES—S.I. UNITS

Fig. 1

NOTES: (1) This diagram gives envelope conditions for design purposes; it does not constitute an accurate representation of any particular climate.

(2) The line BC has no significance other than as illustrating the text.



STANDARD CLIMATES—NON S.I. UNITS

Fig. 1

NOTES: (1) This diagram gives envelope conditions for design purposes; it does not constitute an accurate representation of any particular climate.

(2) The line BC has no significance other than as illustrating the text.

TABLE 1

RELATIVE PRESSURES AND DENSITIES—S.I. UNITS

Air density at sea-level (barometer $1{\cdot}013250 \times 10^5$ N/m² temp 15°C) is 1·2250 kg/m³

Altitude (Pressure Basis) m	Relative Pressures (I.C.A.O.)	Relative Densities Associated with Conditions Stated				
		International Standard (I.C.A.O.)	Tropical Maximum	Temperate and Arctic Maximum	Tropical and Temperate Minimum	Arctic Minimum
0	1·000	1·000	0·906	0·951	1·138	1·291
500	0·942	0·953	0·862	0·905	1·072	1·190
1000	0·887	0·907	0·820	0·862	1·010	1·097
1500	0·835	0·864	0·780	0·820	0·955	1·011
2000	0·785	0·822	0·741	0·779	0·908	0·949
2500	0·737	0·781	0·703	0·740	0·862	0·892
3000	0·692	0·742	0·668	0·703	0·818	0·837
3500	0·649	0·705	0·633	0·667	0·776	0·792
4000	0·608	0·669	0·600	0·632	0·735	0·750
4500	0·570	0·634	0·568	0·599	0·696	0·709
5000	0·533	0·601	0·538	0·568	0·659	0·670
5500	0·498	0·569	0·509	0·537	0·623	0·633
6000	0·466	0·539	0·481	0·508	0·589	0·597
6500	0·435	0·509	0·454	0·480	0·556	0·563
7000	0·405	0·481	0·428	0·453	0·525	0·531
7500	0·378	0·454	0·404	0·428	0·495	0·500
8000	0·351	0·429	0·380	0·403	0·466	0·470
8500	0·327	0·404	0·358	0·380	0·439	0·442
9000	0·303	0·381	0·337	0·357	0·412	0·415
9500	0·282	0·358	0·316	0·336	0·388	0·389
10000	0·261	0·337	0·297	0·316	0·364	0·365
10500	0·242	0·317	0·279	0·296	0·341	0·341
11000	0·223	0·297	0·261	0·276	0·317	
11500	0·206	0·275	0·244	0·255	0·293	
12000	0·191	0·254	0·229	0·236	0·271	
12500	0·176	0·235	0·214	0·218	0·250	
13000	0·163	0·217	0·201	0·201	0·231	
13500	0·151	0·200	0·186		0·214	
14000	0·139	0·185	0·172		0·197	
14500	0·129	0·171	0·159		0·182	
15000	0·119	0·158	0·147		0·169	

TABLE 1

RELATIVE PRESSURES AND DENSITIES—NON-S.I. UNITS

Air density at sea-level (barometer 29·92 in (1013·2 mbar) temp 15°C) is 0·002378 slugs/ft³

Altitude (Pressure Basis) ft	Relative Pressures (I.C.A.O.)	Relative Densities Associated with Conditions Stated				
		International Standard (I.C.A.O.)	Tropical Maximum	Temperate and Arctic Maximum	Tropical and Temperate Minimum	Arctic Minimum
0	1·000	1·000	0·906	0·951	1·138	1·291
1,000	0·964	0·971	0·879	0·923	1·098	1·229
2,000	0·930	0·943	0·853	0·896	1·058	1·169
3,000	0·896	0·915	0·827	0·869	1·020	1·112
4,000	0·864	0·888	0·802	0·843	0·983	1·058
5,000	0·832	0·862	0·778	0·818	0·953	1·007
6,000	0·801	0·836	0·754	0·793	0·923	0·970
7,000	0·772	0·811	0·731	0·769	0·895	0·934
8,000	0·743	0·786	0·708	0·745	0·868	0·899
10,000	0·688	0·738	0·664	0·699	0·814	0·832
12,000	0·636	0·693	0·623	0·656	0·763	0·779
14,000	0·587	0·650	0·583	0·615	0·714	0·728
16,000	0·542	0·609	0·545	0·575	0·668	0·680
18,000	0·499	0·570	0·509	0·538	0·624	0·634
20,000	0·460	0·533	0·475	0·502	0·583	0·590
22,000	0·422	0·498	0·443	0·469	0·543	0·550
24,000	0·388	0·464	0·413	0·437	0·504	0·511
26,000	0·355	0·432	0·384	0·407	0·470	0·474
28,000	0·325	0·403	0·357	0·378	0·437	0·440
30,000	0·297	0·374	0·331	0·351	0·405	0·407
32,000	0·271	0·347	0·306	0·326	0·375	0·377
33,000	0·259	0·334	0·295	0·313	0·361	0·362
34,000	0·247	0·322	0·283	0·302	0·347	0·348
35,000	0·235	0·310	0·273	0·290	0·334	
36,000	0·224	0·298	0·262	0·277	0·318	
37,000	0·214	0·284	0·252	0·264	0·303	
38,000	0·204	0·271	0·242	0·252	0·289	
39,000	0·194	0·258	0·232	0·240	0·275	
40,000	0·185	0·246	0·223	0·229	0·263	
41,000	0·176	0·235	0·214	0·218	0·250	
42,000	0·168	0·224	0·206	0·208	0·238	
44,000	0·153	0·203	0·189		0·217	
46,000	0·139	0·185	0·171		0·197	
48,000	0·126	0·168	0·156		0·179	
50,000	0·114	0·152	0·141		0·162	

1.7 **Resistance to Fire**

(a) **Fireproof.** Capable of withstanding for a period of at least 15 minutes the application of heat by the Standard Flame (see (c)).

(b) **Fire-resistant.** As for Fireproof but the period of application to be 5 minutes instead of 15 minutes.

(c) **Standard Flame.** A flame the characteristics of which are similar to those produced by the sources described in BS 3G.100, Part 2, Section 3, Sub-section 3—13.

1.8 **Operating Control.** That part of the control system which is manipulated by a flight-crew member (e.g. a wheel, lever, push button).

1.9 **Flammable/Inflammable.** That which will ignite readily or explode.

1.10 **Emergency Landing/Alighting.** A controlled forced landing/alighting made necessary by an occurrence specified in the Requirements, e.g. partial or total power loss.

NOTE: In a descent following partial power loss the rotorcraft retains lift and control in the normal manner, in a descent following total power loss the rotorcraft is in autorotative flight.

1.11 **Crash Landing.** A landing made with the Rotorcraft out of control.

1.12 **Critical Power-unit.** The Power-unit, the failure of which gives the most adverse effect in the requirement immediately under consideration.

1.13 **Power-unit Failure Point.** For the determination of take-off performance, the point at which sudden complete failure of a Power-unit is assumed to occur.

1.14 **Decision Point.** For the determination of take-off performance, the latest point at which, as a result of Power-unit failure or some other contingency, the pilot is assumed to decide to discontinue a take-off.

NOTE: By distinguishing between Power-unit Failure Point and Decision Point, account is taken of the delay which occurs before a Power-unit failure can be recognised.

1.15 **Rotorcraft.** A heavier-than-air aircraft which derives some or all lift in flight from one or more rotors.

1.16 **Helicopter.** A Rotorcraft which depends principally for its support and motion in flight on power-driven Rotor(s) rotating about substantially vertical axes.

1.17 **Rotor.** A single system of rotating aerofoils.

NOTE: For the purposes of the Requirements the following are also included in the term Rotor: the rotor hub, blade dampers, and those parts of the pitch control mechanisms and the de-icing system which rotate with the aerofoils.

(a) **Main Rotor.** A Rotor, the primary function of which is to provide lift or lift and thrust.

(b) **Auxiliary Rotor.** A Rotor, the primary function of which is to counterbalance the torque reaction of the Main Rotor and/or to change the motion of the helicopter about its vertical axis.

1.18 **Rotor System.** The Rotor(s) and those parts of the Transmission System the continued functioning of which is necessary in maintaining lift and control during autorotation.

1.19 **Abortive Start.** An attempt to start, in which the Engine lights up, but fails to accelerate.

1.20 **False Start.** An attempt to start in which the Engine fails to light up.

2 POWER-PLANT INSTALLATION

2.1 **Power-plant.** A Power-plant is the system of components installed in a Rotorcraft for the purposes of providing power to the Rotor(s) and/or propeller(s).

NOTE: For the purposes of the Requirements the definition includes the Power-unit(s) complete with ancillary parts, the Transmission System where fitted, and any associated protective devices.

2.2 **Power-unit.** A Power-unit is a system of one or more engines and ancillary parts which are together necessary to provide power for lift and/or propulsion independently of continued operation of any other Power-unit.

NOTE: For the purposes of the Requirements the definition excludes separate devices providing power augmentation, and short period lift and thrust producing devices.

2.3 **Transmission System.** The Transmission System consists of all components necessary to transmit power from the engines to the Rotor(s) together with any accessory drive from such components.

NOTE: In the case of a mechanical Transmission System, it includes all gear boxes; clutches; free wheel mechanisms; couplings; shafts and their bearings, together with shafting used for driving, from the transmission, such components as oil cooling fans and Rotorcraft service accessories; cooling fans not included in the bare engine; rotor brakes. In the case of a gaseous Transmission System, it includes the pipes and ducts connecting the Power-unit(s) to the Rotor(s).

3 ROTOR SYSTEMS — SPEED AND TORQUE

3.1 **General**

(a) **Rotor Maximum RPM (Power On).** The maximum rotational speed of the Rotor System permitted* with power applied and approved for use during periods of unrestricted duration.

NOTE: This speed is normally associated with twin engine operation. If different speeds are declared for single engine operation, in association with intermediate or maximum contingency torque, they will be defined accordingly, i.e., Rotor Intermediate Contingency RPM (Power On), and Rotor Maximum Contingency RPM (Power On).

(b) **Rotor Minimum RPM (Power On).** The minimum rotational speed of the Rotor System permitted* with power applied, and approved for use during periods of unrestricted duration.

(c) **Rotor Maximum RPM (Power Off).** The maximum rotational speed of the Rotor System permitted in autorotation and approved for use during periods of unrestricted duration.

(d) **Rotor Minimum RPM (Power Off).** The minimum rotational speed of the Rotor System permitted in autorotation and approved for use during periods of unrestricted duration.

(e) **Rotor Never Exceed RPM.** The maximum rotational speed of the Rotor System which is not to be exceeded in any condition of operation and which is limited in use to a maximum continuous period of 20 seconds. This speed is to be chosen so that it is at least 3% above the maximum rotor speed likely to occur under transient conditions when operating at the speed of (a) or (c).

(f) **Rotor Maximum Continuous Torque.** The maximum torque approved for the Rotor System for use during periods of unrestricted duration.

(g) **Rotor Take-off Torque.** The maximum torque approved for the Rotor system for use during take-off with all engines operating and limited in use to continuous periods of 5 minutes.

(h) **Rotor Maximum Over-Torque.** The maximum torque for the Rotor System that has been determined to have no detrimental effect on the transmission when used for a period of 20 seconds.

NOTES: (1) This torque could occur for example as a result of a defect or mishandling, or as a result of transient changes in normal engine acceleration.

(2) The words 'no detrimental effect' need not include fatigue damage of a cumulative nature.

*In general this will be applicable to flight. However, when a different limiting speed is applicable when the helicopter is on the ground, two speeds will be approved.

3.2 **Single-engined helicopters.** In addition to the general definitions of 3.1 the following apply to single-engined helicopters.

(a) **Rotor Maximum One-hour Torque.** The maximum torque approved for the Rotor System and limited in use to a maximum continuous period of one hour.

3.3 **Multi-engined helicopters.** In addition to the general definitions of 3.1 the following apply to multi-engined helicopters.

(a) **Rotor Maximum Contingency Torque.** The maximum torque approved for the Rotor System for use in the event of the failure of one Power-unit, and limited in use to a maximum continuous period of 2½ minutes. (This torque may be applicable only to certain sections of the Transmission and Rotor System.)

(b) **Rotor Intermediate Contingency Torque.** The maximum torque approved for the Rotor System, for use in the event of the failure of one Power-unit during en-route operation. (This torque may be applicable only to certain sections of the Transmission and Rotor System.)

4 WEIGHTS

4.1 **Maximum Weight.** The maximum weight at which the Rotorcraft is suitable for operation.

4.2 **Minimum Weight.** The minimum weight at which the Rotorcraft is suitable for operation.

4.3 **Design Maximum Weight.** The maximum weight at which compliance is shown with structural loading conditions.

4.4 **Design Minimum Weight.** The minimum weight at which compliance is shown with structural loading conditions.

4.5 **Design Unit Weight.** A unit weight used to show compliance with structural design requirements.

4.6 **Maximum Weight appropriate to the Altitude and Temperature.*** The highest weight, not greater than the Maximum Weight defined in paragraph 4.1, at which the relevant airworthiness climb minima are met. The expressions 'Altitude' and 'Temperature' refer to the assumed pressure altitude and assumed atmospheric temperature for the take-off or landing surface.

NOTES: (1) The weight defined in this paragraph 4.6 will be incorporated in performance information. Correct use of this information will be required by operating rules, when applicable.

(2) In specific operations, rotorcraft weight may be further restricted by considerations such as obstacle clearance.

4.7 **Maximum Landing Weight.** The maximum weight at which landing is normally permitted, by considerations other than available performance.

4.8 **Maximum Take-off Weight.** The maximum weight at which take-off is permitted, by considerations other than available performance.

5 SPEEDS

NOTE: Throughout the Requirements wherever comparative values are prescribed, care will be necessary to ensure that values are corrected to EAS.

5.1 **TAS.** The true speed of the Rotorcraft relative to undisturbed air.

5.2 **EAS.** Equivalent air speed. TAS $(\rho/\rho o)^{1/2}$ or TAS $(\sigma)^{1/2}$.

*See paragraph 29.45(j)(4) for definition of WAT curves.

5.3 **IAS.** Indicated air speed. The readings of the pitot-static air-speed indicator as installed in the Rotorcraft, corrected only for the instrument error.

5.4 **CAS.** Calibrated air speed; the air-speed indicator reading corrected for air-speed indicator system errors. CAS is equal to TAS in the standard atmosphere at sea-level.

5.5 **ASIR.** The uncorrected reading on a specified air-speed indicator.

5.6 **VD.** The Maximum Design Forward Speed, EAS.

5.7 **VDF.** The Maximum Demonstrated Flight Speed, EAS.

5.8 **VH.** The Maximum Speed in Level Flight not exceeding Maximum Continuous Power, EAS.

5.9 **Vmp.** The Speed for Minimum Power, EAS.

5.10 **VNE.** The Never Exceed Speed, IAS.

5.11 **VNO.** The Normal Operating Limit Speed, IAS.

5.12 **VY.** The Speed for best rate of climb (EAS for flight requirements, IAS for operating information).

5.13 **V2 Take-off Safety Speed.** A speed used in the determination of take-off performance (EAS for flight requirements, IAS for operating information). For further details see paragraph 29.59(c).

5.14 **Landing Gear Operating Speed, VLO.** A maximum speed, IAS, at which it is safe to extend or to retract the landing gear.

6 STRUCTURAL

6.1 **Primary Structure.** Those portions of the structure, the failure of which would seriously endanger the Rotorcraft.

(a) **Safe Fatigue Life.** The operational period expressed in terms of number of flying hours, number of flights or number of applications of loads during which the possibility of fatigue failure of the part concerned under the action of the repeated loads of variable magnitude in service is estimated to be Extremely Remote.

(b) **Fail-Safe Structure.** A structure which is so designed that after the failure in operation of a part of the Primary Structure, there is sufficient strength and stiffness in the remaining Primary Structure to permit continued operation of the rotorcraft for a limited period.

NOTE: This period will depend upon the nature of the failure and the facilities provided for inspecting such a failure but in no case will the residual strength be less than that which will enable a flight to be completed at a lower but acceptable level of safety.

6.2 **Limit Load.** The maximum load anticipated in normal conditions of operation.

6.3 **Proof Load.** The proof load is the product of the Limit Load and the Proof Factor of safety.

6.4 **Ultimate Load.** The ultimate load is the product of the Limit Load and the Ultimate Factor of safety.

6.5 **Factors of Safety (for static strength)**

(a) **Proof Factor and Ultimate Factor.** Design factors (proof or ultimate) to provide for the possibility of loads greater than those expected in normal conditons of operation, uncertainties in design and variations of structural strength, including variation of strength resulting from deterioration in service.

6.6 **Load Factor.** The ratio of a prescribed load to the total weight of the Rotorcraft; the prescribed load may be expressed in terms of any of the following — aerodynamic forces, inertia forces or ground reaction.

7 TERMS ASSOCIATED WITH PROBABILITY

7.1 **Occurrences.** An Occurrence is a condition involving a potential lowering of the level of airworthiness.

(a) **Failure.** An Occurrence in which a part, or parts, of the rotorcraft fail or malfunction, e.g. runaway. A Failure includes:—

(i) a single failure,

(ii) independent failures in combination within a system, and

(iii) independent failures in combinations involving more than one system,

taking into account:—

(iv) any undetected failure that is already present,

(v) such further failures as would be reasonably expected to follow the Failure under consideration.

NOTE: In assessing the further failures which follow, account should be taken of any resulting more severe operating conditions for items that have not up to that time failed.

(b) **Event.** An Occurrence which has its origin outside the rotorcraft (e.g. atmospheric gusts).

(c) **Error.** An Occurrence arising as a result of incorrect action by the flight crew or maintenance personnel.

7.2 **Probability of Occurrences**

NOTE: Numerical probabilities quoted in terms of rates per hour of flight may be taken to be the same values per flight where this would be more appropriate.

(a) **Frequent.** Likely to occur often during the operational life of each Rotorcraft of the type.

NOTE: Where numerical values are used this may normally be interpreted as more probable than 10^{-3} per hour of flight.

(b) **Reasonably Probable.** Unlikely to occur often during the operation of each Rotorcraft of the type but which may occur several times during the total operational life of each rotorcraft of the type.

NOTE: Where numerical values are used this may normally be interpreted as less probable than 10^{-3} per hour of flight.

(c) **Probable.** A term embracing the total range of Frequent and Reasonably Probable.

(d) **Remote.** Unlikely to occur to each Rotorcraft during its total operational life, but which may occur several times when considering the total operational life of a number of rotorcraft of the type.

NOTE: Where numerical values are used this may normally be interpreted as less probable than 10^{-5} per hour of flight.

(e) **Very Remote.** Unlikely to occur when considering the total operational life of a number of Rotorcraft of the type, but nevertheless has to be considered as being possible.

NOTE: Where numerical values are used this may normally be interpreted as less probable than 10^{-6} per hour of flight.

(f) **Extremely Remote.** Unlikely to occur when considering the total operational life of a fleet of Rotorcraft of the type, but nevertheless has to be considered as being possible.

NOTE: Where numerical values are used this may normally be interpreted as less probable than 10^{-7} per hour of flight.

(g) **Extremely Improbable.** So unlikely to occur that it does not have to be regarded as possible.

NOTE: Where numerical values are used this may normally be interpreted as less probable than 10^{-9} per hour of flight.

7.3 **Effects.** An Effect is a situation arising as a result of an Occurrence.

(a) **Minor Effect.** An Effect which can be readily counteracted by the flight crew; it may involve:—

(i) small increase in flight-crew workload, or

(ii) moderate degradation in performance or handling characteristics, or

(iii) slight modification of the permissible flight envelope.

(b) **Major Effect.** An Effect which produces:—

(i) significant increase in flight-crew workload, or

(ii) significant degradation in performance or handling characteristics, or

(iii) significant modification of the permissible flight envelope,

but will not remove the capability to continue a safe flight and landing without demanding more than normal skill on the part of the flight crew.

(b) **Hazardous Effect.** An Effect which produces:—

(i) a dangerous increase in flight-crew workload, or

(ii) dangerous degradation of performance or handling characteristics, or

(iii) dangerous degradation of the strength of the rotorcraft, or

(iv) marginal conditions for, or injury to, occupants.

(d) **Catastrophic Effect.** An Effect which results in the loss of the Rotorcraft and/or in fatalities.

8 PERFORMANCE

8.1 Altitude and Height

(a) **Altitude.** When not otherwise qualified, pressure altitude, i.e. the expression of atmospheric pressure in terms of altitude, according to the inter-relation of these factors in the International Standard Atmosphere.

NOTE: This would be obtained by setting the sub-scale of an accurate pressure type altimeter to 1013·2 mbar.

(b) **Height.** The true vertical clearance distance between the lowest part of the rotorcraft and the relevant datum.

8.2 Atmospheric Temperature

(a) **Temperature.** Unless otherwise qualified, the temperature of the free air stream, expressed in °C.

(b) **ISA.** The temperature of the International Standard Atmosphere appropriate to a particular altitude.

(c) **Maximum Temperature.** The maximum atmospheric temperature, appropriate to the altitude, at which all requirements are met.

(d) **Minimum Temperature.** The minimum atmospheric temperature appropriate to the altitude, at which all requirements are met.

8.3 **Atmospheric Humidity**

(a) **Humidity.** Unless otherwise qualified, the moisture content excluding free water, of the free air stream.

NOTE: It may be expressed as a relative humidity or as an absolute humidity.

(b) **Reference Humidity.** The relationship between altitude, temperature and Reference Humidity is defined as follows:—

— at temperatures at and below ISA, 80% relative humidity,

— at temperatures at and above ISA and ISA + 28°C, 34% relative humidity,

— at temperatures between ISA + 28°C, the relative humidity varies linearly between the humidities specified for those temperatures.

9 EXTERNAL LOADS The requirements of section 29.252 apply to rotorcraft/load combinations classified as either Class A or Class B as follows:—

9.1 **Class A.** A Rotorcraft/load combination in which the load may be carried either inside the rotorcraft but with some portion extending outside the fuselage, or wholly externally, and, in both cases where the load:—

(a) cannot be jettisoned by remote control,

(b) cannot normally move relative to the rotorcraft,

(c) does not extend below the landing gear, and

(d) would not touch the ground in any of the landing cases of sections 29.725 and 29.727.

9.2 **Class B.** A Rotorcraft/load combination in which the external load is:—

(a) freely suspended from the Rotorcraft by means of a single attachment point,

(b) lifted clear of the land or water during the operation subsequent to the rotorcraft becoming airborne, and

(c) provided with a means of jettisoning the load by remote control.

10 ENGINE POWER

10.1 **Piston Engines**

(a) **Take-off Power.** The output shaft power for use during take-off, and balked landing and limited in use to a continuous period of not more than 5 minutes.

(b) **Maximum Continuous Power.** The output shaft power for use during periods of unrestricted duration.

NOTE: It should not be assumed that Maximum Continuous Power is necessarily appropriate to normal operations. The power to be used in such operations is a matter between the constructor and the operator.

10.2 **Turbine Engines**

(a) **Take-off Power and/or Thrust.** The power and/or thrust for use during take-off and balked landing, and limited in use to a continuous period of not more than 5 minutes.

(b) **Maximum Continuous Power and/or Thrust.** The power and/or thrust for use during periods of unrestricted duration.

(c) **Intermediate Contingency Power and/or Thrust.** The power and/or thrust for use after take-off when a Power-unit has failed or been shut down, during periods of unrestricted duration.

(d) **Maximum Contingency Power and/or Thrust.** The power and/or thrust for use when a Power-unit has failed or been shut down during take-off, balked landing and limited in use for a continuous period of not more than 2½ minutes.

NOTE: The 2½ minute period for use of Maximum Contingency Power and/or Thrust is additional to the 5 minute or 10 minute period at Take-off Power and/or Thrust (see (c)) and may be added to the take-off limitation at any point in time.

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Subpart A — General

29.1 Applicability

(a) This BCAR 29 prescribes airworthiness standards for the issue of type certificates, and changes to those certificates, for Rotorcraft.

(b) Each person who applies for a certificate or change must show compliance with the applicable requirements of BCAR 29 or with variations therefrom which, taking account of compensating factors, are agreed by the Authority to give at least an equivalent level of safety.

(c) The Authority reserves the right to withhold approval when, in its opinion, a rotorcraft has unsafe characteristics, even though the design complies literally with the text of the requirements.

(d) Rotorcraft must be certificated in accordance with either the Group A or Group B requirements of this BCAR 29. (See section 29.3.) For rotorcraft with a maximum total weight authorised of less than 2730 kg (6000 lb), the extent to which the relevant requirements are applicable will need to be discussed with the Authority. (See ACB 29.1.)

29.2 Definitions and abbreviations

Terms and abbreviations used in BCAR 29 carry the meaning defined in BCAR 29-1.

29.3 Rotorcraft Groups

(a) *Group A.* A Group A Rotorcraft is one for which the probability of occurrence of failures from all causes that would prevent safe flight and landing is Very Remote.

(b) *Group B.* Group B Rotorcraft are all Rotorcraft other than Group A. (See ACB 29.3.)

29.4 Special conditions

Where the airworthiness requirements of BCAR 29 do not contain adequate or appropriate safety standards for a rotorcraft because of design features that are novel or unusual for this class of rotorcraft, special conditions will be specified to establish a level of safety equivalent to that established in the certification process so that such special conditions as are agreed can be taken into account.

29.5 Calculations and tests

(a) Calculations and tests must be to the satisfaction of the Authority. Full details of the methods of calculation, the design criteria employed, and the grounds on which it is claimed that these are reliable, must be available to the Authority for examination. Adequate notice of intention to make tests must be given to the Authority, and whenever the Authority requires to witness the test, suitable facilities must be provided.

(b) All test equipment used must be acceptable to the Authority. All measuring equipment used for the tests must be calibrated periodically to the satisfaction of the Authority.

29.6 Instrument flight

(a) Approval for instrument flight must be dependent on meeting the applicable requirements for instrument flight and those for Group A performance of Subpart B.

(b) The increase in gust velocities for instrument flight must be agreed with the Authority; the gust requirements of section 29.341 are only intended to cover flight in clear air.

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Subpart B — Flight

GENERAL

29.21 Proof of compliance

(a) Each requirement of this Subpart must be met at each appropriate combination of weight and centre of gravity within the range of loading conditions for which certification is requested. This must be shown—

(1) By tests upon a rotorcraft of the type for which certification is requested, or by calculations based on, and equal in accuracy to, the results of testing; and

(2) By systematic investigation of each required combination of weight and centre of gravity, if compliance cannot be reasonably inferred from combinations investigated.

(b) The controllability, stability, and trim of the rotorcraft must be shown for each altitude up to the maximum expected in operation. (See ACB 29.21.)

29.23 Weight disposition and loading intensity

(a) *Weight disposition.* If certain weight and centre of gravity combinations are associated with limits on the disposition of weight which might in practice be exceeded, appropriate limitations must be established which must not exceed:—

(1) The limits selected by the Applicant;

(2) The limits for which compliance with the structural and engineering requirements has been shown;

(3) The limits for which compliance with the applicable flight requirements is shown.

(b) *Loading intensity.* Limitations on the maximum intensity of loading must be established for all flooring likely to be used for the carriage of concentrated loads. These limitations must not exceed:—

(1) The limits selected by the Applicant;

(2) The limits for which compliance with the structural requirements has been shown.

29.25 Weight limits

(a) *Maximum weight.* The maximum weight (the highest weight at which compliance with each applicable requirement of BCAR 29 is shown) or, at the option of the Applicant, the highest weight for each altitude and for each practicably separable operating condition, such as take-off, en-route operation, and landing, must be established so that it is not more than—

(1) The highest weight selected by the Applicant;

(2) The design maximum weight (the highest weight at which compliance with each applicable structural loading condition of BCAR 29 is shown); or

(3) The highest weight at which compliance with each applicable flight requirement of BCAR 29 is shown.

(b) *Minimum weight.* The minimum weight (the lowest weight at which compliance with each applicable requirement of BCAR 29 is shown) must be established so that it is not less than—

(1) The lowest weight selected by the Applicant;

(2) The design minimum weight (the lowest weight at which compliance with each structural loading condition of BCAR 29 is shown); or

(3) The lowest weight at which compliance with each applicable flight requirement of BCAR 29 is shown.

(c) [*Reserved for BCAR 29*]

29.27 Centre of gravity limits

The extreme forward and aft centres of gravity and, where critical, the extreme lateral centres of gravity must be established for each weight established under section 29.25. Such an extreme may not lie beyond—

(a) The extremes selected by the Applicant;

(b) The extremes within which the structure is proven; or

(c) The extremes within which compliance with the applicable flight requirements is shown. (See ACB 29.27.)

29.29 Empty weight and corresponding centre of gravity

(a) The empty weight and corresponding centre of gravity must be determined by weighing the rotorcraft without the crew and payload, but with—

(1) Fixed ballast;

(2) Unusable fuel; and

(3) Full operating fluids, including—

(i) Oil;

(ii) Hydraulic fluid; and

(iii) Other fluids required for normal operation of rotorcraft systems, except water intended for injection in the engines.

(b) The condition of the rotorcraft at the time of determining empty weight must be one that is well defined and can be easily repeated, particularly with respect to the weights of fuel, oil, coolant, and installed equipment. (See ACB 29.29.)

29.31 Removable ballast

[*Deleted in BCAR 29*]

29.33 Main rotor speed and pitch limits

(a) *Main rotor speed limits.* A range of main rotor speeds must be established that—

(1) With power on, provides adequate margin to accommodate the variations in rotor speed occurring in any appropriate manoeuvre, and is consistent with the kind of governor or synchroniser used; and

(2) With power off, allows each appropriate autorotative manoeuvre to be performed throughout the ranges of airspeed and weight for which certification is requested.

(b) *Normal main rotor high pitch limits (power-on).* For rotorcraft, except helicopters required to have a main rotor low speed warning under paragraph (e) of this section, it must be shown with power on and without exceeding approved engine maximum limitations, that main rotor speeds substantially less than the minimum approved main rotor speed will not occur under any sustained flight condition. This must be met by—

(1) [*Deleted in BCAR 29*]

(2) Inherent rotorcraft characteristics that make unsafe low main rotor speeds unlikely; or

29.33(b) (continued)

(3) Adequate means to warn the pilot of unsafe main rotor speeds.

(c) *Normal main rotor low pitch limit (power-off).* It must be shown, with power off, that—

(1) The normal main rotor low pitch limit provides sufficient rotor speed, in any autorotative condition, under the most critical combinations of weight and airspeed: and

(2) It is possible to prevent overspeeding of the rotor without exceptional piloting skill.

(d) [*Deleted in BCAR 29*]

(e) *Main rotor low speed warning for rotorcraft.* For each single-engine rotorcraft and each multi-engine rotorcraft that does not have an approved device that automatically increases power on the operating engines when one engine fails, or has rotor speed decay characteristics such that rapid pilot response is critical there must be a main rotor low speed warning which meets the following requirements (see ACB 29.33(e)):

(1) The warning must be furnished to the pilot in all flight conditions, including power-on and power-off flight, when the speed of a main rotor approaches a value that can jeopardise safe flight.

(2) The warning may be furnished either through the inherent aerodynamic qualities of the rotorcraft or by a device giving an audible warning.

(3) The warning must be clear and distinct under all conditions, and must be clearly distinguishable from all other warnings.

(4) If a warning device is used, the device must automatically de-activate and reset when the low-speed condition is corrected. The device must also be equipped with a means for the pilot to manually silence the audible warning before the low-speed condition is corrected.

(5) If a device is used it must be set to operate at a rotor speed such that when the pilot initiates corrective action in response to the warning, he can regain a safe rotor speed without difficulty.

PERFORMANCE

29.45 General (See ACB 29.45)

(a) The performance prescribed in this subpart must be determined—

(1) With normal piloting skill; and

29.45(a) (continued)

(2) Without exceptionally favourable conditions.

(b) Compliance with the performance requirements of this subpart must be shown—

(1) For still air at sea-level with a standard atmosphere; and

(2) For the range of atmospheric variables selected by the Applicant.

(c) The available power must correspond to engine power, not exceeding the approved power, less—

(1) Installation losses; and

(2) The power absorbed by the accessories and services appropriate to the particular ambient atmospheric conditions and the particular flight condition.

(d) For reciprocating-engine-powered rotorcraft, the performance, as affected by engine power, must be based on a relative humidity of 80% in a standard atmosphere.

(e) For turbine-engine-powered rotorcraft, the performance, as affected by engine power, must be based on relative humidity of—

(1) 80%, at temperatures at and below ISA; and

(2) 34%, at temperatures at and above ISA plus 28°C.

Between these two temperatures, the relative humidity must vary linearly.

(f) [*Reserved for BCAR 29*]

(g) *Use of devices.* If credit is to be taken for the use of such devices as power augmentation, etc. in meeting performance requirements:—

(1) The devices when functioning normally must not be liable in the manner in which they are used, to give inconsistent results in the behaviour of the rotorcraft under operational conditions, and

(2) Suitable allowance must be made for the probability of the devices becoming inoperative. (See ACB 29.45(g).)

(h) *Landing gear.* If credit for ability to retract the landing gear on Group B Rotorcraft is to be taken in meeting performance requirements, it must be possible, irrespective of the failure of the Critical Power-unit to extend the landing gear in not more than 5 seconds, at all speeds up to the speed selected for establishing the en-route gradient of descent, or 1·5 times the speed for the best rate of climb, whichever is the greater. If the landing gear is

29.45(h) (continued)

not power-operated the foregoing requirement must be met without undue exertion or attention from the pilot. If the system is power-operated at least one complete cycle at the maximum permissible rate of operation must be possible after failure of the Critical Power-unit. (See ACB 29.45(h).)

(i) *Fuselage attitude.* Where the fuselage angle of pitch and/or yaw has a significant effect upon the performance, all climb data must be related to the most adverse likely condition.

(j) *Definitions.* For the purposes of the performance prescribed in this subpart, the following definitions apply:—

(1) *Gradient.* For deriving and applying Flight Manual information, gradient is the tangent of the angle of climb expressed as a percentage.

(2) *Gross Performance.* The Gross Performance obtained from measured performance is such that the performance of any rotorcraft of the type, measured at any time, is at least as likely to exceed the Gross Performance as not. (See ACB 29.45(j)(2).)

(3) *Net Performance.* The Gross Performance modified in the manner prescribed in the relevant requirement to make appropriate allowance for those variations from the Gross Performance which are not dealt with in the operational performance rules.

(4) *WAT Curve.* A diagram giving the variation of Maximum Weight as limited by the appropriate airworthiness climb minima with take-off and landing surface altitude and temperature. This term is qualified by the words "Take-off" or "Landing" or "Take-off and Landing " as appropriate.

(k) *Power-unit failure*

(1) Power-unit failure must be assumed to result in complete and immediate loss of power from the affected Power-unit except for that momentarily applied by the inertia of moving parts. No further auxiliary power may be assumed to be supplied from that particular Power-unit.

(2) Where the operation of a power operated service (e.g. retractable landing gear) is directly affected by Power-unit failure, allowance must be made for any unfavourable effect on performance with one or two Power-units inoperative as appropriate. The unfavourable effect must be taken into account for any operation of the service at or following the earliest point at which Power-unit failure is presumed to occur for a particular performance requirement. (See ACB 29.45(k).)

29.51 Take-off data: general

(a) The take-off data required by sections 29.53(b), 29.59, 29.61, 29.63, 29.64 and 29.67(a)(1) and (2) must be determined—

(1) At each weight, altitude, and temperature selected by the Applicant;

(2) With the operating engines within the following limitations:

(i) Up to Maximum Continuous Power for Rotorcraft with piston engines;

(ii) Up to Maximum Continuous Power and/or Thrust for Rotorcraft with one turbine engine;

(iii) For multi-turbine-engined Rotorcraft, up to Maximum Continuous Power and/or Thrust or Maximum Take-off Power and/or Thrust with all Power-units operating. In the event of one or more Power-units failing during the take-off, up to Maximum Contingency Power and/or Thrust may be used; and

(3) With the rotorcraft assumed to follow a straight track.

(b) Take-off data must—

(1) Be determined on a smooth, dry, hard surface;

(2) Be corrected to assume a level take-off surface;

(3) Describe the area necessary for movement on the Take-off Surface, as well as the related airspace;

(4) Include scheduled spaces and areas which must include appropriate allowance for the dimensions of the rotorcraft. A suitable margin acceptable to the Authority must also be included (see ACB 29.51(b)(4)); and

(5) Be scheduled for all wind conditions in which the rotorcraft is permitted to operate. (See ACB 29.51(b).)

(c) No take-off made to determine the data required by this section may require exceptional piloting skill or alertness, or exceptionally favourable conditions.

29.53 Take-off: Group A

(a) *General.* The take-off performance must be determined and scheduled so that, if one engine fails at any time after the start of take-off, the rotorcraft can—

29.53(a) (continued)

(1) Return to, and stop safely on, the Rejected Take-off Area; or

(2) Continue the take-off and climbout, and attain a configuration and airspeed allowing compliance with paragraph 29.67(a)(2). (See ACB 29.53(a).)

(b) *Decision Point.* The Decision Point must be a combination of height time or speed selected by the applicant in establishing the flight paths under section 29.59. The Decision Point must be obtained so as to avoid the critical areas of the height-speed envelope established under section 29.79. (See ACB 29.53(b).)

(c) *Landing gear.* Retraction of the landing gear must not be initiated before either the Decision Point or a height of 50 ft, whichever height is the greater, is reached.

29.59 Take-off path: Group A

(a) The Take-off Space Required and the Rejected Take-off Area must be established so that the take-off, climbout, and rejected take-off are accomplished with a safe, smooth transition between each stage of the manoeuvre. The take-off may be begun in any manner if—

(1) The take-off surface is defined; and

(2) Adequate safeguards are maintained to ensure proper centre of gravity and control positions.

(b) *Rejected Take-off Area.* The Rejected Take-off Area must be established and is that area on the Take-off Surface required to accelerate from the Starting Point with all Power-units operating to the Power-unit Failure Point, to continue to the Decision Point with the Critical Power-unit inoperative, and thereafter to come to a stop from the Decision Point.

(c) *Take-off Space Required.* The Take-off Space Required must be determined using a technique in accordance with paragraph 29.53(a) and must be the greater of the spaces determined by the following sub-paragraphs. The Take-off Space Required must be established in terms of the Decision Point criterion.

(1) The space required, with all Power-units operating, to accelerate from the Starting Point to the Decision Point and thereafter continue either up to the point at which the Take-off Safety Speed, V_2, or a height of 50 ft is reached, whichever height is the greater;

29.59(c) (continued)

(2) The space required to accelerate with all Power-units operating from the Starting Point to the Power-unit Failure Point and thereafter with the Critical Power-unit inoperative to continue to the Decision Point and to continue the take-off, reaching the Take-off Safety Speed, V_2 (which must be not less than the speed at which the take-off minimum climb performance of section 29.67 is met), or a height of 50 ft, whichever is the greater; and

(3) The space involved in the determination of paragraph 29.59(b). (See ACB 29.59(c).)

(d) If the Decision Point is scheduled at a height greater than 35 ft, the flight path between the Decision Point and V_2 must not fall below a height of 35 ft.

29.61 Take-off Climb-out Path: Group A

(a) The Net Take-off Climb-out Path must extend from the appropriate maximum height scheduled at the end of the Take-off Space Required to a height of 1000 ft above the Take-off Surface. The path must be determined as follows (see ACB 29.61(a))—

(1) The effect on performance, if significant, of the power used for the retraction of the landing gear must be established;

(2) It must be assumed that, at the commencement of the path, the landing gear is in the most adverse position relative to the maximum height(s) scheduled in the take-off data;

(3) At not less than the Take-off Safety Speed, V_2, used in meeting the rate of climb requirements of paragraph 29.67(a)(1);

(4) The airspeed and configuration used in meeting the climb requirement of paragraph 29.67(a)(3) must be attained by the end of the Net Take-off Climb-out Path;

(5) *Derivation.* The Net Take-off Climb-out Path must be the Gross Take-off Climb-out with one Power-unit inoperative, diminished by an amount to be agreed with the Authority but which must not be less than that used in determining the en-route net data with one Power-unit inoperative (see paragraph 29.67(a)(4) and ACB 29.61(a)(5)); and

(6) *Significant turn.* The radius of turn, and the reduction in gradient during a defined rate of turn appropriate to the airspeed used in establishing the Net Take-off Climb-out Path must be determined.

29.61 (continued)

(b) The Net Take-off Climb-out Path may not fall below a profile originating at the 50 ft height point at the end of the Take-off Space Required and extending at a gradient of 3% up to a height of 500 ft above the Take-off Surface and thereafter extending at a gradient of 1·5% up to a height of 1000 ft.

29.63 Take-off: Group B

The Take-off Space Required to take-off and climb over a 100-ft obstacle must be established with the landing gear extended and with the most unfavourable centre of gravity. The take-off may be begun in any manner if—

(a) The take-off surface is defined;

(b) Adequate safeguards are maintained to ensure proper centre of gravity and control positions; and

(c) The take-off performance is determined and scheduled such that in the event of the Critical Power-unit becoming inoperative at any point during the take-off within the Take-off Space Required a landing can be made safely. (See ACB 29.63.)

29.64 Take-off path: Group B

The Take-off Climb-out Path must extend from the maximum height scheduled in the take-off data to a height of at least 1000 ft. The path must be determined as detailed below.

(a) The effect on performance, if significant, of the power used for the retraction of the landing gear must be established.

(b) The minimum height from which, in the event of the Critical Power-unit becoming inoperative, extension of the landing gear can be completed before the rotorcraft alights, must be established. The retraction of the landing gear must not be initiated below this height.

(c) The associated air speed(s) selected by the Applicant must be within the range of airspeeds from which a controlled landing may be made in the event of the failure of the Critical Power-unit.

(d) The Take-off Climb-out Path must be the Gross Take-off Climb-out Path with all power-units operating.

29.65 Climb: all engines operating

(a) The steady rate and corresponding gradient of climb must be determined for each Group A and B Rotorcraft—

(1) With Maximum Continuous Power on each Power-unit;

(2) With the landing gear retracted;

(3) For the weights, altitudes, and temperatures for which certification is requested; and

(4) At VY for standard sea-level conditions at maximum weight and at speeds selected by the applicant at or below VNE for other conditions.

(b) [*Reserved for BCAR*]

(c) [*Deleted in BCAR*]

(d) *En Route – All Power-units operating – Group B.* The rate and corresponding gradient of climb at an indicated airspeed not lower than the speed for best rate of climb, with all Power-units operating at Maximum Continuous Power Conditions, must not be less than 200 ft/min and 4% respectively at all altitudes between the altitude of the Take-off Surface and 1000 ft above it.

(e) *Take-off with ground run – Group B.* For a technique which requires the attainment of a specified forward speed on the surface, before unstick, the sum of the acceleration and gradient of climb at each point in the all-Power-units-operating take-off path, must be at least equivalent to a gradient of climb of 8%.

29.67 Climb: one engine inoperative

(a) For Group A Rotorcraft the net rate of climb must be the gross performance diminished by a rate of climb agreed with the Authority, but not less than that of sub-paragraph (4) of this paragraph. For Group A Rotorcraft, the following apply:

(1) The steady net rate of climb without ground effect must be at least 100 ft/min from the end of the Take-off Space Required up to a height of 500 ft above the Take-off Surface for each weight, altitude, and temperature for which take-off data are to be scheduled, with—

(i) The Critical Power-unit inoperative and the remaining Power-units not exceeding Maximum Contingency Power and/or Thrust;

(ii) The most unfavourable centre of gravity for take-off;

(iii) [*Reserved for BCAR 29*]

(iv) The Take-off Safety Speed, V2 (see paragraph 29.53(c)); and

(v) Cowl flaps or other means of controlling the engine-cooling air supply in the position that provides adequate cooling at the temperatures and altitudes for which certification is requested.

(2) The steady net rate of climb must be at least 50 ft/min from a height of 500 ft up to a height of 1000 ft above the Take-off and Landing Surfaces for each weight, altitude, and temperature for which take-off data are to be scheduled, with—

(i) The Critical Power-unit inoperative and the remaining Power-units at Maximum Continuous Power or (for helicopters for which certification for the use of Intermediate Contingency Power is requested), at Intermediate Contingency Power;

(ii) The most unfavourable centre of gravity for take-off;

(iii) The landing gear retracted;

(iv) A speed not less than V2 (see paragraph 29.59(c)(2)); and

(v) Cowl flaps, or other means of controlling the engine-cooling air supply, in the position that provides adequate cooling at the temperature and altitudes for which certification is requested.

(3) The steady en-route net rate and gradient of climb must be not less than 50 ft/min, and 0·5% respectively at all altitudes between the altitude of the Take-off Surface and 1000 ft above it, at which the Rotorcraft is expected to operate and at any weight within the range of weights for which certification is requested, must be determined with—

(i) The Critical Power-unit inoperative, and the remaining Power-units at Maximum Continuous Power and (for helicopters for which certification for the use of Intermediate Contingency Power is requested), at Intermediate Contingency Power;

(ii) The most unfavourable centre of gravity;

(iii) The landing gear retracted;

(iv) The speed not less than that for the best rate of climb; and

29.67(a) (continued)

(v) Cowl flaps or other means of controlling the engine-cooling air supply in the position that provides adequate cooling at the temperatures and altitudes for which certification is requested.

(4) The en-route net gradient of climb with Critical Power-unit inoperative is the gross gradient of climb, diminished by:—

(i) A gradient corresponding to a rate of climb of 100 ft/min, or a gradient of 1% whichever is the greater for Rotorcraft with two Power-units.

(ii) A gradient approved by the Authority for Rotorcraft with more than two Power-units. (See ACB 29.67(a).)

(b) For multi-engine Group B Rotorcraft meeting the requirements for Group A in section 29.79, the steady rate of climb (or descent) must be determined at the speed for best rate of climb (or minimum rate of descent) with one Power-unit inoperative and the remaining Power-units at Maximum Continuous Power and (for helicopters for which certification for the use of Intermediate Contingency Power is requested), at Intermediate Contingency Power. (See ACB 29.67.)

29.71 Rotorcraft angle of glide: Group B

For each Group B Rotorcraft, except multi-engine Rotorcraft meeting the requirements of paragraph 29.67(b) and the powerplant installation requirements of Group A, the steady angle of glide must be determined in autorotation—

(a) At the forward speed for minimum rate of descent as selected by the Applicant;

(b) At the forward speed for best glide angle;

(c) At Maximum Weight; and

(d) At the rotor speed or speeds selected by the Applicant.

29.73 Performance at minimum operating speed

(a) For each Group A and all multi-engined Rotorcraft, the hovering performance must be determined over the ranges of weight, altitude, and temperature for which take-off data are scheduled—

29.73(a) (continued)

(1) With one Critical Power-unit inoperative and the remaining Power-units up to Maximum Contingency Power and/or Thrust;

(2) With not more than Take-off Power on each Power-unit;

(3) With the landing gear extended; and

(4) At a height consistent with the procedure used in establishing the Take-off Space Required and Rejected Take-off Area.

(b) For each Group B Rotorcraft—

(1) The hovering performance must meet the requirements of either subparagraphs (i) or (ii) of this paragraph and must be determined over the ranges of weight, altitude, and temperature for which certification is requested, with Take-off Power on each Power-unit; the landing gear extended; and the Rotorcraft in ground effect at a height consistent with normal take-off procedures;

(i) The rate of climb at zero airspeed in free air must be positive.

(ii) The ability to complete a take-off from the hover in ground effect at a height appropriate to the take-off technique must be demonstrated to the satisfaction of the Authority, and a means of checking the required performance levels must be agreed and included in the Flight Manual as a pre-flight hovering drill.

(2) For a technique which involves vertical flight in free air, the rate of climb at zero airspeed with all Power-units operating must not be less than 100 ft/min.

(c) [*Reserved for BCAR*]

29.75 Landing

(a) *General.* For each rotorcraft—

(1) The corrected landing data must—

(i) Be determined on a smooth, dry, hard surface;

(ii) Assume a level Landing Surface;

(iii) Define the effect of a wet surface where credit is claimed for the use of wheel brakes and where significant forward speeds at touchdown are involved;

(iv) Describe the area necessary for movement on the Landing Surface, as well as the related air space; and

29.75(a) (continued)

(v) Include scheduled spaces and areas which must include appropriate allowance for the dimensions of the Rotorcraft. A suitable margin acceptable to the Authority must also be included.

(2) The approach and landing may not require exceptional piloting skill or exceptionally favourable conditions;

(3) The landing must be made without excessive vertical acceleration or tendency to bounce, nose over, ground loop, or porpoise, and

(4) The landing data required by paragraphs (b) and (c) of this section and by sections 29.77 and 29.78 must be determined—

(i) At each weight, altitude, and temperature selected by the Applicant;

(ii) With each operating Power-unit within the following limitations—

(A) For Rotorcraft with piston engines, up to Maximum Continuous Power.

(B) For Rotorcraft with one turbine engine, up to Maximum Continuous Power and/or Thrust.

(C) For multi-turbine-engined Rotorcraft, up to Maximum Continuous Power and/or Thrust with all Power-units operating. In the event of one or more Power-units failing during, or before the landing up to Maximum Contingency Power and/or Thrust; and

(iii) For all wind conditions in which the Rotorcraft is permitted to operate. (See ACB 29.75.)

(b) *Group A.* For Group A Rotorcraft—

(1) The landing performance must be determined and scheduled so that, if one Power-unit fails at any point in the approach path, the Rotorcraft can either land and stop safely or climb out from a point in the approach path and attain a Rotorcraft configuration and speed allowing compliance with the climb requirement of paragraph 29.67(a)(2);

(2) The approach and landing paths must be established, with one Power-unit inoperative, so that the transition between each stage can be made smoothly and safely;

(3) The approach and landing speeds must be selected by the applicant and must be appropriate to the type of Rotorcraft;

29.75(b) (continued)

(4) The approach and landing path must be established to avoid the critical areas of a height-speed envelope established—

(i) Under section 29.79; or

(ii) For the landing condition with one Power-unit inoperative;

(5) It must be possible to make a safe landing on a prepared Landing Surface after complete power failure occurring during normal cruise;

(6) The Landing Space Required to land and come to a complete stop, from a point 100 ft above the Landing Surface, or the minimum height from which a balked landing can be made, whichever is the higher, must be determined from the approach and landing paths established in accordance with paragraphs (b)(2) through (b)(4) of this section; and

(7) When determining the Landing Space Required with one Power-unit inoperative, it must be assumed to be inoperative throughout and the technique chosen must be such that, in the event of the failure of a second Power-unit, it must be possible to comply with paragraph (a) of this section, and to complete the landing in the space prescribed without hazard to the occupants.

(c) *Group B.* For each Group B Rotorcraft—

(1) The Landing Space Required to land and come to a complete stop from a point 100 ft above the Landing Surface or the minimum height from which, in the event of a Power-unit failure at any point with minimum forward speed, a landing without damage to the rotorcraft or hazard to the occupants can be made, whichever is the higher, must be determined with—

(i) Glide speeds appropriate to the type of Rotorcraft and chosen by the Applicant; and

(ii) The approach and landing made with power off and entered from steady autorotation; and

(2) Each multi-engine Group B Rotorcraft that meets the powerplant installation requirements for Group A must meet the requirements of—

(i) Paragraph (c)(1) of this section; or

(ii) Paragraphs (b)(2) through (b)(6) of this section.

29.77 Balked landing: Group A

For Group A Rotorcraft, the balked landing path must be established so that—

(a) With one Power-unit inoperative, the transition from each stage of the manoeuvre to the next stage can be made smoothly and safely; and

(b) From a combination of height and speed in the approach path selected by the Applicant, a safe climb-out can be made at speeds allowing compliance with the climb requirements of paragraphs 29.61(b) and 29.67(a)(1) and (2).

29.78 Balked landing: Group B

For Group B Rotorcraft, the balked landing path must be established. It must extend from the steady approach conditions with all Power-units operating to the flight conditions at which the appropriate take-off climb minima of paragraphs 29.65(d), (e) and 29.73(b) are met.

29.79 Height-speed envelope

(a) If there is any combination of height and forward speed (including hover) under which a safe landing cannot be made under the applicable power failure condition in paragraph (b) of this section, a height-speed envelope must be established for—

(1) *Group A.* Combinations of weight, pressure altitude, and ambient temperature for which take-off and landing are Approved; and

(2) *Group B*

(i) Altitude, from standard sea-level conditions to the maximum altitude for which take-off and landing are Approved; and

(ii) Weight, from the Maximum Weight (at sea-level) to the highest weight approved for take-off and landing at each altitude. For rotorcraft, this weight need not exceed the highest weight allowing hovering out-of-ground-effect at each altitude.

(b) The applicable power failure conditions are—

(1) For Group A Rotorcraft, sudden failure of the Critical Power-unit with the remaining Power-units at the greatest power for which certification is requested;

(2) For Group B Rotorcraft, complete power failure; and

29.79(b) (continued)

(3) For multi-engine Group B Rotorcraft for which certification under the powerplant installation requirements of Group A is requested, the condition specified in either subparagraph (1) or (2) of this paragraph.

FLIGHT CHARACTERISTICS

29.141 General

The rotorcraft must—

(a) Except as specifically required in the applicable section, meet the requirements of this section and of sections 29.143, 29.161, 29.171 through 29.181 and 29.251 (see ACB 29.141 and Appendix A paragraph A29.3(b)(5))—

(1) *Altitude and temperature.* At the normally expected operating altitudes and temperatures. (See ACB 29.141(a)(1).)

(2) *Loading.* At each weight between and including the Maximum and Minimum Weight and over a range of centre of gravity positions greater than that for which certification is desired (see ACB 29.141(a)(2));

(3) For power-on operations, under any condition of speed, power, and rotor rpm for which certification is requested;

(4) For power-off operations, under any condition of speed and rotor rpm for which certification is requested that is attainable with the controls rigged in accordance with the approved rigging instructions and tolerances; and

(5) *Ground effect.* With the absence of ground effect unless otherwise specified.

(b) Be able to maintain any required flight condition and make a smooth transition from any flight condition to any other flight condition without exceptional piloting skill, alertness, or strength, and without danger of exceeding the limit load factor under any operating condition probable for the type, including—

(1) Sudden failure of one engine, for multi-engine rotorcraft meeting transport Group A engine isolation requirements;

(2) Sudden, complete power failure, for other rotorcraft; and

(3) Sudden, complete control system failures specified in section 29.695.

29.141 (continued)

(c) Have any additional characteristics required for night or instrument operation, if certification for those kinds of operation is requested. Requirements for helicopter instrument flight are contained in Appendix B; and

(d) Exhibit no unsatisfactory handling qualities either during the tests conducted in order to show compliance with the requirements, or in a general qualitative assessment of the handling qualities which must also be carried out.

29.143 Controllability and manoeuvrability

(a) The rotorcraft must be safely controllable and manoeuvrable with sufficient margin of control movement and blade freedom to correct for atmospheric turbulence and to permit reasonable control of the attitude of the rotorcraft with possible combinations of power and collective pitch,

(1) During steady flight;

(2) During any manoeuvre appropriate to the type, including—

(i) Take-off;

(ii) Climb;

(iii) Level flight;

(iv) Turning flight;

(v) Descent (power-on and power-off); and

(vi) Landing (power-on and power-off);

(3) Over an envelope of horizontal velocities exceeding by an agreed amount the envelope of horizontal velocities between which the rotorcraft will be permitted to fly;

(4) During accelerated manoeuvres including steep turns and straight pull-outs;

(5) During changes of forward speed at constant collective pitch settings and during changes between translational flights and hovering;

(6) During all changes of engine power;

(7) During and after changes of collective pitch at the maximum appropriate rate in all significant flight conditions. (See ACB 29.143(a).)

(b) The margin of cyclic control must allow satisfactory roll and pitch control at VNE with—

(1) Critical weight;

(2) Critical centre of gravity;

(3) Critical rotor rpm; and

(4) Power off and power on.

29.143 (continued)

(c) A wind velocity of not less than 17 knots must be established in which the rotorcraft can be operated without loss of control on or near the ground in any manner appropriate to the type (such as crosswind take-offs, sideward flight, and rearward flight), with—

(1) Critical centre of gravity; and

(2) Critical rotor rpm.

(d) The rotorcraft, after (1) failure of one engine, in the case of multi-engine rotorcraft that meet transport Group A engine isolation requirements or (2) complete power failure in the case of other rotorcraft, must be controllable over the range of speeds and altitudes for which certification is requested when such Power-unit failures occur with Maximum Continuous Power and critical weight. A technique must be established for landing the rotorcraft following loss of power without hazard to the occupants. (See ACB 29.143(d).)

(e) [*Deleted in BCAR 29*]

(f) Control forces must not be excessive and there may not be any undesirable discontinuities in control force gradients.

29.161 Trim control

(a) Both in normal operations, and in those conditions associated with Power-unit failure for which performance characteristics are to be scheduled, it must be possible to trim the rotorcraft in such conditions of loading, speed and power as will ensure that the pilot will not be unduly fatigued or distracted by the effort which would otherwise be required for safe handling of the rotorcraft. (See ACB 29.161(a).)

(b) [*Deleted in BCAR 29*]
(See paragraph 29.143(f).)

29.171 Stability: general

(a) The rotorcraft must be able to be flown, without undue pilot fatigue or strain, in any normal manoeuvre for a period of time as long as that expected in normal operation. At least three landings and take-offs must be made during this demonstration.

(b) *Stability in turns.* There must be no serious tendency for the rotorcraft to tighten up in the turn of its own accord during a turn at normal accelerations up to 1·5 g at all engine powers.

29.171 (continued)

(c) *Stability with all controls free.* The rotorcraft under smooth air conditions must exhibit no dangerous behaviour if, in straight steady trimmed level flight at any speed between the speed for best rate of climb and VNO, all controls are abandoned for a period of 5 seconds.

(d) *Control balance.* There must be no noticeable overbalance of the yawing, rolling and pitching controls. (See Appendix B and ACB 29.171.)

29.173 Static longitudinal stability

(a) The longitudinal cyclic control must be designed so that, with the throttle and collective pitch held constant, a rearward movement of the control is necessary to obtain a speed less than the trim speed, and a forward movement of the control is necessary to obtain a speed more than the trim speed—

(1) For power-on operations over the full range of altitude and rotor rpm for which certification is requested; and

(2) For power-off operations, over the range of altitude and rotor rpm for which certification is requested that is attainable with the controls rigged in accordance with the Approved rigging instructions and tolerances.

(b) [*Deleted in BCAR 29*]

29.175 Demonstration of static longitudinal stability

[*Deleted in BCAR 29*]

29.181 Dynamic stability

There may be no short period oscillation of the rotorcraft, and no unsafe short period oscillation of any rotor blades which is not heavily damped under any permissible flight condition, both with controls fixed and controls free.

GROUND HANDLING CHARACTERISTICS

29.231 General

(a) The rotorcraft must have satisfactory ground handling characteristics including freedom from uncontrollable tendencies in any condition expected in operation.

(b) *Towing.* All recommended towing techniques must be demonstrated to be safe in conditions typical of the most adverse likely to be encountered.

29.235 Taxying condition

(a) The rotorcraft must be safely controllable and manoeuvrable when it is taxied over the roughest ground that may reasonably be expected in normal operation.

(b) *Limitations.* The ground speed, if applicable, up to which it is safe to taxy must be determined.

(c) *Ground speed limitions at take-off and touch-down.* A horizontal ground speed up to which it is safe to take off and touch-down must be demonstrated.

29.237 Wind velocities

(a) A wind speed up to which it is safe to accelerate the rotor(s) from the stationary condition up to normal operating speed must be established.

(b) A wind speed up to which it is safe to taxy in any direction must be determined.

29.239 Spray characteristics

[*Deleted in BCAR 29*]

29.241 Excessive oscillation

The rotorcraft may have no excessive oscillation (including ground resonance) which is not readily controllable under all permissible ground operating conditions.

MISCELLANEOUS FLIGHT REQUIREMENTS

29.251 Vibration

Each part of the rotorcraft must be free from flutter and excessive vibration and from buffeting of such severity as to interfere with control of the rotorcraft, or to cause structural damage to the rotorcraft or excessive fatigue to the crew. This requirement must be met whether the primary flight controls are moved or not, in all conditions specified in paragraph 29.143(a).

29.252 External load operation: flight characteristics requirements

(a) The Applicant must demonstrate to the Authority, by performing the flight tests prescribed in paragraphs (b), and (c) of this section, as applicable, that the representative rotorcraft-load combinations have satisfactory flight characteristics. For the purposes of this demonstration, the external-load weight (including the external-load attaching means) is the Maximum Weight for which authorisation is requested.

(b) *Class A rotorcraft-load combinations.* The flight test must consist of at least the following manoeuvres:

(1) Take-off and landing.

(2) Demonstration of adequate directional control while hovering.

(3) Acceleration from a hover.

(4) Horizontal flight including gentle turns at an air speed at least 10% or 5 knots, whichever is the greater, above the maximum airspeed for which certification is sought. This certification speed must be such that it is not necessary to exceed the Normal Operating Speed, VNO.

(c) *Class B rotorcraft-load combinations.* The flight test must consist of at least the following manoeuvres:

(1) Pickup of the external load.

(2) Demonstration of adequate directional control while hovering.

(3) Acceleration from a hover.

(4) Horizontal flight including gentle turns at an air speed at least 10% or 5 knots, whichever is the greater, above the maximum airspeed for which certification is sought. This certification speed must be such that it is not necessary to exceed the Normal Operating Speed, VNO.

29.251 (continued)

(5) Demonstration of winch operation, if a winch is installed to hoist the external load.

(6) Manoeuvring of the external load into release position and its release, under probable flight operation conditions, by means of each of the quick-release controls installed on the rotorcraft.

(7) The ability to jettison representative loads up to the maximum weight by means of the devices required by paragraph 29.865(b) must be demonstrated in flight.

(d) The external load attaching means must be such that oscillatory movements of a Class B load do not transmit excessive motion to the airframe. (See BCAR 29—1, paragraph 9 and ACB 29.252.)

Subpart C — Structure

GENERAL

29.301 Loads

(a) Strength requirements are specified in terms of limit loads (the maximum loads to be expected in service) and ultimate loads (limit loads multiplied by prescribed ultimate factors of safety). Unless otherwise provided, prescribed loads are limit loads.

(b) Unless otherwise provided, the specified air, ground, and water loads must be placed in equilibrium with inertia forces, considering each item of mass in the rotorcraft. These loads must be distributed to closely approximate or conservatively represent actual conditions.

(c) If deflections under load would significantly change the distribution of external or internal loads, this redistribution must be take into account.

(d) *Weight and weight distribution.* Unless otherwise stated, each structural requirement must be complied with:

(1) At all practicable weights from the Design Minimum Weight to the Design Maximum Weight;

(2) When the centre of gravity of the rotorcraft is in the most adverse position, within the operating limitations for which certification is sought;

(3) When the weight is distributed in the most adverse manner, within the oeprating limitations for which certification is sought.

(e) Structural design loads must be calculated for the likely ranges of fuel and oil densities that are anticipated in service. (See ACB 29.301(e).)

29.303 Factor of safety (strength)

Unless otherwise provided, proof and ultimate factors must not be less than 1·0 and 1·5 respectively, except that Rotor Blades must have a proof factor of at least 1·2. These factors apply to external and inertia loads unless its application to the resulting internal stresses is more conservative. (See ACB 29.303.)

29.305 Strength and deformation

(a) The structure must be able to support limit loads without detrimental or permanent deformation. In making tests to establish compliance with proof load conditions, the Proof Load must be supported until static equilibrium is reached. At any load up to Proof Load the deformation may not interfere with safe operation.

(b) The structure must be able to support ultimate loads without failure. This must be shown by—

(1) Applying ultimate loads to the structure in a static test for at least 3 seconds; or

(2) Dynamic tests simulating actual load application.

(c) Where structural flexibility is such that any rate of load application likely to occur in the operating conditions might produce transient stresses appreciably higher than those corresponding to static loads, the effects of this rate of application must be considered.

29.307 Proof of structure

(a) Compliance with the strength and deformation requirements of this Subpart must be shown for each critical loading condition for the primary structure as a whole (including rotor, landing gear, etc.), by a combination of structural analysis and/or substantiating strength tests. Structural analysis (static or fatigue) may be used alone if the structure conforms to those for which experience has shown this method to be reliable. In other cases, substantiating load tests must be made. (See ACB 29.307(a).)

(b) Proof of compliance with the strength requirements of this Subpart must include—

(1) Dynamic and endurance tests of rotors, transmission, and rotor controls;

(2) Limit load tests of the control system, including control surfaces;

(3) Operation tests of the control system;

(4) Flight stress measurement tests;

(5) Landing gear drop tests; and

(6) Any additional tests required for new or unusual design features.

29.307 (continued)

(c) *Correction of test results.* Results obtained from strength tests must be corrected for departures from the mechanical properties and dimensions assumed in the design calculations. (See ACB 29.307(c).)

29.309 Design limitations

The following flight envelope values and limitations must be established to show compliance with the structural requirements of this Subpart:

(a) The Design Maximum and Design Minimum Weights.

(b) The main rotor rpm ranges, power on and power off.

(c) The maximum forward speeds for each main rotor rpm within the ranges determined under paragraph (b) of this section.

(d) The maximum rearward and sideward flight speeds.

(e) The centre of gravity limits corresponding to the limitations determined under paragraphs (b), (c), and (d) of this section.

(f) The rotational speed ratios between each powerplant and each connected rotating component.

(g) The positive and negative limit manoeuvring load factors. (See ACB 29.309.)

FLIGHT LOADS

29.321 General

(a) The flight load factor must be assumed to act normal to the longitudinal axis of the rotorcraft, and to be equal in magnitude and opposite in direction to the rotorcraft inertia load factor at the centre of gravity.

(b) Compliance with the flight load requirements of this Subpart must be shown—

(1) At each weight from the Design Minimum Weight to the Design Maximum Weight,

(2) With any practical distribution of disposable load within the operating limitations in the rotorcraft Flight Manual; and

(3) With a sufficient number of points on the envelope investigated to ensure that the critical load for each component of the structure has been obtained.

29.337 Limit manoeuvring load factor

The rotorcraft must be designed for—

(a) A positive limit manoeuvring load factor of 3·0 and a negative limit manoeuvring load factor of 0·5 at all forward speeds from zero to Maximum Demonstrated Flight Speed, V_{DF}; or

(b) Any lesser positive limit manoeuvring load factor not less than 2·0, for which—

(1) The probability of being exceeded is shown by analysis and flight tests to be extremely remote; and

(2) The selected values are appropriate to each weight condition between the Design Maximum and Design Minimum Weights.

29.339 Resultant limit manoeuvring loads

(a) The loads resulting from the application of limit manoeuvring load factors are assumed to act at the centre of each Rotor hub and at each auxiliary lifting surface, and to act in directions and with distributions of load among the rotors and auxiliary lifting surfaces, so as to represent each critical manoeuvring condition,

(b) The rotorcraft must withstand the maximum loads which arise from the most severe movements of the controls which it is anticipated will occur during operational flight including the emergency conditions after engine failure. The most adverse combinations of flight speed, rotor rotational speed and control movements must be included.

29.341 Gust loads

(a) The rotorcraft must be able to withstand the loads resulting from encounters with sharp-edged gusts. (See ACB 29.341(a).)

(b) The following assumptions must be made:—

(1) that the rotorcraft is flying in a trimmed unaccelerated flight condition corresponding to any point on, or within the design flight envelope,

(2) that in the conditions of subparagraph (1) of this paragraph, the rotorcraft encounters a gust of velocity 35 ft/sec from any direction, upwards, downwards, sideways, or intermediate,

(3) that the induced loads on the rotorcraft due to the gust are balanced by inertia forces on the whole rotorcraft,

29.341(b) (continued)

(4) that during the application of the gust there is no change in the trimmed condition of the rotorcraft.

(c) The gust requirements of sub-paragraph (b)(2) of this section are only intended to cover flight in clear air. The increase in gust velocities for instrument flight conditions must be agreed with the Authority.

(d) *Gust gradient distance.* For individual blade stressing it must be assumed that a vertical gust intensity of 50 ft/sec increases linearly from zero to the maximum value while the rotorcraft travels a distance of 100 ft. For design purposes the worst combination of rotor speed and forward speed must be considered, in conjunction with this gust gradient.

29.351 Yawing conditions

(a) Each rotorcraft must be designed for the loads resulting from the manoeuvre specified in paragraph (b) of this section, with—

(1) Unbalanced aerodynamic moments about the centre of gravity reacted in a rational or conservative manner considering the principal masses furnishing the reacting inertia forces;

(2) Rotor Maximum RPM (Power On);

(3) All forward speeds between a speed equal to the maximum sideways flight speed established under paragraph 29.143(c), and V_{NE} or V_H whichever is the less.

(b) In unaccelerated flight with zero yaw, it is assumed that—

(1) The cockpit directional control is suddenly displaced to the maximum deflection limited by the control stops or by maximum pilot effort;

(2) The rotorcraft then yaws to a resulting sideslip angle; and

(3) The directional control is then suddenly returned to neutral.

29.352 Sideward flight conditions

(a) Under the conditions of trimmed unaccelerated flight at all flight speeds the lower sideways velocity defined by subparagraphs (1) and (2) of this paragraph must be superimposed:—

(1) The rotorcraft is considered to be flying at the maximum sideways velocity in either direction for which it can be trimmed;

29.352(a) (continued)

(2) A sideways velocity of 50 ft/sec in either direction.

(b) Both the power-on and power-off states must be considered.

29.361 Engine and transmission system torque loads

The whole structure and in particular the structural components not covered by engine and transmission type tests must have an ultimate factor of 1·5 under the combination of paragraphs (a) and (b) below:—

(a) (1) For turbine engine installations—

(i) [*Reserved for BCAR 29*]

(ii) the limit engine torque is obtained by multiplying the mean torque by a factor of 1·25; and

(2) For reciprocating engines, the mean torque multiplied by—

(i) 1·5, for engines with five or more cylinders; and

(ii) 2·0, 3·0, and 4·0, for engines with four, three, and two cylinders, respectively. (See ACB 29.361.)

(b) Loads due to acceleration in flight.

29.362 Starting torque loads (See paragraph 29.547(e))

(a) The rotor head system and in particular the rotor blades must have an Ultimate Factor of 1·5 when the maximum starting torque is applied.

(b) The design value of the starting torque used must be the maximum which can be applied under the system provided and at the rate at which it can be applied by the system.

(c) On prototype rotorcraft, starting tests must be carried out to check the resulting stresses in the blades.

CONTROL SURFACE AND SYSTEM LOADS

29.391 General

Each auxiliary Rotor, each fixed or movable stabilising or control surface, and each system operating any flight control must meet the requirements of sections 29.395 through 29.399, and 29.411.

29.395 Control system

(a) The reaction to the loads prescribed in section 29.397 must be provided by—

(1) The control stops only;

(2) The control locks only;

(3) The irreversible mechanism only (with the mechanism locked and with the control surface in the critical positions for the effective parts of the system within its limit of motion);

(4) The attachment of the control system to the rotor blade pitch control horn only (with the control in the critical positions for the affected parts of the system within the limits of its motion); and

(5) The attachment of the control system to the control surface horn (with the control in the critical positions for the affected parts of the system within the limits of its motion).

(b) *Primary flight control systems.* Each primary flight control system, including its supporting structure, must be designed to withstand the loads resulting from the limit pilot forces prescribed in section 29.397, or the maximum loads that can be obtained in normal operation, including any failure of the power source of the system whichever are greater. Where the system design or the normal operating loads are such that a part of the system cannot react the pilot-applied forces prescribed in section 29.397, that part of the system must be designed to withstand the maximum loads that can be obtained in normal operation. The minimum design loads must, in any case, provide a rugged system for service use, including consideration of fatigue, jamming, ground gusts, control inertia, and friction loads. In the absence of a rational analysis, the design loads resulting from 0·60 of the specified pilot-applied forces are acceptable minimum design loads. (See ACB 29.395(b).)

(c) *Other control systems.* For systems other than primary flight control systems the following apply:—

(1) Each system must have the factors of safety of section 29.303 under the maximum loads likely to be experienced under all expected operating conditions; and

(2) Where a power-assisted control system is installed, the system must have the factors of safety of section 29.303 under the manually applied loads which are likely to occur in the event of failure of the power source of the system.

29.395 (continued)

(d) *Control chains and cables.* Control chains and cables must achieve the following when subjected to the maximum (unfactored) design loads:—

(1) Control chains — An ultimate factor of 3·0.

(2) Control cables — An ultimate factor of 2·0.

(e) Where the simultaneous application of loads in more than one system (e.g. cyclic and collective pitch systems) could result in critical loads, the system must have the factor of safety of section 29.303 under combination loads of 50% of the magnitude of the loads in paragraph (a) of this section acting together.

29.397 Limit pilot forces and torques

(a) The limit pilot forces are as follows:

(1) For foot controls, 580 N (130 lbf).

(2) For stick controls, 450 N (100 lbf) fore and aft, and 300 N (67 lbf) laterally.

(b) [*Deleted in BCAR 29*]

(c) Where a power-assisted control system, the failure of which would necessitate the use of high manual forces, is installed, consideration must also be given to the case of the pilots acting together. The loads assumed to be applied individually must be 0·75 times the loads of paragraph (a) of this section or 1·0 times the loads of 29.395(b) whichever are the greater.

29.398 Powered flight controls, automatic pilot and stability augmentation systems

(a) Power-operated and power-assisted primary flight control systems must comply with the strength requirements of section 29.391 as far as they are applicable. In addition, power-operated systems must have the factors of safety prescribed in section 29.303 under the maximum load which can be developed in the systems under all expected operating conditions (e.g. the loads corresponding to automatic-pilot effort if they alone can produce higher loads than the human pilot).

29.398 (continued)

(b) System servo-motors, their mountings and their connections to the flying control must have Proof and Ultimate Factors of not less than 1·0 and 1·5 respectively, with the maximum loads including the loads arising from fault conditions, which could be imposed by the automatic system or from the flying control system (up to its design load), whichever is the greater. (See ACB 29.398(b).)

29.399 Dual control system

Each dual primary flight control system must be able to withstand the loads that result when pilot forces not less than 0·75 times those obtained under section 29.395 are applied—

(a) In opposition; and

(b) In the same direction.

29.401 Auxiliary rotor assemblies

[*Deleted in BCAR 29*]

29.403 Auxiliary rotor attachment structure

[*Deleted in BCAR 29*]

29.411 Ground clearance: tailguards

(a) It must be impossible for main structural components (e.g. tail rotor, tail surfaces) to contact the landing surface during a normal landing.

(b) If a tailguard is required to show compliance with paragraph (a) of this section—

(1) Suitable design loads must be established for the guard; and

(2) The guard and its supporting structure must be designed to withstand those loads.

29.413 Stabilising and control surfaces

[*Deleted in BCAR 29*]

GROUND LOADS

29.471 General

(a) *Loads and equilibrium.* For limit ground loads—

(1) [*Deleted in BCAR 29*]

29.471(a) (continued)

(2) In each specified landing condition, the external loads must be placed in equilibrium with linear and angular inertia loads in a rational or conservative manner.

(b) *Critical centres of gravity.* The critical centres of gravity within the range for which certification is requested must be selected so that the maximum design loads are obtained in each landing gear element.

29.473 Ground loading conditions and assumptions

(a) For specified landing conditions, all weights up to a Design Maximum Landing Weight must be investigated. A rotor lift may be assumed to act through the centre of gravity throughout the landing impact. This lift may not exceed two-thirds of the aircraft weight.

(b) Unless otherwise prescribed, for each specified landing condition, the rotorcraft must be designed for a limit load factor of not less than the limit inertia load factor substantiated under section 29.725.

(c) [*Deleted in BCAR 29*]

29.475 Tyres and shock absorbers

Unless otherwise prescribed, for each specified landing condition, the tyres must be assumed to be in their static position and the shock absorbers to be in their most adverse likely position.

29.477 Landing gear arrangement

Sections 29.235, 29.479 through 29.485, and 29.493 apply to landing gear with two wheels aft, and one or more wheels forward, of the centre of gravity.

29.479 Level landing conditions

(a) *Attitudes.* Under each of the loading conditions prescribed in paragraph (b) of this section, the rotorcraft is assumed to be in each of the following level landing attitudes:

(1) An attitude in which each wheel contacts the ground simultaneously.

(2) An attitude in which the aft wheels contact the ground with the forward wheels just clear of the ground.

29.479 (continued)

(b) *Loading conditions.* The rotorcraft must be designed for the following landing loading conditions:

(1) Vertical loads applied under section 29.471.

(2) The loads resulting from a combination of the loads applied under subparagraph (1) of this paragraph with drag loads varying from 0 to 0·25 times the vertical load of subparagraph (1) of this paragraph on each of the units applied at the hub.

(3) The vertical load at the instant of peak drag load combined with a drag component simulating the forces required to accelerate the wheel rolling assembly up to the specified ground speed, with—

(i) The ground speed for determination of the spin-up loads being at least 75 % of the optimum forward flight speed for minimum rate of descent in autorotation; and

(ii) The loading conditions of this subparagraph applied to the landing gear and its attaching structure only.

(4) If there are two wheels forward, a distribution of the loads applied to those wheels under subparagraphs (1) and (2) of this paragraph in a ratio of 40 : 60.

(c) *Pitching moments.* Pitching moments are assumed to be resisted by—

(1) In the case of the attitude in paragraph (a)(1) of this section, the forward landing gear; and

(2) In the case of the attitude in paragraph (a)(2) of this section, the angular inertia forces.

29.481 Tail-down landing conditions

(a) The rotorcraft is assumed to be in the maximum nose-up attitude allowing ground clearance by each part of the rotorcraft.

(b) In this attitude, ground loads are assumed to act perpendicular to the ground.

29.483 One-wheel landing conditions

For the one-wheel landing condition, the rotorcraft is assumed to be in the level attitude and to contact the ground on one aft wheel. In this attitude—

29.483 (continued)

(a) The vertical load must be the same as that obtained on that side under paragraph 29.479(b)(1); and

(b) The unbalanced external loads must be reacted by rotorcraft inertia.

29.485 Lateral drift landing conditions

(a) In each of the attitudes prescribed in paragraph 29.479(a) and section 29.481, the rotorcraft structure must be able to withstand the following loads applied simultaneously:—

(1) A vertical load equal to 50% of the ground reaction obtained in the appropriate landing condition; and

(2) A drag load varying from 0 to 50% of the vertical load of subparagraph (1) of this paragraph on each of the units applied at the hub; and

(3) A side load applied at the ground varying between 0 to 80% of the vertical load of subparagraph (1) of this paragraph on one main unit acting inwards and 60% of the same vertical load on the other main unit acting outwards.

(4) For the attitude of paragraph 29.479(a)(1) a vertical load on the nosewheel equal to 50% of the ground reaction obtained in the appropriate level landing condition combined with a side load applied at the ground varying from 0 to 80% of this vertical load.

(b) For fully castoring wheels, the side loads may be applied at the centre of the axle.

29.493 Braked roll conditions

Under braked roll conditions with the shock absorbers in their static positions—

(a) The limit vertical load must be based on a load factor of at least—

(1) 1·33 times the vertical load on the aft wheels with the rotorcraft in the most critical attitude at the Maximum Design Weight;

(2) 1·0, for the attitude specified in paragraph 29.479(a)(2); and

(b) The structure must be designed to withstand, at the ground contact point of each wheel with brakes, a drag load acting both backwards and forwards of at least the lesser of—

(1) The vertical load multiplied by a coefficient of friction of 0·8; and

(2) The maximum value based on limiting brake torque.

29.497 Ground loading conditions: landing gear with tail wheels

(a) *General.* Rotorcraft with landing gear with two wheels forward and one wheel aft of the centre of gravity must be designed for loading conditions as prescribed in this section.

(b) *Level landing attitude with only the forward wheels contacting the ground.* In this attitude—

(1) The vertical loads must be applied under sections 29.471 through 29.475 and comply with section 29.725;

(2) The vertical load at each axle must be combined with a drag load at that axle varying from 0 to 0·25 of that vertical load; and

(3) Unbalanced pitching moments are assumed to be resisted by angular intertia forces.

(c) *Level landing attitude with all wheels contacting the ground simultaneously.* In this attitude, the rotorcraft must be designed for landing loading conditions as prescribed in paragraph (b) of this section.

(d) *Maximum nose-up attitude with only the rear wheel contacting the ground.* The attitude for this condition must be the maximum nose-up attitude expected in normal operation, including autorotative landings. In this attitude—

(1) The appropriate ground loads specified in paragraph (b)(1) and (2) of this section must be determined and applied, using a rational method to account for the moment arm between the rear wheel ground reaction and the rotorcraft centre of gravity; or

(2) The probability of landing with initial contact on the rear wheel must be shown to be extremely remote.

(e) *Level landing attitude with only one forward wheel contacting the ground.* In this attitude, the rotorcraft must be designed for ground loads as specified in paragraph (b) of this section.

(f) *Lateral drift landing conditions.* In each of the attitudes prescribed in paragraphs (b) and (c) of this section the rotorcraft structure must be able to withstand the following loads applied simultaneously:—

(1) A vertical load on the forward wheels equal to 50% of the ground reaction obtained in the appropriate landing condition; and

(2) A drag load on the forward wheels varying from 0 to 50% of the vertical load of subparagraph (1) of this paragraph on each of the units applied at the hub; and

29.497(f) (continued)

(3) A side load applied at the ground varying between 0 to 80% of the vertical load of subparagraph (1) of this paragraph on one main unit acting inwards and 60% of the same vertical load on the other main unit acting outwards.

(4) For the attitude of paragraph (c) of this section, a vertical load on the tailwheel equal to 50% of the ground reaction obtained in the appropriate level landing condition combined with a side load applied at the ground varying from 0 to 80% of this vertical load.

(5) For a full swivelling landing gear, without a lock, steering device, or shimmy damper the side loads may be applied at the centre of the axle.

(g) *Braked roll conditions in the level landing attitude.* In the attitudes specified in paragraphs (b) and (c) of this section, and with the shock absorbers in their static positions, the rotorcraft must be designed for braked roll loads as follows:

(1) The limit vertical load must be based on a limit vertical load factor of not less than—

(i) 1·0, for the attitude specified in paragraph (b) of this section; and

(ii) 1·33 times the vertical load on the forward wheel with the rotorcraft in the most critical attitude at the Maximum Design Weight.

(2) For each wheel with brakes, a drag load acting both backwards and forwards must be applied, at the ground contact point, of not less than the lesser of—

(i) 0·8 times the vertical load; and

(ii) The maximum based on limiting brake torque.

(h) *Rear wheel turning loads in the static ground attitude.* In the static ground attitude, and with the shock absorbers and tyres in their static positions, the rotorcraft must be designed for rear wheel turning loads as follows:

(1) A vertical ground reaction equal to the static load on the rear wheel must be combined with an equal side load.

(2) The load specified in subparagraph (1) of this paragraph must be applied to the rear landing gear—

(i) Through the axle, if there is a swivel (the rear wheel being assumed to be swivelled 90° to the longitudinal axis of the rotorcraft); or

29.497(h) (continued)

(ii) At the ground contact point if there is a lock, steering device or shimmy damper (the rear wheel being assumed to be in the trailing position).

(i) *Taxying condition.* The rotorcraft and its landing gear must be designed for the loads that would occur when the rotorcraft is taxied over the roughest ground that may reasonably be expected in normal operation.

29.501 Ground loading conditions: landing gear with skids

(a) *General.* Rotorcraft with landing gear with skids must be designed for the loading conditions specified in this section. In showing compliance with this section, the following apply:

(1) The Design Maximum Weight, centre of gravity, and load factor must be determined under sections 29.471 through 29.475.

(2) Structural yielding of elastic spring members under limit loads is acceptable providing adequate inspection procedures are included in the Maintenance Manual.

(3) Design ultimate loads for elastic spring members need not exceed those obtained in a drop test of the gear to the reserve energy absorption conditions of section 29.727.

(4) Compliance with paragraphs (b) through (e) of this section must be shown with—

(i) The gear in its most critically deflected position for the landing condition being considered; and

(ii) The ground loads rationally distributed along the bottom of the skids.

(b) *Vertical loads in the level landing attitude.* In the level attitude, and with the rotorcraft contacting the ground along the bottom of both skids, the vertical loads must be applied as prescribed in paragraph (a) of this section.

(c) *Drag loads in the level landing attitude.* In the level attitude; and with the rotorcraft contacting the ground along the bottom of both skids, the vertical loads specified in paragraph (b) of this section must be combined with horizontal drag loads of between 0 and 50% applied at the ground.

(d) *Sideloads in the level landing attitude.* In the level attitude, and with the rotorcraft contacting the ground along the bottom of both skids, the following apply:

(1) The vertical load must be—

29.501(d) (continued)

(i) Equal to the vertical loads obtained in the condition specified in paragraph (b) of this section; and

(ii) Divided equally among the skids.

(2) The vertical load must be combined with a horizontal sideload of the most critical load between 0 and 0·25 times the vertical load on both skids.

(3) The total sideload must be applied along the length of each skid.

(4) The unbalanced moments are assumed to be resisted by angular inertia.

(5) The skid gear must be investigated for—

(i) Inward acting sideloads; and

(ii) Outward acting sideloads.

(e) *One-skid landing loads in the level attitude.* In the level attitude, and with the rotorcraft contacting the ground along the bottom of one skid only, the following apply:

(1) The vertical load on the ground contact side must be the same as that obtained on that side in the condition specified in paragraph (b) of this section.

(2) The unbalanced moments are assumed to be resisted by angular inertia.

(f) *Special conditions.* In addition to the conditions specified in paragraphs (b) and (c) of this section, the rotorcraft must be designed for the following loads:—

(1) A ground load acting up and aft at an angle of 45° to the longitudinal axis of the rotorcraft. This load must be—

(i) Equal to 1·33 times the Maximum Design Weight;

(ii) Distributed symmetrically among the skids;

(iii) Concentrated at the forward end of the straight part of the skid; and

(iv) Applied only to the forward end of the skid and its attachment to the rotorcraft.

(2) With the rotorcraft in the level landing attitude, a vertical ground load equal to one half of the vertical load determined under paragraph (b) of this section. This load must be—

(i) Applied only to the skid and its attachment to the rotorcraft; and

(ii) Concentrated at a point midway between the skid attachments.

29.505 Ski landing conditions

[*Reserved for BCAR 29*]

29.511 Ground load: unsymmetrical loads on multiple-wheel units

(a) In dual-wheel gear units, 60% of the total ground load for the gear unit must be applied to each wheel in turn and 40% to the other.

(b) To provide for the case of one deflated tyre, 60% of the specified load for the gear unit must be applied to each wheel in turn except that the vertical ground load may not be less than the maximum static value.

(c) In determining the total load on a gear unit, the transverse shift in the load centroid, due to unsymmetrical load distribution on the wheels, may be neglected.

29.512 Rotors turning with rotorcraft on the ground

The rotorcraft structure must be designed to withstand Limit Loads arising when:—

(a) The rotorcraft is stationary on the ground;

(b) The Rotor System is not supporting any of the rotorcraft weight;

(c) The landing gear is prevented from moving by chocks or other means; and

(d) With the Main Rotor at Rotor Maximum RPM (Power On) the directional control is applied as quickly as practicable to give the maximum horizontal thrust.

29.513 Reserve energy absorption alighting loads

Both wheeled and skid landing gear units, their attachments, and local airframe structure must be designed to withstand the vertical loads developed during the reserve energy absorption test prescribed in section 29.727.

WATER LOADS

29.519 Hull type rotorcraft: water-based, amphibian, and limited amphibian

[*Reserved for BCAR 29*]

29.521 Float landing conditions

[*Reserved for BCAR 29*]

MAIN COMPONENT REQUIREMENTS

29.547 Rotor structure

(a) Each rotor assembly (including rotor hubs and blades) must be designed as prescribed in this section.

(b) [Reserved for FAR]

(c) The rotor structure must be designed to withstand the following loads prescribed in sections 29.337 through 29.341, and 29.351:

(1) Critical flight loads.

(2) Limit loads occurring under normal conditions of autorotation.

(d) The rotor structure must be designed to withstand loads simulating—

(1) For the rotor blades, hubs, and flapping hinges, the impact force of each blade against its stop during ground operation. This load must be no less than that obtained on a stationary rotor from application of a vertical load on each landing gear unit of 1·67 times the maximum reaction, and any combination of drag and side loads on each landing gear unit equal to from 0 and 0·25 times the vertical load, (see ACB 29.547(d)(1)); and

(2) Any other critical condition expected in normal operation.

(e) The rotor structure must be designed to withstand the limit torque at any rotational speed, including zero. In addition:—

(1) The limit torque need not be greater than the torque defined by a torque-limiting device (where provided), and may not be less than the greater of—

(i) The maximum torque likely to be transmitted to the rotor structure, in either direction, by the transmission or by sudden application of the rotor brake; and

(ii) The limit engine and transmission system torque specified in section 29.361.

(2) The limit torque must be equally and rationally distributed to the rotor blades.

(f) *Loads at blade tip.* The rotor blades must have Proof and Ultimate Factors of 1·2 and 1·5 respectively under the following loads applied separately:—

29.547 (continued)

(1) *Vertical load.* A vertically applied load at the tip of one blade of the lesser of either 225 N (50 lbf) or the load which produces a 305 mm (12 in) vertical deflection at the tip.

(2) *Horizontal load*

(i) For blades not fitted with friction dampers, a horizontally applied load at the tip of one blade of 225 N (50 lbf) minimum, or such higher load as the Authority may prescribe; or

(ii) For blades fitted with friction dampers, the greater of either a horizontally applied load at the tip of one blade of 225 N (50 lbf) or 1·5 times the load applied at the tip required to overcome the friction damper.

29.549 Fuselage and rotor pylon structures

(a) Each fuselage and rotor pylon structure must be designed to withstand—

(1) The critical loads prescribed in sections 29.337 through 29.341, and 29.351;

(2) The applicable ground loads prescribed in sections 29.235, 29.471 through 29.485, 29.493, 29.497, 29.505, and 29.521; and

(3) The loads prescribed in paragraphs 29.547 (d)(1) and (e)(1)(i).

(b) Rotor thrust, the torque reaction of each Transmission System, and the balancing air and inertia loads occurring under accelerated flight conditions, must be considered.

(c) Each engine mount and adjacent fuselage structure must be designed to withstand the loads occurring under accelerated flight and landing conditions, including engine torque.

[(d) Deleted in FAR]

(e) If approval for the use of Maximum Contingency Power is requested, each engine mount and adjacent structure must be designed to withstand the loads resulting from a limit torque equal to 1·25 times the mean torque for Maximum Contingency Power combined with 1 g flight loads.

29.551 Auxiliary lifting surfaces

Each auxiliary lifting surface must be designed to withstand—

(a) The critical flight loads in sections 29.337 through 29.341, and 29.351;

(b) The applicable ground loads in sections 29.235, 29.471 through 29.485, 29.493, 29.505, and 29.521; and

(c) Any other critical condition expected in normal operation.

29.552 Blade stripping

The Primary Structure, and in particular the structure which in the event of failure might endanger the occupants, must have an Ultimate Factor of 1·5 under the load condition when the rotorcraft is assumed to be hovering in ground effect at the Rotor Never Exceed RPM and any likely part of the secondary structure of one blade is lost. The resulting out-of-balance aerodynamic loads must be reacted by inertia loads on the rotorcraft.

EMERGENCY LANDING CONDITIONS

29.561 General

(a) The rotorcraft, although it may be damaged in Emergency Landing conditions on land or water, must be designed as prescribed in this section to protect the occupants under those conditions.

(b) The structure must be designed to give each occupant every reasonable chance of escaping serious injury in a Crash Landing when—

(1) Proper use is made of seats, belts, and other safety design provisions;

(2) The wheels are retracted (where applicable); and

(3) The occupant experiences the following ultimate inertia forces relative to the surrounding structure:

(i) Upward — 3·0 g.

(ii) Forward — 4·0 g.

(iii) Sideward — 3·0 g.

(iv) Downward — 6·0 g.

(v) Backwards — 3·0 g.

or any combination of these forces up to a maximum resultant of 6·0 g.

(c) The supporting structure must be designed to restrain, under any load up to those specified in paragraph (b)(3) of this section, any item of mass that could injure an occupant or nullify any of the escape facilities provided if it came loose in a Crash Landing. (See ACB 29.561(c).)

29.561 (continued)

(d) Any fuselage structure in the area of internal fuel tanks below the passenger floor level must be designed to resist the crash impact loads specified in this section, and to protect the fuel tanks from rupture, if rupture is likely when those loads are applied to that area.

29.563 Structural ditching provisions

(a) Structural strength considerations of ditching provisions must be made in accordance with this section and with paragraph 29.801(e).

(b) The rotorcraft, together with any equipment fitted for emergency alighting on water must achieve an ultimate factor of safety of 1·0 on the loads arising from impact with the water at a vertical velocity of 1·5 m/sec (5 ft/sec) and a forward speed equal to two-thirds of the best autorotational descent speed (Vy) and with angles of yaw up to 15°. (See ACB 29.563(b).)

FATIGUE EVALUATION

29.571 Fatigue evaluation of flight structure

(a) The strength and fabrication of the rotorcraft must be such as to ensure that the possibility of disastrous fatigue failure of the Primary Structure and other Class 1 Parts under the action of repeated loads of variable magnitude expected in service, is Extremely Remote throughout its operational life. The method of complying with this must be agreed with the Authority. (See ACB 29.571(a).)

(b) Parts of the Primary Structure and other Class 1 Parts, which may be critical from fatigue aspects, must be subjected to such analysis and substantiating load tests as to demonstrate, either:—

(1) a Safe Fatigue Life (see ACB 29.571(b)(1)) or

(2) that such parts of the Primary Structure exhibit the characteristics of a Fail-Safe Structure. (See ACB 29.571(b)(2).)

29.572 Fatigue evaluation of systems

(a) Those parts of the Rotor and Transmission System which by the failure analysis of paragraph 29.917(d) are shown to require an established Safe Fatigue Life must be tested to the satisfaction of the Authority. (See ACB 29.572(a).)

(b) A complete vibration survey of the primary flight control system must be carried out to a schedule agreed with the Authority as part of the determination of components critical from fatigue aspects. (See ACB 29.571(b)(1)(3).)

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Subpart D — Design and Construction

GENERAL

29.601 Design

(a) The rotorcraft may have no design features or details that experience has shown to be hazardous or unreliable .

(b) The suitability of each questionable design detail and part must be established by tests .

(c) This Subpart prescribes requirements relating to the design and construction of the rotorcraft and its component parts other than engines, propellers and equipment.

(d) *Failures*

(1) The design of a rotorcraft to be certificated in either Group A or Group B must be such that, with the exception of the Rotor and Transmission Systems, the probability of a Catastrophic Effect from all system causes is Extremely Remote. (See ACB 29.601(d)(1).)

(2) The design of a rotorcraft to be certificated in Group A must be such that, with the exception of the Rotor and Transmission Systems the probability of a Failure resulting in an Emergency Landing within a specified period of time, which must not be less than 10 minutes is not greater than Extremely Remote. (See ACB 29.601(d)(2) and ACB 29.917 for Rotor and Transmission Systems requirements.)

29.602 Operation of Essential Services

(a) *For Power-unit Failures:–*

(1) *Rotorcraft with one Power-unit (Group B).* Following Power-unit failure, Essential Services must be available for the maximum time likely to be required to enable an Emergency Landing to be completed.

(2) *Rotorcraft with two Power-units*

(i) For Group A rotorcraft following the failure of one Power-unit, all Essential Services must continue to function and perform adequately. (See ACB 29.602 (a)(2)(i).)

(ii) For Group B rotorcraft following the failure of one Power-unit, Essential Services must be available for the maximum time likely to be required to enable an Emergency Landing to be completed. (See ACB 29.602(a)(2)(ii).)

29.602(a) (continued)

(3) *Rotorcraft with more than two Power-units.* Following the failure of more than one Power-unit, Essential Services must be available for the maximum time likely to be required to enable an Emergency Landing to be completed. (See ACB 29.602(a)(3).)

(4) *Failure of all Power-units.* Following the failure of all Power-units, Essential Services must be available for the maximum time likely to be required to enable an Emergency Landing to be completed.

(b) *Accessory drive failure.* Where the failure of a part driven by the Transmission System will affect the power supply for Essential Services (see section 29.1163) then:—

(1) For Group A Rotorcraft, paragraphs (a)(2), (a)(3) and (a)(4) of this section apply as appropriate, or

(2) For Group B Rotorcraft, paragraph (a) of this section applies, as appropriate. (See ACB 29.602(b).)

29.603 Materials

The suitability and durability of materials used for parts, the failure of which could adversely affect safety, must —

(a) Be established on the basis of experience or tests;

(b) Conform to Approved material specifications that ensure their having the strength and other properties assumed in the design data (see ACB 29.603(b)), and

(c) Take into account the effects of environmental conditions, such as temperature and humidity, expected in service.

29.604 Reduction of normal acceleration

Essential Services and Equipment, the failure to function of which could result in a Catastrophic Effect must function satisfactorily when subjected to a reduction of normal acceleration. The magnitude and associated duration of the reduction of normal acceleration must be agreed with the Authority. (See ACB 29.604.)

29.605 Fabrication methods

(a) The methods of fabrication employed in the Primary Structure must be such as to produce a consistently sound structure (see Subpart C). This structure must also be reliable with respect to maintenance of the required strength under all conditions anticipated in operation. Where a fabrication process requires close control to attain these objectives the process must be performed according to an Approved process specification. (See ACB 29.603(b).)

(b) Each new aircraft fabrication method must be substantiated by a test programme. (See ACB 29.605(b).)

29.606 Incidental loads

All items of equipment and parts of systems must be installed and supported so as to withstand loads arising from vibration, rough landing conditions and handling during maintenance operations, together with loads from fluid pressures where appropriate.

29.607 Locking of fasteners

(a) An Approved means of locking must be provided on all connecting elements in the Primary Structure, fluid systems, control and other mechanical systems essential to the safe operation of the rotorcraft.

(b) Each removable bolt, screw, nut, pin, or other fastener whose loss could jeopardise the safe operation of the rotorcraft must incorporate two separate locking devices. The fastener and its locking devices may not be adversely affected by the environmental conditions associated with the particular installation.

(c) No self-locking nut may be used on any bolt subject to rotation in operation unless a non-friction locking device is used in addition to the self-locking device.

29.609 Protection of structure

Each part of the structure must —

(a) Be suitably protected against deterioration or loss of strength in service when maintained in accordance with the Maintenance Manual due to any cause, including —

29.609(a) (continued)

(1) Weathering;

(2) Corrosion; and

(3) Abrasion; and

(b) Have provisions for ventilation and drainage where necessary to prevent the accumulation of corrosive, flammable, or noxious fluids. (See ACB 29.609.)

29.610 Lightning protection (see also section 29.899)

(a) There must be means provided to conduct lightning strikes effectively so that the rotorcraft and its occupants will not be endangered. The means provided must:—

(1) Minimise damage to the rotorcraft structure or components;

(2) Prevent the passage of such electrical currents as will cause dangerous malfunctioning of the rotorcraft or its systems and equipment; and

(3) Prevent the occurrence of high potential differences within the rotorcraft. (See ACB 29.610(a).)

(b) *General.* Compliance with paragraph (a) of this section must be established by the provision of an electrically conducting cage to the satisfaction of the Authority. This cage must constitute, or be electrically connected to, the main earth system. (See ACB 29.610(b).)

(c) *External metal parts.* External metal parts must either be:—

(1) Electrically bonded to the main earth system by Primary Conductors, or

(2) So designed and/or protected that a lightning discharge will not endanger the rotorcraft or its occupants. (See ACB 29.610(c).)

(d) *External non-metallic parts.* External non-metallic parts must be so designed and installed that:—

(1) They are provided with effective lightning diverters which will safely carry lightning discharges, or

(2) Damage to them by lightning discharge will not endanger the rotorcraft or its occupants, or

(3) The probability of a lightning strike on the insulated portion is Extremely Improbable because of the shielding afforded by other portions. (See ACB 29.610(d).)

29.610 (continued)

(e) *Rotor blade and control surface hinges and bearings.* All rotor blade and control surface hinges and bearings must either:—

(1) Be of a type that is capable of withstanding a lightning discharge without dangerous damage of seizure, or

(2) Be provided with at least one Primary Conductor across each bearing or hinge. (See ACB 29.610(e).)

29.611 Inspection and maintenance provisions

Adequate means must be provided to permit the inspection and maintenance of such parts of the rotorcraft as are required to be inspected and maintained in accordance with the Maintenance Manual. Regions where normal means of access cannot be provided must be defined in the Overhaul Manual as well as the means of access to and inspection of such regions. (See ACB 29.611.)

29.612 Identification of pipe lines

If pipe-line markings are employed they must be such as to minimise the risk of confusion by servicing or maintenance personnel and must be approved by the Authority. (See ACB 29.612.)

29.613 Material strength properties and design values

(a) Material strength properties must be based on enough tests of material meeting specifications to establish design values on a statistical basis;

(b) Design values must be chosen so that the probability of any structure being under strength because of material variations is Extremely Remote;

(c) The strength, detail design, and fabrication of the structure must minimise the probability of disastrous fatigue failure, particularly at points of stress concentration;

(d) Material specifications must be those contained in documents accepted either specifically by the Authority or by having been prepared by an organisation or person which the Authority accepts has the necessary capabilities.

29.619 Special factors

(a) The special factors prescribed in sections 29.621 through 29.625 apply to each part of the structure whose strength is —

(1) Uncertain;

(2) Likely to deteriorate in service before normal replacement; or

(3) Subject to appreciable variability due to —

(i) Uncertainties in manufacturing processes; or

(ii) Uncertainties in inspection methods.

(b) For each part of the rotorcraft to which sections 29.621 through 29.625 apply, the factor of safety prescribed in section 29.303 must be multiplied by a special factor equal to —

(1) The applicable special factors prescribed in sections 29.621 through 29.625; or

(2) Any other factor great enough to ensure that the probability of the part being understrength because of the uncertainties specified in paragraph (a) of this section is Extremely Remote.

29.621 Casting factors

[*Reserved for BCAR 29*]

29.623 Bearing factors

(a) Except as provided in paragraph (b) of this section, each part that has clearance (free fit), and that is subject to pounding or vibration, must have a bearing factor large enough to provide for the effects of normal relative motion.

(b) No bearing factor need be used on a part for which any larger special factor is prescribed.

29.625 Fitting factors

For each fitting (part or terminal used to join one structural member to another) the following apply:

(a) For each fitting whose strength is not proven by limit and ultimate load tests in which actual stress conditions are simulated in the fitting and surrounding structures, a fitting factor of at least 1·15 must be applied to each part of —

29.625(a) (continued)

(1) The fitting;

(2) The means of attachment; and

(3) The bearing on the joined members.

(b) No fitting factor need be used —

(1) For joints made under approved practices and based on comprehensive test data (such as continuous joints in metal plating, welded joints, and scarf joints in wood); and

(2) With respect to any bearing surface for which a larger special factor is used.

(c) For each integral fitting the part must be treated as a fitting up to the point at which the section properties become typical of the member.

29.629 Flutter prevention and stiffness

(a) Structural distortion in flight must be reduced to a minimum to ensure that the control and stability of the rotorcraft are not being seriously impaired and that flutter and other vibration effects are prevented.

(b) It must be demonstrated that the natural frequency of any part of the rotorcraft which may be excited by Rotor vibration is remote from the fundamental rotor frequency and its higher harmonics. In particular the Rotor mounting must be so checked.

(c) It must be demonstrated that all rotor blades are free of any dangerous characteristics, including flutter and resonance:—

(1) By flight test, at Rotor speeds up to 1·1 times the Never Exceed Speed VNE, and

(2) By ground test, at Rotor speeds up to 1·05 times the Rotor Never Exceed RPM, account being taken of any engine condition likely to be critical during power-on operation. (See ACB 29.629.)

29.631 Bird strikes

The probability of a Catastrophic Effect as a result of the rotorcraft striking a bird must be Extremely Remote. (See ACB 29.631.)

ROTORS

29.652 Rotor blade design

(a) The design of the main rotor blades and their articulation must be such that under all possible conditions of loading their functioning will be satisfactory. In particular, the rotor blades must possess such torsional stiffness qualities as to prevent any serious changes of aerodynamic contour and characteristics under all possible flight conditions.

(b) *Flutter, vibration and buffeting.* There must be no possibility of the occurrence of dangerous mechanical characteristics, such as unintentional bending loads being imposed upon the blades, in any permissible operating condition.

29.653 Pressure venting and drainage of rotor blades

(a) For each rotor blade —

(1) There must be means for venting the internal pressure of the blade;

(2) Drainage holes must be provided for the blade; and

(3) The blade must be designed to prevent water from becoming trapped in it.

(b) Paragraph (a)(1) and (2) of this section does not apply to sealed rotor blades capable of withstanding the maximum pressure differentials expected in service.

29.659 Rotor balance

(a) Means must be provided to enable the balance of the Rotor(s) and rotor blades to be adjusted to within the limits specified by the constructor.

(b) The rotor and blades must be balanced as necessary to —

(1) Prevent excessive vibration; and

(2) Prevent flutter as specified in section 29.629.

(c) The structural integrity of a mass balance installation must be substantiated.

(d) The blades must be so designed that they will maintain acceptable balance characteristics under all permitted flight conditions and ambient conditions e.g. pressure, temperature, humidity and icing.

29.661 Rotor blade clearance

There must be enough clearance between the rotor blades and other parts of the Rotorcraft to prevent the blades from striking any part of the Rotorcraft during any operating condition. The clearance must also be such that the probability of the blades striking any part of the rotorcraft during any foreseeable manoeuvre that might inadvertently occur must be Extremely Remote. (See ACB 29.661.)

29.663 Ground resonance prevention means

(a) The reliability of the means for preventing ground resonance must be shown either by analysis and tests, or reliable service experience, or by showing that malfunction of a single means will not cause ground resonance.

(b) The probable range of variations, during service, of the damping action of the ground resonance prevention means must be investigated during testing.

CONTROL SYSTEMS

29.671 General

(a) Each control and control system must operate with the ease, smoothness, and positiveness appropriate to its function.

(b) Each element of each flight control system must be designed, or distinctively and permanently marked, to minimise the probability of any incorrect assembly that could result in the malfunction of the system. (See ACB 29.671(b).)

(c) [*Reserved for BCAR 29*]

(d) The primary flight control system (see section 29.673) together with the trimming control system must be such that the likelihood of Failure (including disconnection) of any element which could result in a dangerous measure of control being applied or lost at any speed up to VNO is predicted to be:—

(1) Extremely Improbable for Group A rotorcraft; and

(2) Extremely Remote for Group B rotorcraft. (See ACB 29.671(d).)

(e) Control systems must be designed so that they function satisfactorily under the extremes of Temperature and Humidity which are likely to be encountered in flight or on the ground.

29.672 Stability augmentation systems (See section 29.1329 for automatic pilot systems)

(a) For any failure of the stability augmentation system, or any other occurrence which is not Extremely Improbable the rotorcraft must be safely controllable and capable of prolonged flight without undue pilot effort. Additional unrelated probable failures affecting the control system must be considered. Also:—

(1) The system includes all those actuators, sensors, power supplies, etc., which are necessary to the performance of the automatic system function; and

(2) Any part of the system which is not disengaged from the flying controls when the system is not in use must be regarded as part of the flying control system and must meet the requirements for such systems.

(b) The pilot must be provided with a control mounted on the cyclic control which, when operated, frees the rotorcraft from the control of the automatic system, unless it can be shown that any Failure in the system which is Recurrent will only result in a Minor Effect.

(c) The system must provide a positive indication that it is in operation and of the mode of operation in which it is functioning. A suitably compelling warning must be given of the system ceasing to operate correctly if in such a situation crew action is necessary (if not readily apparent to the pilot due to the failure effects) to prevent a hazardous situation resulting. (See ACB 29.672.)

29.673 Primary flight controls

Primary flight controls are those used by the pilot for the immediate control of the pitch, roll, yaw, climb and descent of the rotorcraft.

29.675 Stops

(a) Each control system must have stops that positively limit the range of motion of the pilot's controls.

(b) Each stop must be located in the system so that the range of travel of its control is not appreciably affected by —

(1) Wear;

(2) Slackness; or

(3) Take-up adjustments.

29.675 (continued)

(c) Each stop must be able to withstand the loads corresponding to the design conditions for the system.

(d) For each main rotor blade —

(1) Stops that are appropriate to the blade design must be provided to limit travel of the blade about its hinge points; and

(2) Adequate clearance must be provided to prevent blades contacting any rigid droop stops during any operation other than starting and stopping the Rotor or when the Rotor is parked.

29.679 Control system locks

If there is a device to lock the control system with the rotorcraft on the ground or water, there must be means to —

(a) Automatically disengage the lock when the pilot operates the controls in a normal manner, or limit the operation of the rotorcraft so as to give unmistakable warning to the pilot before take-off; and

(b) Prevent the lock from engaging in flight.

29.681 Limit load static tests

(a) Compliance with the limit load requirements of this Part must be shown by tests in which —

(1) The direction of the test loads produces the most severe loading in the control system; and

(2) Each fitting, pulley, and bracket used in attaching the system to the main structure is included;

(b) Compliance must be shown (by analyses or individual load tests) with the special factor requirements for control system joints subject to angular motion.

29.683 Operation tests

It must be shown by operation tests that, when the controls are operated from the pilot compartment with the control system loaded to provide 80% of the control system limit loads at the pilot's control, the system is free from —

29.683 (continued)

(a) Jamming;

(b) Excessive friction; and

(c) Excessive deflection. (See ACB 29.683.)

29.685 Control system details

(a) Each detail of each control system must be designed to prevent jamming, chafing, and interference from cargo, passengers, loose objects, or the freezing of moisture. (See ACB 29.685(a).)

(b) There must be means in the cockpit to prevent the entry of foreign objects into places where they would jam the system.

(c) There must be means to prevent the slapping of cables, chains or tubes against other parts.

(d) Cable systems must be designed as follows:

(1) Cables, cable fittings, turnbuckles, splices and pulleys must be Approved.

(2) The design of cable systems must prevent any hazardous change in cable tension throughout the range of travel under any operating conditions and temperature and humidity variations. The tension at which the cables are to be rigged on the ground to avoid undue slackness must be declared.

(3) No cable smaller than $\frac{1}{8}$ in diameter may be used in any primary control system.

(4) Pulley kinds and sizes must correspond to the cables with which they are used.

(5) Pulleys and sprockets must have close fitting guards to prevent the cables or chains from being displaced or fouled. (See ACB 29.685(d).)

(6) Pulleys must lie close enough to the plane passing through the cable to prevent the cable from rubbing against the pulley flange.

(7) No fairlead may cause a change in cable direction of more than 3°.

(8) No clevis pin subject to load or motion and retained only by cotter pins may be used in the control system.

(9) Turnbuckles attached to parts having angular motion must be installed to prevent binding throughout the range of travel.

(10) There must be means for visual inspection at each fairlead, pulley, terminal, and turnbuckle, and other various parts of the control system which necessitate periodic inspection and maintenance in accordance with the Maintenance Manual.

29.685 (continued)

(e) Control system joints subject to angular motion must incorporate the following special factors with respect to the ultimate bearing strength of the softest material used as a bearing:

(1) 3·33 for push-pull systems other than ball and roller bearing systems.

(2) 2·0 for cable systems.

(f) For control system joints, the manufacturer's static, non-Brinell rating of ball and roller bearings may not be exceeded.

(g) *Static friction.* The design of the primary flight control system must ensure that the static friction in the system has no material adverse effect on the stability and control characteristics necessary to comply with section 29.141. (See ACB 29.685(g).)

(h) The operating control(s) for collective pitch must be located at the left hand side of the pilot(s).

29.687 Spring devices

(a) Each control system spring device whose failure could cause flutter or other unsafe characteristics must be reliable.

(b) Compliance with paragraph (a) of this section must be shown by tests simulating service conditions.

29.691 Autorotation control mechanism

Each main rotor blade pitch control mechanism must allow rapid entry into autorotation after power failure.

29.695 Power boost and power-operated control system

(a) If a power boost or power-operated control system is used, an alternate system must be immediately available that allows continued safe flight and landing in the event of —

(1) Any single failure in the power portion of the system; or

(2) The failure of all engines.

(b) Each alternate system may be a duplicate power portion or a manually-operated mechanical system. The power portion includes the power source (such as hydraulic pumps), and such items as valves, lines, and actuators.

29.695 (continued)

(c) The failure of mechanical parts (such as piston rods and links), and the jamming of power cylinders, must be considered unless they are Extremely Improbable. (See ACB 29.695.)

29.696 Essential Services

Control systems for Essential Services must be designed so that when a movement to one position has been selected, a different position can be selected without having to wait for completion of the initially selected movement. It must not be necessary for the pilot to follow other than a normal control sequence in selecting the new position. Following this selection, the service being operated must start to move to the finally selected position without further flight crew action. The movement(s) which follow and the time taken must not be such as to affect adversely the safe operation of the rotorcraft. (See section 29.602.)

LANDING GEAR

29.723 Shock absorption tests

The landing inertia load factor and the reserve energy absorption capacity of the landing gear must be substantiated by the tests prescribed in sections 29.725 and 29.727, respectively. These tests must be conducted on the complete rotorcraft or on units consisting of wheel, tyre, and shock absorber in their proper relation.

29.725 Limit drop test

The limit drop test must be conducted as follows:

(a) The following descent velocity, to be absorbed by the landing gear without permanent distortion —

(1) For single-engined rotorcraft 2·6 m/sec (8·5 ft/sec), or the maximum probable vertical velocity of descent likely to occur at ground contact in a normal power-off landing if less, but not less than 2·0 m/sec (6·5 ft/sec);

(2) For multi-engined rotorcraft 2·0 m/sec (6·5 ft/sec).

(b) If considered, the rotor lift specified in paragraph 29.473(a) must be introduced into the drop test by appropriate energy absorbing devices or by the use of an equivalent mass.

29.725 (continued)

(c) Each landing gear unit must be tested in the attitude simulating the landing condition that is most critical from the standpoint of the energy to be absorbed by it.

(d) When an equivalent mass is used in showing compliance with paragraph (b) of this section, the following formulae may be used instead of more rational computations.

$$W_e = W\left[\frac{h + (1 - L)\,d}{h + d}\right]; \text{ and } n = n_j\,\frac{W_e}{W} + L$$

where:

W_e = the equivalent weight to be used in the drop test (lb).

$W = W_M$ for main gear units (lb), equal to the static reaction on the particular unit with the rotorcraft in the most critical attitude. A rational method may be used in computing a main gear static reaction, taking into consideration the moment arm between the main wheel reaction and the rotorcraft centre of gravity.

$W = W_N$ for nose gear units (lb), equal to the vertical component of the static reaction that would exist at the nose wheel, assuming that the mass of the rotorcraft acts at the centre of gravity and exerts a force of 1·0 *g* downward and 0·25 *g* forward.

$W = W_T$ for tailwheel units (lb) equal to whichever of the following is critical—

(1) The static weight on the tailwheel with the rotorcraft resting on all wheels; or

(2) The vertical component of the ground reaction that would occur at the tailwheel assuming that the mass of the rotorcraft acts at the centre of gravity and exerts a force of 1*g* downward with the rotorcraft in the maximum nose-up attitude considered in the nose-up attitude considered in the nose-up landing conditions

h = the free drop height equivalent to that required to give the required vertical velocity of descent at touchdown

L = ratio of assumed rotor lift to the rotocraft weight

d = deflection under impact of the tyre (at the proper inflation pressure) plus the vertical component of the axle travel (inches) relative to the drop mass

n = limit inertia load factor

n_j = the load factor developed during impact on the mass used in the drop test (i.e., the acceleration dv/dt in g's recorded in the drop test plus 1·0).

29.727 Reserve energy absorption drop test

The reserve energy absorption drop test must be conducted as follows:

29.727 (continued)

(a) The energy to be absorbed by the landing gear without failure must be 1·5 times that specified in paragraph 29.725(a).

(b) Rotor lift, where considered in a manner similar to that prescribed in paragraph 29.725(b), may not exceed 1·5 times the lift allowed under that paragraph.

(c) [*Deleted in BCAR 29*]

29.729 Retracting mechanism

(a) *General.* The landing gear, retracting mechanism, wheel well doors, and supporting structure must be designed for —

(1) The loads occurring in any manoeuvring condition with the gear retracted;

(2) The combined friction, inertia, and air loads occurring during retraction and extension at any airspeed up to the design Landing Gear Operating Speed, V_{LO};

(3) The flight loads, including those in yawed flight, occurring with the gear extended at any airspeed up to the design Landing Gear Extended Speed, V_{LE};

(4) The ground load conditions contained in Subpart C of BCAR 29 occurring with the gear extended; and

(5) *Operating conditions.* The ability to retract and extend the landing gear satisfactorily under the most adverse flight conditions occurring throughout a range of:—

(i) Airspeeds from zero to the Landing Gear Operating Speed, V_{LO}; and

(ii) Accelerations from 0·8*g* to 1·3*g*. (See ACB 29.729(a).)

(b) *Landing gear lock.* Reliable automatic means must be provided to secure the landing gear in the correct landing position. Reliable means must also be provided to secure the landing gear and its doors in the correct retracted position, unless it is established that inadvertent movement of the landing gear or doors from that position in flight, over the full range of speeds up to V_{DF}, would not adversely affect the safe operation of the rotorcraft.

(c) *Emergency operation*

(1) When other than manual power is used to operate the gear, emergency means must be provided for extending the gear in the event of —

29.729(c) (continued)

(i) Any Reasonably Probable Failure in the normal retraction system; or

(ii) The failure of any single source of hydraulic, electric, or equivalent energy.

(2) The emergency system must be such that, when the appropriate actions for extending the landing gear by the emergency method are correctly performed, the extension will then proceed to completion irrespective of any actions, correct or incorrect, which may have been carried out with the normal control.

(d) *Operation tests.* Proper and safe functioning of both normal and emergency landing gear operating mechanism must be established, to the satisfaction of the Authority, by rig testing and by flight, landing and taxying tests on the complete rotorcraft.

(e) *Position indicator.* There must be means to indicate to the pilot or appropriate members of the flight crew when the gear is secured in the extreme positions. (See ACB 29.729(e).)

(f) *Control.* The location and operation of the retraction control must meet the requirements of section 29.777.

29.731 Wheels

(a) Each landing gear wheel must be Approved.

(b) The maximum static load rating of each wheel may not be less than the corresponding static ground reaction with —

(1) Maximum weight; and

(2) Critical centre of gravity.

(c) The maximum limit load rating of each wheel must equal or exceed the maximum radial limit load determined under the applicable ground load requirements of this BCAR 29.

29.733 Tyres

Tyres fitted to the rotorcraft wheels and inflated to the recommended pressures must:—

(a) Have a proper fit on the rim of the wheel; and

(b) Have a rating that is not exceeded under —

(1) The design maximum weight;

29.733(b) (continued)

(2) A load on each main wheel tyre equal to the static ground reaction corresponding to the critical centre of gravity; and

(3) A load on nose-wheel tyres (to be compared with the dynamic rating established for those tyres) equal to the reaction obtained at the nose wheel, assuming that the mass of the rotorcraft acts at the most critical centre of gravity and exerts a force of 1·0*g* downward and 0·25*g* forward, the reactions being distributed to the nose and main wheels according to the principles of statics with the drag reaction at the ground applied only at wheels with brakes.

(c) For tyres installed on a retractable landing gear system, at the maximum size of the tyre type expected in service, have a clearance to surrounding structure and systems that is adequate to prevent contact between the tyre and any part of the structure or systems.

29.735 Wheel brakes

(a) *General.* Wheel brakes must be installed on the main wheels of all rotorcraft with wheeled landing gear that are:—

(1) Controllable by the pilot without interfering with other controls;

(2) Usable during power-off landings; and

(3) Adequate to —

(i) Counteract any normal unbalanced torque when starting or stopping the rotor; and

(ii) Hold the rotorcraft parked on a 10° slope on a dry, smooth pavement.

(4) Suitably protected from the ingress of any foreign matter (e.g. water, dirt or oil) which might interfere with their satisfactory functioning.

(b) *Tests.* Wheel brakes must be tested as follows:—

(1) Prototype brake installations must be tested over the full range of operating pressure during ground handling, landing and take-off as necessary to demonstrate the satisfactory functioning and behaviour of the brake installation, and of the rotorcraft when braked.

(2) Series brake installations must be tested to a schedule agreed by the Authority.

29.737 Skis

[*Reserved for BCAR 29*]

FLOATS AND HULLS

29.751 Main float buoyancy

[*Reserved for BCAR 29*]

29.753 Main float design

[*Reserved for BCAR 29*]

29.755 Hull buoyancy

[*Reserved for BCAR 29*]

29.757 Hull and auxiliary float strength

[*Reserved for BCAR 29*]

PERSONNEL AND CARGO ACCOMMODATIONS

29.770 General

(a) The design of all compartments (occupied or likely to be occupied in flight) must reduce to a minimum the possibility of danger or injury to occupants in both normal and emergency conditions.

(b) Variations to the requirements for rotorcraft with pressurisation systems must be agreed with the Authority.

29.771 Pilot compartment

For each pilot compartment —

(a) The compartment and its equipment must allow each pilot to perform his duties without unreasonable concentration or fatigue;

(b) If there is provision for a second pilot, the rotorcraft must be controllable with equal safety from either pilot seat;

29.771 (continued)

(c) The vibration and noise characteristics of cockpit equipment may not interfere with safe operation of the rotorcraft;

(d) Inflight leakage of rain or snow that could distract the crew or harm the structure must be prevented;

(e) The temperature must be suitable for safe control of the rotorcraft. (See ACB 29.771(e).)

(f) *Communication with passengers.* Where the compartment is separated from the passenger compartment by a partition a means of aural communication must be provided between the pilots and passengers;

(g) *Signal pistol and discharger.* Where a signal pistol is carried:—

(1) It must be demonstrated that the pistol can be readily used, discharging clear of the rotorcraft;

(2) A mounting must be provided such that the pistol can be loaded, fired and unloaded in the firing position;

(3) Provision must be made for the stowage of the signal pistol and cartridges. (See ACB 29.771(g).)

29.773 Pilot compartment view

(a) *Non-precipitation conditions.* For non-precipitation conditions, the following apply:

(1) Each pilot compartment must be arranged and shown by flight tests to give the pilots a sufficiently extensive, clear, and undistorted view for safe operation.

(2) Each pilot compartment must be free of glare and reflection that could interfere with the pilot's view. If certification for night operation is requested, this must be shown by night flight tests.

(b) *Precipitation conditions.* For precipitation conditions, the following apply:

(1) Each pilot must have a sufficiently extensive view for safe operation —

(i) In heavy rain at forward speeds up to V_H or V_{NO}, whichever is the lesser; and

(ii) In the most severe icing conditions for which certification is requested.

(2) The first pilot must have a window that —

29.773(b) (continued)

(i) Is openable under the conditions prescribed in subparagraph (1) of this paragraph; and

(ii) Provides the view prescribed in that subparagraph; and

(iii) When opened and in normal use does not result in an excessive draught on the pilot's face.

(c) Means must be provided for preventing the pilot(s) essential view windscreen and windows from being obscured by misting.

(d) On rotorcraft where two pilots' stations are provided, and where, for compliance with paragraph (b) of this section means are provided for maintaining the windscreen and windows in a clear condition, the means must be so arranged that no Reasonably Probable Failure of such means result in a reduction of the cleared field of view such as seriously to interfere with the ability of the flight crew to continue the operation and land safely. (See ACB 29.773(d).)

29.775 Windshields and windows

(a) Windshields and windows must be made of material which will not break into dangerous fragments.

(b) Windshields must be designed so that either:—

(1) They are made of material which will not cause a serious reduction in the field of view by becoming suddenly opaque, or

(2) Any one panel becoming opaque will not cause a serious reduction in the field of view.

(c) In the event of any Reasonably Probable Failure, a transparency heating system must be incapable of raising the temperature of any windshield or window to a point where there would be a danger of fire or structural failure.

29.777 Cockpit controls

(a) Cockpit controls must be —

(1) Located to provide convenient operation and to prevent confusion and inadvertent operation;

29.777(a) (continued)

(2) Located and arranged so that there is full and unrestricted movement of each control and combined controls without interference from the cockpit structure or the pilot's clothing when pilots from 157 cm (62 in) to 183 cm (72 in) in height are seated;

(3) Such that each pilot can at all control positions exert adequate control forces for the operation to be performed; and

(4) Designed and located to minimise the risk of inadvertent operation either by personnel entering or leaving the rotorcraft or by flight crew moving normally in the cockpit. (See ACB 29.777(a).)

(b) Cockpit controls other than those which when in use are under constant supervision (e.g. primary flight controls) must maintain any chosen setting without subsequent attention by the flight crew and must not tend to creep under control loads or vibration. (See ACB 29.777(b).)

(c) Cockpit controls intended for operation by the pilot during take-off, approach and landing and during discontinued approach and baulked landing must be arranged so that their operation during these manoeuvres does not necessitate the pilot having to change hands on the cyclic pitch control.

(d) The co-ordination of the controls essential to the safe operation of the rotorcraft must not require undue skill.

29.779 Sense of movement

(a) *Primary flight controls.* When the primary flight controls consist of a cyclic control stick in front of each pilot a collective pitch lever at the side of each pilot and a pair of rudder pedals for each pilot, they must operate as follows:—

(1) A forward displacement of the cyclic control stick to cause the rotorcraft to pitch nose-down and/or produce forward movement of the rotorcraft.

(2) A displacement of the cyclic control stick towards the right to cause the rotorcraft to bank right hand down, and/or produce movement in the starboard direction.

(3) A forward displacement of the right hand rudder pedal to cause the rotorcraft to turn to the right.

(4) An upward displacement of the collective pitch lever to cause the rotorcraft to climb.

29.779 (continued)

(b) *Engine power controls.* Engine power controls must be such that —

(1) For twist-grip power controls, a clockwise movement as viewed from the free end of the collective pitch lever is necessary to increase power and an anticlockwise movement is necessary to decrease power.

(2) For twin-engined installations using twist-grip power controls the No. 1 engine twist-grip shall be nearest the free end of the collective pitch lever, and the No. 2 engine twist-grip shall be rearward of the No. 1 twist-grip.

(3) For power controls other than twist-grip power controls, a forward movement of the Operating Control is necessary to increase power and a rearward movement of the Operating Control is necessary to decrease power.

(c) *Retractable landing gear.* For retractable landing gear with other than manually-operated systems, one movement of one operating control must be sufficient to initiate and complete the retraction or extension of the landing gear.

(d) Where practicable the sense of motion involved in the operation of all controls must correspond with the sense of the response either of the rotorcraft or, if the rotorcraft response is relatively unimportant, of the part operated. (See ACB 29.779.)

29.783 Doors

(a) Each closed cabin must have at least one adequate and easily accessible external door.

(b) No passenger door may be located with respect to any rotor disc or engine intake and efflux so as to endanger persons following appropriate instructions for the use of that door.

(c) There must be means for locking crew and external passenger doors and for preventing their opening in flight inadvertently or as a result of mechanical failure. It must be possible to open external doors from inside and outside the cabin even though persons may be crowded against the door on the inside of the rotorcraft. The means of opening must be simple, rapid, obvious, and so arranged and marked that it can be readily located and operated even in darkness.

(d) There must be reasonable provisions to prevent the jamming of any external door, in a crash, as a result of fuselage deformation.

29.783 (continued)

(e) There must be means for direct visual inspection of the locking mechanism by crew members to determine whether the external doors (including passenger, crew, service, and cargo doors) are fully locked. There must be visual indication provided to indicate to appropriate crew members when normally used external doors are closed and fully locked.

(f) For outward-opening external doors usable for entrance or egress, there must be an auxiliary safety latching device to prevent the door from opening when the primary latching mechanism fails. If the door does not meet the requirements of paragraph (c) of this section with this device in place, suitable operating procedures must be established to prevent the use of the device during take-off and landing.

(g) If an integral stair is installed in a passenger entry door that is qualified as a passenger emergency exit, the stair must be designed so that under the following conditions the effectiveness of passenger emergency egress will not be impaired:

(1) The door, integral stair, and operating mechanism have been subjected to the inertia forces specified in paragraph 29.561(b)(3), acting separately relative to the surrounding structure.

(2) The rotorcraft is in the normal ground attitude and in each of the attitudes corresponding to collapse of one or more legs, or primary members, as applicable, of the landing gear.

29.785 Seats, safety belts, and harnesses

(a) The seats, safety belts, shoulder harnesses, and adjacent parts of the rotorcraft, at each station designated for occupancy during take-off and landing, must be designed so that a person making proper use of these facilities will not suffer serious injury in an emergency landing as a result of the inertia forces specified in section 29.561. (See ACB 29.785(a).)

(b) Each seat, safety belt and harness must be approved. (See ACB 29.785(a)(ii).)

(c) Safety belts and harnesses must be provided as follows:—

(1) Each occupant must be protected from head injury by —

(i) A safety belt and harness that will prevent the head from contacting any injurious object;

(ii) A safety belt plus the elimination of any injurious objects within striking radius of the head; or

29.785(c) (continued)

(iii) A safety belt plus a cushioned rest that will support the arms, shoulders, head, and spine.

(2) Each pilot's seat must be fitted with a safety harness or a lap/diagonal shoulder strap system. (See ACB 29.785(c).)

(d) If seat backs do not have a firm hand hold, there must be hand grips or rails along each aisle to let the occupants steady themselves while using the aisle in moderately rough air; and

(e) Each projecting object that would injure persons seated or moving about in the rotorcraft in normal flight must be padded.

(f) Each seat and its supporting structure must be designed for an occupant weight of 77 kg (170 lb), considering the maximum load factors, inertia forces, and reactions between the occupant, seat, and safety belt or harness corresponding with the applicable flight and ground load conditions, including the emergency landing conditions of section 29.561. In addition —

(1) Each pilot seat must be designed for the reactions resulting from the application of the pilot forces prescribed in section 29.397; and

(2) The inertia forces prescribed in section 29.561 must be multiplied by a factor of 1·33 in determining the strength of the attachment of —

(i) Each seat to the structure; and

(ii) Each safety belt or harness to the seat or structure. (See ACB 29.785 (f)(2).)

(3) For safety harnesses the loads must be as follows, unless otherwise approved by the Authority:—

(i) It must be assumed that the prescribed upward load may be applied either by the thighs only, or by the shoulders only unless it can be shown that such distribution cannot be achieved.

(ii) The minimum range of forward load distribution which must be considered is 100% of the forward load applied to the belt and 60% of the forward load applied to the belt and 40% to the shoulder straps. (See ACB 29.785(f)(3).)

(g) Seats facing aft must have suitable backs and head-rests to assist in the safe restraint of the occupants in emergency conditions. (See ACB 29.785(g).)

29.785 (continued)

(h) Side-facing seats must be arranged so that not more than two occupants can lean against any third in Crash Landing conditions up to the accelerations prescribed in 29.561(b). (See ACB 29.785(a).)

(i) *Installation.* The installation must meet the following:—

(1) The seat installation must, as far as possible, be such as not to unduly restrict access to any part of the cabin in flight or emergency conditions and must not obstruct access to or use of any essential or emergency equipment or exits.

(2) Safety belts must lie in a plane which is approximately 45° to the plane of the longitudinal and lateral axis of the rotorcraft when worn across the groins of the wearer. (See ACB 29.785(i).)

29.787 Cargo and baggage compartments

(a) Each cargo and baggage compartment must be designed for its placarded maximum weight of contents and for the critical load distributions at the appropriate maximum load factors corresponding to the specified flight and ground load conditions, except the emergency landing conditions of section 29.561.

(b) There must be means to prevent the contents of any compartment from becoming a hazard by shifting under the loads specified in paragraph (a) of this section.

(c) Cargo and baggage compartments must either,

(1) Be positioned so that if the contents break loose during a Crash Landing they are unlikely to cause injury to the occupants or restrict any of the escape facilities provided for use after a Crash Landing, or

(2) Together with the means of restraint, required by paragraph (b) of this section, and their attachments, when containing the maximum authorised weight of cargo and baggage at the critical loading distribution, have sufficient strength to withstand the crash load conditions specified in section 29.561, taking account of any conditions which might otherwise be expected to reduce the ability of the attachments and means of restraint from developing their intended design capacity.

(d) If cargo compartment lamps are installed, each lamp must be installed so as to prevent contact between lamp bulb and cargo. (See ACB 29.787.)

29.799 Water systems

(a) Where water is provided in rotorcraft for consumption or use by the occupants (excluding water supplies for water closets), the associated system must be designed so as to ensure that no contamination of the water supply is possible as a result of storage in or passage through the system.

(b) Water systems in which waste water can be discharged from the rotorcraft in flight must be designed so that water cannot leave the rotorcraft in the form of lumps of ice. (See ACB 29.799.)

29.801 Ditching

(a) Where approval for flight over water is desired, the rotorcraft must meet the requirements of this section and sections 29.807(d), 29.1411 and 29.1415. (See ACB 29.801(a).)

(b) Each practicable design measure, compatible with the general characteristics of the rotorcraft, must be taken to minimise the probability that in an emergency alighting on water, the behaviour of the rotorcraft would cause injury to the occupants or would make it impossible for them to escape through the exits provided.

(c) The probable behaviour of the rotorcraft in a water landing must be investigated by model tests conducted so that the results would be valid for the declared conditions, or by flight tests in declared conditions, or by comparison with rotorcraft of similar configuration for which the ditching characteristics are known. Scoops, flaps, projections, and any other factors likely to affect the hydrodynamic characteristics of the rotorcraft must be considered. (See ACB 29.801(c).)

(d) It must be shown that, in the declared conditions, the flotation time and trim of the rotorcraft will allow the occupants to leave the rotorcraft by the exits provided and enter the liferafts required by section 29.1415. Appropriate allowances must be made for any one buoyancy compartment to be completely flooded or deflated, and for any other likely structural damage or leakage. (See ACB 29.801(d).)

(e) During an emergency alighting on water (as prescribed in paragraphs (c) and (d) of this section), the external doors and windows must be designed to withstand the probable maximum local pressures.

29.801 (continued)

(f) A sea anchor, or similar device may not be assumed to be used in demonstrating compliance with the requirements of paragraphs (b) through (e) of this section, but may be assumed to be used to assist in the deployment of liferafts in accordance with section 29.1411.

(g) In all wind and surface conditions in which the rotorcraft is likely to be operated, the rotorcraft must be able to drift for five minutes with engines inoperative and controls not operated, aided, if necessary, by a sea anchor.

(h) *Declared conditions.* Declared conditions are those in which compliance with the requirements have been demonstrated. If these conditions are less than those detailed in ACB 29.801(c) they must be included in the Flight Manual as limitations. (See paragraph 29.1583(e) and ACB 29.801(h).)

(i) *Techniques and procedures.* Emergency Alighting on water techniques and procedures must be established and included in the Flight Manual in the event of:—

(1) The failure of all Power-units.

(2) For Group B Rotorcraft, the failure of one Power-unit.

29.803 Emergency evacuation

(a) Each crew and passenger area must have means for rapid evacuation in a Crash Landing, with the landing gear (1) extended and (2) retracted, considering the possibility of fire.

(b) Passenger entrance, crew, and service doors may be considered as emergency exits if they meet the requirements of this section and of sections 29.805 through 29.815.

(c) [*Reserved for BCAR 29*]

29.805 Flight crew emergency exits

(a) For rotorcraft with passenger emergency exits that are not convenient to the flight crew, there must be two flight crew emergency exits, either one on each side of the rotorcraft or one on the side and another in the roof or floor in the flight crew area.

(b) Each flight crew emergency exit must be of sufficient size and must be located so as to allow rapid evacuation of the flight crew. This must be shown by test where there is doubt as to the suitability of any design.

29.807 Passenger emergency exits

(a) *Type.* For the purpose of BCAR 29, the types of passenger emergency exit are as follows:

(1) *Type I.* This type must have a rectangular opening of not less than 610 mm (24 in) wide by 1219 mm (48 in) high, with corner radii not greater than one-third the width of the exit, in the passenger area at floor level and as far away as practicable from areas that might become potential fire hazards in a crash.

(2) *Type II.* This type is the same as Type I, except that the opening must be at least 508 mm (20 in) wide by 1118 mm (44 in) high and if located over a wing or sponson a step up inside the rotorcraft of not more than 254 mm (10 in) and a step down outside the rotorcraft of not more than 432 mm (17 in).

(3) *Type III.* This type is the same as Type I, except that —

(i) The opening must be at least 508 mm (20 in) wide by 914 mm (36 in) high; and

(ii) The exits need not be at floor level but if they are located over a wing or sponson a step up inside the rotorcraft of not more than 508 mm (20 in) and a step down outside the rotorcraft of not more than 686 mm (27 in) is permissible.

(4) *Type IV.* This type must have a rectangular opening of not less than 483 mm (19 in) wide by 660 mm (26 in) high, with corner radii not greater than one-third the width of the exit, with a step up inside the rotorcraft of not more than 737 mm (29 in) and if located over a wing or sponson a step down outside the rotorcraft of not more than 914 mm (36 in).

(5) For rotorcraft having a Maximum Weight not exceeding 2730 kg (6000 lb) the emergency exit must consist of an opening that will admit an ellipse not less than 483 mm (19 in) x 660 mm (26 in). Openings with dimensions larger than those specified in this section may be used, regardless of shape, if the base of the opening has a flat surface of not less than the specified width.

(b) *Passenger emergency exits; side-of-fuselage.* Emergency exits must be accessible to the passengers and, except as provided in paragraph (d) of this section, must be provided in accordance with the following table:

29.807(b) (continued)

Passenger seating capacity	Emergency exits for each side of the fuselage			
	Type I	Type II	Type III	Type IV
1 through 19	---	---	1 or ---	2
20 through 39	---	1	---	1
40 through 59	1	---	---	1
60 through 79	1	---	1 or ---	2
80 through 109	1	---	1	1

(See ACB 29.807(b).)

(1) For rotorcraft having a Maximum Weight not exceeding 2730 kg (6000 lb) there must be one emergency exit as defined by paragraph 29.807(a)(5) on each side of the fuselage.

(2) Where the passenger accommodation is divided into two or more compartments each compartment must be provided with exits, unless the passage ways connecting compartments are such that they would not become blocked or retard passenger movement in the event of a Crash Landing.

(c) *Additional passenger emergency exits.* In addition to the requirements of paragraph (b) of this section —

(1) There must be enough openings in the top, bottom, or ends of the fuselage to allow evacuation with the rotorcraft on its side; or

(2) The probability of the rotorcraft coming to rest on its side after an Emergency Landing must be Extremely Remote.

(d) *Ditching emergency exits for passengers.* If certification with ditching provisions is requested, ditching emergency exits must be provided in accordance with the following requirements, unless the emergency exits required by paragraph (b) of this section already meet them:

(1) With the rotorcraft in the configuration for overwater flight, the most adverse static water level(s) must be established.

(2) Emergency exits located above the water level(s) established in subparagraph (1) of this paragraph must be provided on each side of the fuselage and the number and size must be related to the seating capacity as follows:— (See ACB 29.807(d).)

29.807(d) (continued)

Passenger seating capacity (inclusive)	Ditching emergency exits each side of fuselage	
	Type III	Type IV
1 to 19	1	—
20 to 29	1	1
30 to 39	1	2
40 to 59	2	1
60 to 79	2	2

(e) *Ramp exits.* One Type I exit only, or one Type II exit only, that is required in the side of the fuselage under paragraph (b) of this section, may be installed instead in the ramp of floor ramp rotorcraft if —

(1) Its installation in the side of the fuselage is impractical; and

(2) Its installation in the ramp meets section 29.813.

(f) *Tests.* The proper functioning of each emergency exit must be shown by test.

29.809 Emergency exit arrangement

(a) Each emergency exit must consist of a moveable door or hatch in the external walls of the fuselage and must provide an unobstructed opening to the outside.

(b) Each emergency exit must be openable from the inside and from the outside even though the occupants may be crowding to the maximum extent likely against the door.

(c) The means of opening each emergency exit must be simple, rapid and obvious and may not require exceptional effort.

(d) There must be means for locking each emergency exit and for preventing opening in flight inadvertently or as a result of mechanical failure.

(e) There must be means to minimise the probability of the jamming of any emergency exit in a Crash Landing as a result of fuselage deformation.

(f) *Flights during which the Air Navigation Order requires escape apparatus to be carried.* Each land-based rotorcraft emergency exit (other than exits located over the wing) more than 1·82 m (6 ft) from the ground with the rotorcraft on the

29.809(f) (continued)

ground and the landing gear extended or which would be more than 1·82 m (6 ft) from the ground if any of the landing gear should collapse, break or fail to function, must have an Approved slide, or its equivalent, for each floor level exit, and an Approved rope, or its equivalent, for other exits. If a rope is used, it must be —

(1) Able, with its attachment, to withstand a 180 kg (400 lb) static load; and

(2) Attached to the fuselage structure at or above the top of the emergency exit opening, or (for the pilot's emergency exit window where the stowed rope would reduce the pilot's view in flight), at another approved location.

(g) Exits for which the initial opening movement is outward must have a means of direct visual inspection provided to ascertain that the exit is fully locked.

(h) *Means of escape.* Where a rotorcraft may be required to carry escape apparatus, suitable provision must be made for its stowage and attachment. (See ACB 29.809.)

(i) Non-jettisonable doors used as ditching emergency exits must have means to enable them to be secured in a position in which they do not interfere with egress and remain so secured in all sea states and wave heights/length ratios up to the maximum demonstrated to comply with the requirements of section 29.801.

29.811 Emergency exit marking

(a) Each passenger emergency exit, its means of access, and its means of opening must be conspicuously marked for the guidance of occupants using the exits in light and in darkness (e.g. by the use of luminous paint or emergency lighting). For rotorcraft equipped for over water flights such markings must remain adequate if the rotorcraft is capsized and the cabin submerged.

(b) The identity and location of each passenger emergency exit must be recognisable from a distance equal to the width of the cabin.

(c) The location of each passenger emergency exit must be indicated by a sign visible to occupants approaching along the main passenger aisle. There must be a locating sign —

(1) Next to or above the aisle near each floor emergency exit, except that one sign may serve two exits if both exits can be seen readily from that sign; and

29.811(c) (continued)

(2) On each bulkhead or divider that prevents fore and aft vision along the passenger cabin, to indicate emergency exits beyond and obscured by it, except that if this is not possible the sign may be placed at another appropriate location.

(d) Each passenger emergency exit marking and each locating sign must have white letters 25 mm (1 in) high on a red background 50 mm (2 in) high, be self or electrically illuminated, and have a minimum luminescence (brightness) of at least 160 microlamberts. The colours may be reversed if this will increase the emergency illumination of the passenger compartment.

(e) The location of each passenger emergency exit operating handle and instructions for opening must be shown —

(1) For each emergency exit, by a marking on or near the exit that is readable from a distance of 760 mm (30 in); and

(2) For each Type I or Type II emergency exit with a locking mechanism released by rotary motion of the handle, by —

(i) A red arrow, with a shaft at least 19 mm (¾ in) wide and a head twice the width of the shaft, extending along at least 70° of arc at a radius approximately equal to three-quarter of the handle length; and

(ii) The word 'open' in red letters 25 mm (1 in) high, placed horizontally near the head of the arrow.

(f) A source of light, independent of the main lighting system, must be installed to —

(1) Illuminate each passenger emergency exit marking and locating sign; and

(2) Provide enough general lighting in the passenger cabin so that the average illumination, when measured at 1016 mm (40 in) intervals at seat armrest height on the centre line of the main passenger aisle, is at least 0·05 foot-candles.

(g) Each light required by paragraph (f) of this section must be designed to be operable manually, and to operate automatically when armed (if necessary), from the independent lighting system required by paragraph (f) of this section in a Crash Landing and whenever the rotorcraft's normal electrical power to the light is interrupted.

(h) Each emergency exit, and its means of opening, must be marked on the outside of the rotorcraft for the guidance of rescue personnel. In addition, the following apply:

29.811(h) (continued)

(1) There must be a 50 mm (2 in) coloured band outlining each passenger emergency exit.

(2) Each outside marking, including the band, must have colour contrast to be readily distinguishable from the surrounding fuselage surface. The contrast must be such that, if the reflectance of the darker colour is 15% or less, the reflectance of the lighter colour must be at least 45%. 'Reflectance' is the ratio of the luminous flux reflected by a body to the luminous flux it receives. When the reflectance of the darker colour is greater than 15%, at least a 30% difference between its reflectance and the reflectance of the lighter colour must be provided.

(i) [*Reserved for BCAR 29*]

29.813 Emergency exit access

(a) Each passageway between passenger compartments, and each passageway leading to Type I and Type II emergency exits, must be —

(1) Unobstructed; and

(2) At least 508 mm (20 in) wide.

(b) For each emergency exit covered by paragraph 29.809(f), there must be enough space adjacent to that exit to allow a crew member to assist in the evacuation of passengers without reducing the unobstructed width of the passageway below that required for that exit.

(c) There must be access from each aisle to each Type III and Type IV exit, and

(1) For rotorcraft that have a passenger seating configuration, excluding pilot seats, of 20 or more, the projected opening of the exit provided must not be obstructed by seats, berths, or other protrusions (including seatbacks in any position) for a distance from that exit of not less than the width of the narrowest passenger seat installed on the rotorcraft;

(2) For rotorcraft that have a passenger seating configuration, excluding pilot seats, of 19 or less, there may be minor obstructions in the region described in subparagraph (1) of this paragraph, if there are compensating factors to maintain the effectiveness of the exit. (See ACB 29.813.)

29.815 Main aisle width

The main passenger aisle width between seats must equal or exceed the values in the following table:

Passenger seating capacity	Minimum main passenger aisle width	
	Less than 635 mm (25 in) from floor	635 mm (25 in) and more from floor
	mm (in)	mm (in)
10 or less	305 mm (12 in)	457 mm (18 in)
11 through 19	305 mm (12 in)	508 mm (20 in)
20 or more	381 mm (15 in)	508 mm (20 in)

[*FAR Note deleted in BCAR 29*]

29.831 Ventilation

(a) Each passenger and crew compartment must be ventilated. It must not be possible for the rate of supply of fresh air to fall below 0·225 kg/min (0·5 lb/min) per person in any foreseeable normal and emergency conditions.

(b) Crew and passenger compartment air must be free from harmful or hazardous concentrations of gases or vapours.

(c) The concentration of carbon monoxide may not exceed one part in 20,000 parts of air during forward flight. If the concentration exceeds this value under other conditions, there must be suitable operating restrictions.

(d) There must be means to ensure compliance with paragraphs (b) and (c) of this section under any reasonably probable failure of any ventilating, heating, or other system or equipment.

(e) The fresh air supply to compartments normally occupied by passengers or crew must not, unless suitably ducted, pass through any compartment inaccessible in flight.

(f) In rotorcraft employing a recirculating air-conditioning system, it must be possible to stop the system and still maintain the fresh air supply in compliance with paragraphs (a) and (e) of this section. (See ACB 29.831.)

29.833 Heaters

Each combustion heater must be Approved and must meet the fire protection requirements of section 29.859.

FIRE PROTECTION

29.851 Fire extinguishers

(a) *Hand fire extinguishers.* For hand fire extinguishers the following apply:

(1) Each hand fire extinguisher must be Approved.

(2) The kinds and quantities of each extinguishing agent used must be appropriate to the kinds of fires likely to occur where that agent is used.

(3) Each extinguisher for use in a personnel compartment must be designed to minimise the hazard of toxic gas concentrations.

(b) *Built-in fire extinguishers.* If a built-in fire extinguishing system is required —

(1) The capacity of each system, in relation to the volume of the compartment where used and the ventilation rate, must be adequate for any fire likely to occur in that compartment.

(2) Each system must be installed so that —

(i) No extinguishing agent likely to enter personnel compartments will be present in a quantity that is hazardous to the occupants; and

(ii) No discharge of the extinguisher can cause structural damage.

29.853 Compartment interiors

For each compartment to be used by the crew or passengers —

(a) The materials (including finishes or decorative surfaces applied to the materials) must meet the following test criteria as applicable: (See ACB 29.853(a).)

(1) Interior ceiling panels, interior wall panels, partitions, galley structure, large cabinet walls, structural flooring, and materials used in the construction of stowage compartments (other than underseat stowage compartments and compartments for stowing small items such as magazines and maps) must be self-

29.853(a) (continued)

extinguishing when tested in accordance with the 'Vertical' test in Appendix F of BCAR 29, or other Approved equivalent methods. The average burn length may not exceed 150 mm (6 in) and the average flame time after removal of the flame source may not exceed 15 seconds. Drippings from the test specimen may not continue to flame for more than an average of 3 seconds after falling.

(2) Floor covering, textiles (including draperies and upholstery), seat cushions, padding, decorative and non-decorative coated fabrics, leather, trays and galley furnishings, electrical conduit, thermal and acoustical insulation and insulation covering, air ducting joint and edge covering, cargo compartment liners, insulation blankets, cargo cover, and transparencies, molded and thermoformed parts, air ducting joints, and trim strips (decorative and chafing) that are constructed of materials not covered in paragraph (a)(3) of this section, must be self-extinguishing when tested in accordance with the 'Vertical' test in Appendix F of BCAR 29, or other Approved equivalent methods. The average burn length may not exceed 200 mm (8 in) and the average flame time after removal of the flame source may not exceed 15 seconds. Drippings from the test specimen may not continue to flame for more than an average of 5 seconds after falling.

(3) Acrylic windows and signs, parts constructed in whole or in part of elastomeric materials, edge lighted instrument assemblies consisting of two or more instruments in a common housing, seat belts, shoulder harnesses, and cargo and baggage tiedown equipment, including containers, bins, pallets, etc., used in passenger or crew compartments, may not have an average burn rate greater than 64 mm/min (2·5 in/min) when tested in accordance with the 'Horizontal' test of Appendix F of BCAR 29 or other Approved equivalent methods.

(4) Except for electrical wire and cable insulation, and for small parts (such as knobs, handles, rollers, fasteners, clips, grommets, rub strips, pulleys, and small electrical parts) that the Authority finds would not contribute significantly to the propagation of a fire, materials in items not specified in paragraphs (a)(1), (a)(2), or (a)(3) of this section may not have a burn rate greater than 100 mm/min (4 in/min) when tested in accordance with the 'Horizontal' test in Appendix F of BCAR 29 or other Approved equivalent methods.

29.853 (continued)

(b) [Reserved for FAR]

(c) If smoking is to be prohibited, there must be a placard so stating, and if smoking is to be allowed —

(1) There must be an adequate number of self-contained removable ashtrays; and

(2) Where the crew compartment is separated from the passenger compartment, there must be at least one illuminated sign (using either letters or symbols) notifying all passengers when smoking is prohibited. Signs which notify when smoking is prohibited must —

(i) When illuminated, be legible to each passenger seated in the passenger cabin under all probable lighting conditions; and

(ii) Be so constructed that the crew can turn the illumination on and off.

(d) Each receptacle for towels, paper, or waste must be at least Fire-resistant and must have means for containing possible fires. Fire containment must be established by demonstration. (See ACB 29.853(d).)

(e) Lavatories must be considered as non-smoking compartments. Also —

(1) In addition to a placard inside the compartment required by paragraph (c) of this section there must be a 'No Smoking in Lavatory' placard outside the compartment at the point of entry.

(2) An ash container must be provided adjacent to each placard required by sub-paragraph (1) of this paragraph, and paragraph (c) of this section.

(f) There must be a hand fire extinguisher for the flight-crew members.

(g) At least the following number of hand fire extinguishers must be conveniently located in passenger compartments:

Passenger capacity:	Fire extinguishers
7 through 30	1
31 through 60	2
61 or more	3

29.855 Cargo and baggage compartments

(a) Each cargo and baggage compartment must be constructed of, or lined with, materials that have a resistance to fire at least equivalent to aluminium alloy.

29.855 (continued)

(b) No compartment may contain any controls, wiring, lines, equipment, or accessories whose damage or failure would affect safe operation, unless those items are protected so that —

(1) They cannot be damaged by the movement of cargo in the compartment; and

(2) Their breakage or failure will not create a fire hazard.

(c) The design and sealing of inaccessible compartments must be adequate to contain compartment fires until a landing and safe evacuation can be made, or equipped with fire detecting, indicating and extinguishing apparatus.

(d) Each cargo and baggage compartment that is not sealed so as to contain cargo compartment fires completely without endangering the safety of a rotorcraft or its occupants must be designed, or must have a device, to ensure detection of fires by a crew member while at his station and to prevent the accumulation of harmful quantities of smoke, flame, extinguishing agents, or other noxious gases in any crew or passenger compartment. This must be shown by flight tests.

(e) For rotorcraft used for the carriage of cargo only, the cabin area may be considered a cargo compartment and, in addition to paragraphs (a) through (d) of this section, the following apply:

(1) There must be means to shut off the ventilating airflow to or within the compartment. Controls for this purpose must be accessible to the flight crew in the crew compartment.

(2) Required crew emergency exits must be accessible under all cargo loading conditions.

(f) Sources of heat within each compartment must be shielded and insulated to prevent igniting the baggage and cargo.

29.859 Combustion heater fire protection

(a) *Combustion heater fire zones.* The following combustion heater fire zones must be protected against fire under the applicable provisions of sections 29.1181 through 29.1191, and 29.1195 through 29.1203:

(1) The region surrounding any heater, if that region contains any Flammable fluid system components (including the heater fuel system), that could —

(i) Be damaged by heater malfunctioning; or

29.859(a) (continued)

(ii) Allow flammable fluids or vapours to reach the heater in case of leakage.

(2) Each part of any ventilating air passage that —

(i) Surround the combustion chamber; and

(ii) Would not contain (without damage to other rotorcraft components) any fire that may occur within the passage.

(b) *Ventilating air ducts.* Each ventilating air duct passing through any fire zone must be Fireproof. In addition —

(1) Unless isolation is provided by fireproof valves or by equally effective means, the ventilating air duct downstream of each heater must be Fire-proof for a distance great enough to ensure that any fire originating in the heater can be contained in the duct; and

(2) Each part of any ventilating duct passing through any region having a flammable fluid system must be so constructed or isolated from that system that the malfunctioning of any component of that system cannot introduce flammable fluids or vapours into the ventilating airstream.

(c) *Combustion air ducts.* Each combustion air duct must be Fireproof for a distance great enough to prevent damage from backfiring or reverse flame propagation. In addition —

(1) No combustion air duct may communicate with the ventilating airstream unless flames from backfires or reverse burning cannot enter the ventilating airstream under any operating condition, including reverse flow or malfunction of the heater or its associated components; and

(2) No combustion air duct may restrict the prompt relief of any backfire that, if so restricted, could cause heater failure.

(d) *Heater controls; general.* There must be means to prevent the hazardous accumulation of water or ice on or in any heater control component, control system tubing, or safety control.

(e) *Heater safety contols.* For each combustion heater, safety control means must be provided as follows:

29.859(e) (continued)

(1) Means independent of the components provide for the normal continuous control of air temperature, airflow, and fuel flow must be provided, for each heater, to automatically shut off the ignition and fuel supply of that heater at a point remote from that heater when any of the following occurs:

(i) The heat exchanger temperature exceeds safe limits.

(ii) The ventilating air temperature exceeds safe limits.

(iii) The combustion airflow becomes inadequate for safe operation.

(iv) The ventilating airflow becomes inadequate for safe operation.

(2) The means of complying with subparagraph (1) of this paragraph for any individual heater must —

(i) Be independent of components serving any other heater whose heat output is essential for safe operation; and

(ii) Keep the heater off until restarted by the crew.

(3) There must be means to warn the crew when any heater whose heat output is essential for safe operation has been shut off by the automatic means prescribed in subparagraph (1) of this paragraph.

(f) *Air intakes.* Each combustion and ventilating air intake must be where no flammable fluids or vapours can enter the heater system under any operating condition —

(1) During normal operation; or

(2) As a result of the malfunction of any other component.

(g) *Heater exhaust.* Each heater exhaust system must meet the requirements of sections 29.1121 and 29.1123. In addition —

(1) Each exhaust shroud must be sealed so that no flammable fluids or hazardous quantities of vapours can reach the exhaust systems through joints; and

(2) No exhaust system may restrict the prompt relief of any backfire that, if so restricted, could cause heater failure.

29.859 (continued)

(h) *Heater fuel systems.* Each heater fuel system must meet the powerplant fuel system requirements affecting safe heater operation. Each heater fuel system component in the ventilating airstream must be protected by shrouds so that no leakage from those components can enter the ventilating airstream.

(i) *Drains.* There must be means for safe drainage of any fuel that might accumulate in the combustion chamber or the heat exchanger. In addition —

(1) Each part of any drain that operates at high temperatures must be protected in the same manner as heater exhausts; and

(2) Each drain must be protected against hazardous ice accumulation under any operating condition.

29.861 Fire protection of structure, controls, and other parts

Each part of the structure, controls, and the rotor mechanism, and other parts essential to controlled landing and (for Group A) flight that would be affected by Power-plant fires must be isolated under section 29.1191, or must be —

(a) For Group A and B Rotorcraft, Fireproof.

(b) [*Deleted in BCAR 29*]

29.863 Flammable fluid fire protection

(a) In each area where Flammable fluids or vapours might escape by leakage of a fluid system, there must be means to minimise the probability of ignition of the fluids and vapours, and the resultant hazards if ignition does occur.

(b) Compliance with paragraph (a) of this section must be shown by analysis or tests, and the following factors must be considered:

(1) Possible sources and paths of fluid leakage, and means of detecting leakage.

(2) Flammability characteristics of fluids, including effects of any combustible or absorbing materials.

(3) Possible ignition sources, including electrical faults, overheating of equipment, and malfunctioning of protective devices.

29.863 (b)(continued)

(4) Means available for controlling or extinguishing a fire, such as stopping flow of fluids, shutting down equipment, fireproof containment, or use of extinguishing agents.

(5) Ability of rotorcraft components that are critical to safety of flight to withstand fire and heat.

(c) If action by the flight crew is required to prevent or counteract a fluid fire (e.g. equipment shutdown or actuation of a fire extinguisher), quick acting means must be provided to alert the crew.

(d) Each area where Flammable fluids or vapours might escape by leakage of a fluid system must be identified and defined.

(e) Whenever lagging is used in compartments in which pipes, tanks or equipment containing Flammable fluids are installed, suitable precautions must be taken to prevent the wetting of the lagging by Flammable fluids as a result of normal operation, failures of the equipment, or leakage from joints or unions.

EXTERNAL LOAD ATTACHING MEANS

29.865 External load attaching means

(a) It must be shown that the rotorcraft external load attaching means can withstand a limit static load equal to 2·5 times the maximum external load for which authorisation is requested, applied at any angle from the vertical expected in service but not less than:—

(1) From directly ahead to 90° either side, an angle of 15° to the vertical axis of the rotorcraft; and

(2) From 90° either side to directly rearwards, an angle which increases from 15° to a maximum of 30° directly rearwards. (See ACB 29.865(a).)

(b) *Release devices.* The external load attaching means must include a device to enable the pilot to release the external load quickly both during flight and when in contact with the ground. This quick-release device, and the means by which it is controlled, must comply with the following:

(1) A control for the quick-release device must be installed on one of the pilot's primary controls and must be designed and located so that it may be operated by the pilot without hazardously limiting his ability to control the rotorcraft during an emergency situation.

29.865(b) (continued)

(2) In addition a manual mechanical control for the quick-release device, readily accessible either to the pilot or to another crew member, must be provided.

(3) The quick-release device must function properly with all external loads up to and including the maximum external load for which authorisation is requested.

(4) Release devices and their controls must be arranged so as to minimise the possibility of inadvertent operation.

(5) *Automatic release means.* Any means by which the load is automatically released when it touches the ground shall, to avoid inadvertent release (e.g. in turbulence) be such that the pilot is able to prevent the means from operating in flight. (See ACB 29.865(b)(5).)

(c) A placard or marking must be installed next to the external load attaching means stating the maximum authorised external load as demonstrated under this section.

(d) For rotorcraft approved for carrying external loads which incorporate an automatic device for releasing the loads, the minimum safe weight of the external load must be placarded beside the external load attaching means.

MISCELLANEOUS

29.871 Levelling marks

There must be reference marks for levelling the rotorcraft on the ground.

29.873 Ballast provisions

Ballast provisions must be designed and constructed to prevent inadvertent shifting of ballast in flight.

29.877 [*Reserved for FAR*]

29.899 Electrical bonding and protection against lightning and static electricity (See also section 29.610)

(a) The electrical bonding and protection against lightning and static electricity systems must be such as to:—

(1) Protect the rotorcraft including its systems and equipment;

(2) Prevent dangerous accumulation of electrostatic charge;

(3) Minimise the possibility of electrical shock from the electricity supply and distribution system;

(4) Provide an adequate electrical return path on rotorcraft having earthed electrical systems;

(5) Prevent electrical interference with the functioning of Essential Services or Essential Systems.

(6) Prevent deterioration of structural strength and fatigue characteristics, and to prevent deformation, particularly of composite material structures. (See ACB 29.899(a).)

(b) A schedule for resistance and continuity measurements must be submitted to the Authority. The measurements must also be made on all series rotorcraft. (See ACB 29.899(b).)

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Subpart E — Power-plant

GENERAL

29.901 Installation

(a) For the purpose of this BCAR 29, the Power-plant installation includes each part of the rotorcraft (other than the main and auxiliary rotor structures, that—

(1) Is necessary for propulsion;

(2) Affects the control of the major propulsive units; or

(3) Affects the safety of the major propulsive units between normal inspections or overhauls (see BCAR 29-1, paragraph 2.)

(b) For each Power-plant installation—

(1) The installation must comply with—

(i) The installation instructions provided under JAR-E, Chapter C4-1, paragraph 3; and

(ii) The applicable provisions of this Subpart.

(2) Each component of the installation must be constructed, arranged, and installed to ensure its continued safe operation between normal inspections or overhauls;

(3) Accessibility must be provided to allow any inspection and maintenance necessary for continued airworthiness;

(4) Electrical interconnections must be provided to prevent differences of potential between major components of the installation and the rest of the rotorcraft (see ACB 29.901(b)(4));

(5) Axial and radial expansion of turbine engines may not affect the safety of the installation; and

(6) It must be arranged, so far as is practicable, so that dirt cannot accumulate in inaccessible places.

(c) For each Power-plant and auxiliary Power-unit installation a safety assessment of the power-plant systems must be made to establish the probability and consequences of failures. This assessment must establish that no single failure or malfunction or probable combination of failures will jeopardise the safe operation of the rotorcraft except that—

(1) The failure of structural elements need not be considered if the probability of such failure is Extremely Remote; and

29.901(c) (continued)

(2) The failure of engine rotor discs need not be considered. (See ACB 29.901(c).)

(d) Each auxiliary Power-unit and gas turbine starter installation must meet the applicable provisions of this Subpart.

(e) *Incorrect assembly*

(1) Precautions must be taken in the design and arrangement of the Power-plant installation to minimise the risk of incorrect assembly.

(2) Where non-return valves are such that their correct functioning is essential for the safe operation of the system, design precautions must be taken to minimise the risk of the valve being assembled or connected so that it operates in the reverse sense. (See ACB 29.901(e).)

(f) *Crash fire hazard.* Design precautions must be taken to minimise the risk of fire in the Emergency Landing Conditions of section 29.561. Particular attention must be paid to the design, location and protection of all systems carrying Flammable fluids and the juxtaposition of such systems and items of electrical systems. (See ACB 29.901(f).)

(g) *Ground and flight tests.* The satisfactory functioning of the Power-plant must be demonstrated by ground and flight tests over the range of operating conditions for which certification is required. This will normally include tests in hot climatic conditions. (See ACB 29.901(g).)

29.903 Engines

(a) *Engine type certification.* Each engine must have a type certificate.

(b) *Group A; engine isolation.* For each Group A Rotorcraft, the Power-plants must be arranged and isolated from each other to allow operation, in at least one configuration, so that the failure or malfunction of any engine, or the failure of any system or component that can affect any engine, will not—

(1) Prevent the continued safe operation of the remaining engines; or

(2) Require immediate action by any crew member for continued safe operation. (See ACB 29.903(b).)

29.903 (continued)

(c) *Group A; control of engine rotation.* For each Group A Rotorcraft; there must be means for stopping any engine individually in flight, except that, for turbine engine installations, the means for stopping the engine need be provided only where necessary for safety. In addition—

(1) Each component of the engine stopping system that is located on the engine side of the firewall, and that might be exposed to fire, must be at least Fire-resistant; or

(2) [*Deleted in BCAR 29*]

(3) Means must be provided for stopping combustion and for preventing hazardous rotation of any engine both on the ground and in flight.

(d) [Reserved for FAR]

(e) *Starting*

(1) Means to restart any engine in flight must be provided.

(2) The design must minimise the probability of fire or mechanical damage as a result of starting in any permitted conditions.

(3) *Starting tests.* Any techniques and associated limitations must be established by test. (See ACB 29.903(e)(3).)

(4) Any delay that may be necessary before attempting to restart the engine must not hazard the rotorcraft.

(5) For Group A turbine engine installations:—

(i) An altitude and airspeed envelope within which it is possible to consistently restart the engine must be established by flight test and must be such that it is adequate for the safe operation of the rotorcraft. The envelope must not exceed that recommended by the engine constructor unless otherwise agreed by the Authority.

(ii) If, with all engines inoperative, the windmilling speed of the engine is insufficient to provide the power required for restarting, a power source must be provided for in-flight restarting of engines without undue delay within the relight envelope. Compliance must be demonstrated in flight, simulating the required conditions. (See ACB 29.903(e)(5).)

(6) There must not be a fire hazard when restarting engines after a False Start. (See ACB 29.903(e)(6).)

29.903(e) (continued)

(7) The minimum drainage period following an Abortive Start of False Start before a further attempt to start may be made must be established. Successive attempts to restart up to the maximum number permitted must not involve a risk of fire.

(8) A means of indicating to the flight crew when a starter is energised must be provided, unless it can be established that if the starter remains energised after the engine has started, or subsequently is energised as a result of a failure, no hazard would result.

(f) *Turbine engine installation.* For turbine engine installations, —

(1) *Torching flames.* Precautions must be taken where necessary to minimise the possibility of torching flames from any likely burn-through of any part of the engine causing damage that could hazard the rotorcraft. (See ACB 29.903(f)(1).)

(2) The Power-plant systems associated with engine control devices, systems and instrumentation must be designed to give reasonable assurance that those engine operating limitations that adversely affect turbine rotor structural integrity will not be exceeded in service.

29.907 Powerplant vibration

(a) For turbine-engined rotorcraft each engine must be installed to prevent the harmful vibration of any part of the engine or rotorcraft. (See ACB 29.907(a).)

(b) The addition of the rotor and the Transmission System to the engine may not subject the principal rotating parts of the engine to excessive vibration stresses. This must be shown by a vibration survey. (See ACB 29.907(b).)

(c) Acceptable levels of vibration must be established at specific reference stations on the rotorcraft in order to allow the acceptability of rotorcraft when new, in service and after overhaul to be assessed.

(d) A vibration survey of the Rotor and Transmission System must be made over the full range of both ground and flight conditions. Also—

(1) For twin turbine-engined rotorcraft, the survey must include an investigation of the effects of operating with each engine stopped under all conditions up to Rotor Maximum Contingency Torque and up to 105% of the highest rotor RPM declared together with the effects of engine malfunctioning.

29.907(d) (continued)

(2) For single turbine-engined rotorcraft an investigation of the effects of engine malfunctioning must be carried out.

(e) It must be demonstrated that no dangerous torsional or flexural vibration or whirling of shafting can occur in the rotorcraft at any possible torque and at any rotational speed up to,

(i) In the case of the Rotor System:

(A) 115% of the Rotor Maximum RPM (Power On),

(B) 105% of the Rotor Never Exceed RPM,

whichever is the greater,

(ii) In the case of the remaining parts of the transmission:

(A) 105% of the Rotor Maximum RPM (Power On),

(B) the Rotor Never Exceed RPM,

whichever is the greater. (See ACB 29.907(e).)

29.908 Cooling fans

For cooling fans the following apply:

(a) The effects of failures of the cooling fans must be shown to meet the requirements of the Safety Assessment appropriate to the rotorcraft category having regard to both fan integrity and loss of cooling. (See paragraph 29.917(c).)

(b) Where reliance is placed on cooling fans for continued safe operation, they must possess integrity of the same order as that of the Rotor System, having regard to all possible failure modes. (See ACB 29.908.)

ROTOR AND TRANSMISSION SYSTEM

29.917 Design

(a) *General*

(1) The Transmission System includes any part necessary to transmit power from the engines to the Rotor hubs. This includes gear boxes, shafting, universal joints, couplings, Rotor brake assemblies, clutches, supporting bearings for shafting, any attendant accessory pads or drives, and any cooling fans that are a part of, attached to, or mounted on the Transmission System.

29.917(a) (continued)

(2) The Rotor System includes the Rotors and those parts of the Transmission System necessary to maintain lift and control during autorotation.

(3) A Rotor is a single system of rotating aerofoils together with the rotor hub, blade dampers and those parts of the pitch control mechanisms and the de-icing system which rotates with the aerofoils.

(b) The Rotor and Transmission System must be such as to enable satisfactory functioning over the full range of conditions for which certification is sought and must be designed to meet the requirements as follows:—

(1) *Group A and B Rotorcraft.* The probability of failure from all causes that would prevent a controlled 'power-off' descent and landing must be Very Remote.

(2) *Group A Rotorcraft.* The probability of failure from all causes that would prevent the flight to the intended destination (or for a declared time interval) and a controlled 'power-on' landing must be Very Remote. Any declared time interval must not be less than 10 minutes. (See section 29.1583(o).)

(3) *Group B Rotorcraft.* The probability of failure from all causes that would prevent a controlled 'power-on' landing must be Remote. (See ACB 29.917(b).)

(c) *Safety Assessment*

(1) The results of the Failure Analysis of paragraph (d) of this section together with any other appropriate considerations, must be used to show with reasonable confidence that the basic airworthiness objectives of paragraph (b) of this section will be met for the Rotor and Transmission System.

(2) Using the results from the Failure Analysis, a summary must be made of those failures (including combination of failures) which could affect the ability of the rotorcraft to continue flight or make a controlled landing, or could hazard the occupants, together with estimates of their probability of occurrence.

(3) (i) For compliance with paragraphs (b)(1) and (b)(2) of this section either each failure condition must be assessed to be less probable than 10^{-8} per hour of flight, or all failure conditions taken together must be assessed to be Very Remote.

29.917(c) (continued)

(ii) For compliance with paragraph (b)(3) of this section either each failure condition must be assessed to be Extremely Remote, or all failure conditions taken together must be assessed to be Remote.

(4) Where the probability of prime failures of certain single elements (e.g. shafts, spindles) cannot be sensibly estimated in numerical terms, and the failure of such elements is likely to result in Hazardous Effects, reliance must be placed on their meeting requirements, aimed at providing high integrity, such as ground endurance tests, over-torque and overspeed tests, fatigue life substantiations, etc., and their details stated in the Safety Assessment.

(5) Where the Safety Assessment shows that the acceptability of the design is dependent on one or more of the following, these must be identified in the analysis and appropriately substantiated.

(i) A safe life being determined.

(ii) Critical Parts — all such parts must be listed and appropriate manufacturing procedures established with the Authority. (See paragraphs (c)(4) and (e) of this section.)

(iii) Maintenance actions, including the verification of serviceability of items the failure of which could be dormant, being carried out at stated periods. These periods must be identified accordingly and published in the appropriate Manual.

(iv) The avoidance of single errors of assembly which could be hazardous. The appropriate vital points must be identified for inclusion in the Maintenance Manual.

(v) Verification of satisfactory functioning of safety or other devices at pre-flight or other stated periods; the details must be published in the appropriate Manuals.

(vi) The provision of specific instrumentation not otherwise required.

(6) Where the Safety Assessment objectives are met by the substantiation of a Safe Fatigue Life, the probability of fatigue failure for the component must be Extremely Remote.

29.917 (continued)

(d) *Failure Analysis*

(1) A failure analysis of the complete Rotor and Transmission System must be carried out, in order to assess the likely consequence of all conceivable failures.

(2) Where significant doubt exists on the effects of failures or likely combinations of failures, the Authority may require any assumptions to be verified by test.

(3) Where reliance is placed on safety devices, instrumentation, early warning devices, maintenance checks etc., to limit the effects of a failure, the analysis must cover the safety system failure in combination with the basic Rotor and Transmission System failure. (See ACB 29.917(d).)

(e) *Critical Parts*

(1) *Definition.* Where the Safety Assessment of paragraph (c) of this section shows a part must achieve and maintain a particularly high level of integrity if the design criteria of paragraph (b) of this section are to be met then the part is a Critical Part (an alternative name may be agreed with the Authority).

(2) *Manufacture.* Critical Parts must be subjected to a manufacturing control procedure agreed by the Authority. The procedure must identify:—

(i) The design features influencing the integrity of the Critical Part.

(ii) The detailed manufacturing process including material manufacture, forging procedures, tooling standards and acceptable standards.

(iii) The source of supply.

(iv) The procedure which must be followed before a change can be made to any of the factors in subparagraphs (i) (ii) or (iii) of this paragraph.

(3) Critical Parts and other such parts as may be required by the Authority must be marked, and the constructor must maintain records related to the marking, such that it is possible to establish the relevant manufacturing history of the parts.

29.917 (continued)

(4) In cases where the integrity of the part is dependent on a safe fatigue life, or damage-tolerant characteristics, any change in the manufacturing process or design must be evaluated and subjected to re-testing to establish the effect of the change unless justified as not requiring re-testing. The use of larger reduction factors may be accepted as an alternative to testing representative specimens. (See ACB 29.917(e).)

(f) The Rotor and Transmission System must be designed to minimise the probability and consequences of failure. (See ACB 29.917(f).)

(g) *Torques.* The Rotor and Transmission System must be designed so that:—

(1) It is protected from failure caused by the application of high torques transmitted by the Power-unit(s) or resulting from control movements;

(2) Catastrophic failure must not be caused by an over-torque which can be attained under flight conditions that the rotorcraft would otherwise survive;

(3) A torque limiting device may be incorporated; (see paragraph (i)(4) of this section); and

(4) If any possible torque loading condition necessitates additional inspection or removal of any part is from service, a device must be fitted to automatically record the excursions. (See ACB 29.917(g).)

(h) *Clutches*

(1) The Rotor and Transmission System must be such that any Power-unit can be started without driving the Rotor(s).

(2) Normal clutch engagement must not result in excessive stresses in the Rotor and Transmission System.

(3) Where inadvertent engagement of any clutch is possible, it must not produce damaging stresses in the Rotor and Transmission System. (See ACB 29.917(h).)

(i) *Arrangement.* Rotor and Transmission Systems must be arranged as follows:

(1) Each Rotor and Transmission System of multi-engine rotorcraft must be arranged so that Rotor(s) and other units necessary for oepration and control will continue to be driven by the remaining Power-unit(s) if any Power-unit(s) fails.

29.917(j) (continued)

(2) The Rotor and Transmission System must be so arranged that each rotor necessary for control in autorotation will continue to be driven by the main rotors after disengagement of all Power-units from the main and auxiliary rotors.

(3) The Transmission System must incorporate a unit for each Power-unit to automatically disengage that Power-unit from the main and auxiliary rotors to prevent the Rotor System from driving that Power-unit. The free-wheel must be so located that failure of any component not part of the Rotor System cannot affect the continued operation of the free-wheel. On multi-engined rotorcraft, the free-wheels of each gear train must be designed and arranged such that a single failure cannot affect more than one free-wheel.

(4) If a torque limiting device is used in the Rotor and Transmission System, it must be located so as to allow continued control of the rotorcraft when the device is operating. Such a device must have a torque limiter setting at least 10% above the declared Rotor Maximum Over-Torque value.

(5) If the rotors must be phased for intermeshing, each system must provide constant and positive phase relationship under any operating condition.

(6) If a rotor de-phasing device is incorporated, there must be means to keep the rotors locked in proper phase before operation. At all other points, the design and procedures must minimise the possibility of reassembling the Transmission System so that the Rotors are incorrectly phased.

(j) For equipment drives from the Transmission System see section 29.1163.

(k) *Provision for instruments*

(1) All necessary provision must be made in the Transmission System for the fitment and operation of the mandatory items of equipment prescribed in section 29.1305. Where in presenting the Fault Analysis or in complying with any other requirements, dependence is placed on instrumentation which is not otherwise mandatory, approval of the rotorcraft is dependent on the provision of such instrumentation. (See ACB 29.917(k)(1).)

29.917(k) (continued)

(2) A statement must be submitted to the Authority by the constructor listing the instruments necessary for satisfactory operation of the Rotor and Transmission System. The overall limits of accuracy required of such instruments for the purpose of enabling the flight crew to control satisfactorily the operation of the systems must also be stated so that the suitability of the instruments as installed may be assessed. Due regard must be given to possible inaccuracies in reading the instruments. (See ACB 29.917(l)(2).)

29.921 Rotor brake

(a) If there is a means to control the rotation of the Transmission System independently of the engine, any limitations on the use of that means must be specified, and the control for that means must be guarded to prevent inadvertent operation.

(b) The rotor brake must be designed to minimise the risk of fires initiated by the brake. (See section 29.1151).)

29.923 Rotor and Transmission System and control mechanism tests

[*Reserved for BCAR 29*]

29.927 Additional tests

[*Reserved for BCAR 29*]

29.931 Shafting critical speed

(a) The critical speeds of any shafting must be determined by demonstration except that analytical methods may be used if reliable methods of analysis are available for the particular design.

(b) If any critical speed lies within, or close to, the operating ranges for idling, power-on, and autorotative conditions, the stresses occurring at that speed must be within safe limits. This must be shown by tests.

(c) If analytical methods are used and show that no critical speed lies within the permissible operating ranges, the margins between the calculated critical speeds and the limits of the allowable operating ranges must be adequate to allow for possible variations between the computed and actual values.

29.935 Shafting joints

Each universal joint, slip joint, and other shafting joints whose lubrication is necessary for operation must have provision for lubrication.

29.939 Turbine engine operating characteristics

(a) Turbine engine operating characteristics must be investigated in flight to determine that no adverse characteristics (such as stall, surge, or flameout) are present, to a hazardous degree, during normal and emergency operation within the range of operating limitations of the rotorcraft and of the engine.

(b) (1) The turbine engine air inlet system may not, as a result of airflow distortion during normal operation, cause vibration harmful to the engine.

(2) For multi-engined rotorcraft, the air flow condition at each engine air inlet system must be investigated by operating adjacent engine(s) at the same and at different conditions over the whole range of engine operating conditions.

(3) During the investigation of sub-paragraph (2) of this paragraph the effect of the malfunctioning of adjacent engine(s) must be included. (See ACB 29.907(a)(2).)

(c) For governor-controlled engines, it must be shown that there exists no hazardous torsional instability of the Transmission System associated with critical combinations of power, rotational speed, and control displacement.

29.945 Thrust or power augmentation system

(a) Each engine refrigerant (i.e. normally water-methanol or water) injection system must meet the appropriate requirements of this Subpart.

(b) The quantity of engine refrigerant available for the use of each engine must be sufficient to allow operation of the rotorcraft under the procedures for the use of the augmented power system. (See paragraph 29.1305(a)(5).)

(c) *Engine refrigerant quantity indicators*

(1) Where fluid is intended for use only during take-off, means must be provided to indicate, when the rotorcraft is on the ground, the quantity of fluid in each tank.

29.945(c) (continued)

(2) *Take-off and other conditions.* Where fluid is intended for use during take-off and other flight conditions, means must be provided to indicate to the flight crew, both when on the ground and in flight, the quantity of fluid in each tank. The indicators must comply with the appropriate requirements of paragraphs 29.1337(b)(1) and (b)(6).

FUEL SYSTEM

29.951 General

(a) Each fuel system must be constructed and arranged to ensure a flow of fuel at a rate and pressure established for proper engine and auxiliary power unit functioning under any likely operating conditions, including the manoeuvres for which certification is requested and during which the engine or auxiliary power unit is permitted to be in operation.

(b) Each fuel system must be arranged so that—

(1) No engine or fuel pump can draw fuel from more than one tank at a time; or

(2) There are means to prevent introducing air into the system.

(c) Each fuel system for a turbine engine must be capable of sustained operation throughout its flow and pressure range with fuel initially saturated with water at 80° F and having 0·75 cc of free water per gallon added and cooled to the most critical condition for icing likely to be encountered in operation.

(d) Fuels approved for use must be such that any likely interaction between them and the materials used in the system will not adversely affect the fuel system. Where doubt exists compatibility must be demonstrated by test.

(e) *Leakage and Spillage.* Components, such as tank outlets and drains, from which fuel may leak or be spilled must be positioned so that spilt or leaking fuel cannot cause a fire hazard.

(f) *Tests.* A schedule of ground and flight tests (as appropriate) of the fuel system and its component parts must be prepared and agreed with the Authority.

29.953 Fuel system independence

(a) For Group A rotorcraft—

29.953(a) (continued)

(1) The fuel system must meet the requirements of paragraph 29.903(b); and

(2) Unless other provisions are made to meet subparagraph (1) of this paragraph, the fuel system must allow fuel to be supplied to each engine through a system independent of those parts of each system supplying fuel to other engines.

(b) Each fuel system for a multi-engine Group B Rotorcraft must meet the requirements of paragraph (a)(2) of this section. However, separate fuel tanks need not be provided for each engine. Where a single tank is provided there must be:—

(1) At least two independent vents;

(2) A separate outlet to each engine; and

(3) A shut-off valve at each outlet.

(c) If the fuel supply to any fuel consuming device (other than the main engines) is taken from the main rotorcraft fuel system it must, unless equivalent safety can be shown, be taken direct from the tank and not from a tapping on an engine fuel line.

(d) Where auxiliary Power-units provide Essential Services in flight during emergency conditions, their fuel system must be so arranged that:—

(1) The quantity of fuel available is sufficient to ensure continuous operation of the auxiliary power unit for a period appropriate to the intended use; and

(2) A means is provided to preclude any likely contaminants (e.g. water, ice deposits) affecting the functioning of the auxiliary power unit.

29.954 Fuel system lightning protection

(a) The fuel storage system of the rotorcraft must either be so situated that it is most unlikely to be struck by lightning or must be so protected that in the event of it being struck by lightning a Catastrophic Effect is not likely to occur.

(b) The outlets of venting and jettisoning systems must be so located and designed that:—

(i) The probability of them being struck by lightning is Extremely Remote,

(ii) They will not under any atmospheric conditions which the rotorcraft may encounter produce corona discharges of such magnitudes as will ignite any fuel/air mixtures of the ratios likely to be present,

29.954(b) (continued)

(iii) The fuel and its vapours in Flammable concentrations will not pass close to parts of the rotorcraft which will produce corona discharges capable of igniting fuel/air mixtures.

(c) The fuel system of the rotorcraft must be so designed in relation to the main earth system that the passage of lightning discharges through the main earth system will not produce, by the processes of conduction or induction, such potential differences as will cause electrical sparking through areas where they may be Flammable vapours. (See ACB 29.954.)

29.955 Fuel flow

(a) Each fuel system must provide at least 100% of the fuel flow required under the intended operating conditions and manoeuvres. This must be shown as follows:

(1) Fuel must be delivered to each engine at a pressure within the limits specified in the Engine Type Certificate Data Sheet.

(2) The quantity of fuel in the tank may not exceed the sum of the amount established as the unusable fuel supply for that tank under section 29.959 plus that necessary to show compliance with this section.

(3) Each main pump must be used that is necessary for each operating condition and attitude for which compliance with this section is shown, and the appropriate emergency pump must be substituted for each main pump so used.

(4) [*Deleted in BCAR 29*]

(5) Moving parts of flowmeters must, for the purposes of the test, be fixed in a position that will produce the maximum pressure loss obtainable as a result of malfunctioning.

(b) If an engine can be supplied with fuel from more than one tank—

(1) For piston-engined rotorcraft the fuel system must feed promptly when fuel becomes low in one tank and another tank is selected; or

(2) For turbine-engined rotorcraft the fuel system must prevent interruption of fuel flow to the engine, without attention by the flight crew, when fuel is depleted in the tank supply the engine during normal operation and another tank contains usable fuel.

29.957 Flow between interconnected tanks

(a) Where tank outlets are interconnected and allow fuel to flow between them due to gravity or flight accelerations, it must be impossible for fuel to flow between tanks in quantities great enough to cause overflow from the tank vent when the tanks there are full and when the rotorcraft is operated under the most adverse fuel feed conditions.

(b) If fuel can be pumped from one tank to another in flight—

(1) The design of the vents and the fuel transfer system must prevent structural damage to tanks from overfilling;

(2) [*Deleted in BCAR 29*]

29.959 Unusable fuel quantity

(a) The unusable fuel quantity must be established as not less than the quantity at which the first evidence of malfunction occurs under the most adverse fuel feed condition occurring under any intended operations and flight manoeuvres involving that tank.

(b) The effect on the unusable fuel quantity as a result of a fuel pump failure must be determined for each tank and included in the Flight Manual. (See ACB 29.959).)

29.961 Fuel system hot weather operation

(a) For each rotorcraft—

(1) The fuel system must be arranged to prevent the formation of air locks and vapour locks in the system under normal operating conditions that could cause malfunctioning of the engine; and

(2) Each suction lift fuel system and other fuel systems conducive to vapour formation must be free from vapour lock when using fuel at a temperature of at least 45°C under critical operating conditions.

(b) *Tests.* For each rotorcraft, satisfactory hot weather operation must be shown by showing that there is no evidence of vapour lock or other malfunction when the rotorcraft is climbed from the elevation of the airport selected by the applicant to an altitude of 1525 m (5000 ft) above the airport elevation, or to the maximum altitude expected in operation, whichever is greater.

29.961 (continued)

(c) Compliance with paragraph (b) of this section must be shown in flight, or on the ground under conditions closely simulating flight conditions, and with—

(1) The engines at Take-off Power at the beginning of the test and for the maximum time approved for Take-off Power, and at Maximum Continuous Power thereafter;

(2) The weight including full fuel tanks, minimum crew, and only that ballast necessary to maintain the centre of gravity within allowable limits;

(3) The speed for best rate of climb under the test conditions;

(4) Fuel at a temperature of at least 45°C at the beginning of the demonstration; and

(5) All the fuel pumps in each tank operating, and also with one pump in each tank inoperative. If only one pump is provided, the test must be made with that pump inoperative. (See ACB 29.961.)

(d) If compliance with paragraph (b) of this section is shown in weather cold enough to interfere with the proper conduct of the test, each fuel tank surface, fuel line, and other fuel system parts subject to cold air must be insulated to simulate, insofar as practicable, flight in hot weather.

29.963 Fuel tanks: general

(a) Each fuel tank must be able to withstand, without failure, the vibration, inertia, fluid, and structural loads to which it may be subjected at:—

(i) Limit Load conditions without leakage or detrimental deformation; and

(ii) Ultimate Loads without unacceptable leakage or structural Failure.

(b) Each fuel tank and its installation must be designed or protected to retain fuel without leakage under the emergency landing conditions in section 29.561. In addition, fuel tanks within the fuselage contour must be installed so that exposure of such tanks to scraping action with the ground is unlikely. (See ACB 29.963(b).)

(c) Each flexible fuel tank liner must be Approved or shown to be suitable for the particular application.

(d) Each integral fuel tank must have facilities for inspection and repair of its interior.

29.963 (continued)

(e) *Temperature of components.* The maximum exposed surface temperature of any component in the fuel tank must not exceed 200°C under any normal, malfunction or failure condition.

(f) *Materials, sealants and protective coatings.* Tank materials, sealants and any protective coatings which may be used on tank interior surfaces must be satisfactory for all normal conditions of operation.

(g) *Microbiological contamination.* Tanks must be designed and protected to minimise the possibility of corrosion as a result of microbiological contamination of fuel.

29.965 Fuel tank tests

(a) Each fuel tank must be able to withstand the applicable pressure tests in this section without failure or leakage. If practicable, test pressures may be applied in a manner simulating the pressure distribution in service. (See ACB 29.965(a).)

(b) *Proof pressure tests.* Each type of fuel tank, as installed in the rotorcraft must be subjected to the most critical of the pressures resulting from the conditions of subparagraphs (1) to (4) of this paragraph. In addition it must be shown by analysis or test that tank surfaces can withstand pressures resulting from the conditions of subparagraphs (5) and (6) of this paragraph where these are more critical.

(1) An internal pressure of 24 kN/m^2 (3·5 lbf/in^2).

(2) 125% of the maximum internal tank air pressure which is developed by the effect of ram air.

(3) The maximum pressure that could occur in a tank pressurisation system under all normal conditions and emergency conditions other than Extremely Remote.

(4) The maximum internal pressure developed during refuelling or fuel transfer taking into account the failure of the shut-off device required by paragraph 29.979(e).

(5) The total pressure developed during the most adverse combinations of rotorcraft attitude and fuel load.

(6) The pressure arising from the maximum normal acceleration(s) of the flight loads of Subpart C with the tank full.

(c) For flexible tanks the proof pressure tests must be made with the tank installed in the rotorcraft or in a representative structure.

29.965 (continued)

(d) *Vibration and surging tests.* Each tank with large unsupported or unstiffened flat areas, or with other features whose failure or deformation could cause leakage, must be subjected to the following test or its equivalent:

(1) Each complete tank assembly and its supports must be vibration-tested while mounted to simulate the actual installation.

(2) The tank assembly must be vibrated for 25 hours while two-thirds full of any suitable fluid. The amplitude of vibration may not be less than 0·8 mm (1/32 in) unless otherwise substantiated.

(3) The test frequency of vibration must be as follows:

(i) If no frequency of vibration resulting from any rpm within the normal operating range of engine or rotor system speeds is critical, the test frequency of vibration, in number of cycles per minute (cpm), must, unless a frequency based on a more rational analysis is used, be the number obtained by averaging the maximum and minimum power-on engine speeds (rpm) for reciprocating-engine-powered rotorcraft or 2,000 cpm for turbine-engine-powered rotorcraft.

(ii) If only one frequency of vibration resulting from any rpm within the normal operating range of engine or rotor system speeds is critical, that frequency of vibration must be the test frequency.

(iii) If more than one frequency of vibration resulting from any rpm within the normal operating range of engine or rotor system speeds is critical, the most critical of these frequencies must be the test frequency.

(4) Under subparagraphs (3)(ii) and (iii), the time of test must be adjusted to accomplish the same number of vibration cycles as would be accomplished in 25 hours at the frequency specified in subparagraph (3)(i).

(5) During the test, the tank assembly must be rocked at the rate of 16 to 20 complete cpm through an angle of 15° on both sides of the horizontal (30° total), about the most critical axis, for 25 hours. If motion about more than one axis is likely to be critical, the tank must be rocked about each critical axis for 12½ hours.

29.967 Fuel tank installation

(a) Each fuel tank must be supported so that tank loads are not concentrated on unsupported tank surfaces. In addition—

(1) There must be pads, if necessary, to prevent chafing between each tank and its supports:

(2) The padding must be non-absorbent or treated to prevent the absorption of fuel;

(3) If flexible tank liners are used, they must be supported so that they are not required to withstand fluid loads; and

(4) Each interior surface of tank compartments must be smooth and free of projections that could cause wear of the liner, unless—

(i) There are means for protection of the liner at those points; or

(ii) The construction of the liner itself provides such protection.

(b) Any spaces adjacent to tank surfaces must be adequately ventilated to avoid accumulation of fuel or fumes in those spaces due to minor leakage. If the tank is in a sealed compartment, ventilation may be limited to drain holes that prevent clogging and that prevent excessive pressure resulting from altitude changes. If flexible tank liners are installed, the venting arrangement for the spaces between the liner and its container must maintain the proper relationship to tank vent pressures for any expected flight condition.

(c) The location of each tank must meet the requirements of paragraphs 29.1185 (b) and (c).

(d) No rotorcraft skin immediately adjacent to a major air outlet from the engine compartment may act as the wall of an integral tank.

(e) Each fuel tank must be isolated from personnel compartments by a fumeproof and fuelproof enclosure.

(f) Each fuel tank close to personnel compartments, engines, or combustion heaters must be designed, or protected and installed, to retain its contents under the loads specified in section 29.561.

29.969 Fuel tank expansion space

Each fuel tank must have an expansion space of not less than 2% of the tank capacity. It must be impossible to fill the expansion space inadvertently with the rotorcraft in the normal ground attitude.

29.971 Fuel tank sump

(a) Each fuel tank must have a sump with a capacity of not less than the greater of—

(1) 0·10% of the tank capacity; or

(2) 0·28 litres (0·5 pint).

(b) The capacity prescribed in paragraph (a) of this section must be effective with the rotorcraft in any normal attitude, and must be located so that the sump contents cannot escape through the tank outlet opening.

(c) Each fuel tank must allow drainage of hazardous quantities of water from each part of the tank to its sump with the rotorcraft in the ground attitude.

(d) Each fuel tank sump must have a drain that allows complete drainage of the sump on the ground. (See ACB 29.971.)

29.973 Fuel tank filler connection

(a) Each fuel tank filler connection must prevent the entrance of fuel into any part of the rotorcraft other than the tank itself. In addition—

(1) Each filler must be marked as prescribed in paragraph 29.1557(c)(1);

(2) Each recessed filler connection that can retain any appreciable quantity of fuel must have a drain that discharges clear of the entire rotorcraft; and

(3) Each filler cap must provide a fuel-tight seal under the pressure expected in normal operation.

(b) [*Deleted in BCAR 29*]

(c) Each fuel filling point, except pressure fuelling connection points, must have a provision for electrically bonding the rotorcraft to ground fuelling equipment.

29.975 Fuel tank vents and carburettor vapour vents

(a) *Fuel tank vents.* Each fuel tank must be vented from the top part of the expansion space so that venting is effective under normal flight conditions. In addition

(1) The vents must be arranged to avoid stoppage by dirt or ice formation;

(2) The vent arrangement must prevent siphoning of fuel during normal operation;

29.975(a) (continued)

(3) The venting capacity and vent pressure levels must maintain acceptable differences of pressure between the interior and exterior of the tank, during—

(i) Normal flight operation;

(ii) Maximum rate of ascent and descent; and

(iii) Refuelling and defuelling (where applicable);

(4) Airspaces of tanks with interconnected outlets must be interconnected;

(5) There may be no point in any vent line where moisture can accumulate with the rotorcraft in the ground attitude or the level flight attitude, unless drainage is provided; and

(6) No vent or drainage provision may end at any point—

(i) Where the discharge of fuel from the vent outlet would constitute a fire hazard; or

(ii) From which fumes could enter personnel compartments.

(b) *Carburettor vapour vents.* Each carburettor with vapour elimination connections must have a vent line to lead vapours back to one of the fuel tanks. In addition—

(1) Each vent system must have means to avoid stoppage by ice; and

(2) If there is more than one fuel tank, and it is necessary to use the tanks in a definite sequence, each vapour vent return line must lead back to the fuel tank used for take-off and landing.

(c) Where a system is provided to maintain and control fuel tank pressures on the ground and in flight, it must be automatic in operation. Means must be provided to enable the safety features of the system to be checked prior to the flight.

29.977 Fuel tank outlet

(a) There must be a fuel strainer for the fuel tank outlet or for the booster pump. This strainer must—

(1) For reciprocating-engine-powered rotorcraft, have 8 to 16 meshes per inch; and

(2) For turbine-engine-powered rotorcraft, prevent the passage of any object that could restrict fuel flow or damage any fuel system component.

29.977 (continued)

(b) The clear area of each fuel tank outlet strainer must be at least five times the area of the outlet line.

(c) The diameter of each strainer must be at least that of the fuel tank outlet.

(d) Each finger strainer must be accessible for inspection and cleaning.

(e) For turbine engine installations where the screen is likely to be subject to ice accretion, means must be provided to ensure an adequate fuel flow to the engine in these conditions.

29.979 Pressure refuelling and fuelling provisions below fuel level

(a) *Connections.* Each fuelling connection below the fuel level in each tank must have means to prevent the escape of hazardous quantities of fuel from that tank in case of malfunction of the fuel entry valve.

(b) For systems intended for pressure refuelling, a means in addition to the normal means for limiting the tank content must be installed to prevent damage to the tank in case of failure of the normal means.

(c) The rotorcraft pressure fuelling system (not fuel tanks and fuel tank vents) must withstand an ultimate load that is 2·0 times the load arising from the maximum pressure, including surge, that is likely to occur during fuelling. The maximum surge pressure must be established with any combination of tank valves being either intentionally or inadvertently closed.

(d) The rotorcraft defuelling system (not including fuel tanks and fuel tank vents) must withstand an ultimate load that is 2·0 times the load arising from the maximum permissible defuelling pressure (positive or negative) at the rotorcraft fuelling connection.

(e) An automatic shut-off means or its equivalent must be provided to prevent the quantity of fuel in each tank from exceeding the maximum quantity approved for that tank.

(f) *Drainage.* Provision must be made for the drainage of residual fuel from the pressure refuelling and defuelling system so far as is necessary to remove any hazard. (See ACB 29.979.)

FUEL SYSTEM COMPONENTS

29.991 Fuel pumps

(a) *Main pumps.* Each fuel pump required for proper engine operation, or required to meet the fuel system requirements of this subpart (other than those in paragraph (b) of this section), is a main pump. For each main pump, provision must be made to allow the bypass of positive displacement fuel pumps other than a fuel injection pump (a pump that supplies the proper flow and pressure for fuel injection when that injection is not accomplished in a carburettor) approved as part of an engine.

(b) *Emergency pumps.* There must be emergency pumps or another main pump to feed the engines immediately after the failure of any main pump (other than a fuel injection pump approved as part of the engine).

(c) *Installation.* The following fuel pump installation requirements apply:

(1) [*Deleted in BCAR 29*]

(2) The installation of fuel pumps having seals or diaphragms that may leak must have means for draining leaking fuel; and

(3) Each drain line must discharge where it will not create a fire hazard.

29.993 Fuel system lines and fittings

(a) Each fuel line must be installed and supported to prevent excessive vibration and to withstand loads due to fuel pressure, valve actuation, and accelerated flight conditions.

(b) Each fuel line connected to components of the rotorcraft between which relative motion could exist must have provisions for flexibility.

(c) Each flexible connection in fuel lines that may be under pressure or subjected to axial loading must use flexible hose assemblies.

(d) Flexible hose and their couplings must be of an Approved type or must be shown to be suitable for the particular installation.

(e) No flexible hose that might be adversely affected by high temperatures may be used where excessive temperatures will exist during operation or after engine shutdown.

(f) *Pipeline pressure relief.* Fuel pipelines which can be isolated from the remainder of the fuel system, e.g. by means of valves at each end, must incorporate provisions for the relief of excessive pressure.

29.993 (continued)

(g) *Crash protection.* Each fuel line within the fuselage that might be susceptible to damage caused by deformation of the fuselage in a potentially survivable crash must be designed and installed to allow a reasonable degree of deformation and elongation without leakage. (See ACB 29.993.)

29.995 Fuel valves

In addition to meeting the requirements of section 29.1189, each fuel valve must—

(a) [Reserved for FAR]

(b) Be supported so that no loads resulting from their operation or from accelerated flight conditions are transmitted to the lines attached to the valve.

29.997 Fuel strainer or filter

There must be a fuel strainer or filter between the fuel tank outlet and the inlet of either the fuel metering device or an engine driven positive displacement pump, whichever is nearer the fuel tank outlet. This fuel strainer or filter must—

(a) Be accessible for draining and cleaning and must incorporate a screen or element which is easily removable;

(b) Have a sediment trap and drain, except that it need not have a drain if the strainer or filter is easily removable for drain purposes;

(c) Be mounted so that its weight is not supported by the connecting lines or by the inlet or outlet connections of the strainer or filter itself, unless adequate strength margins under all loading conditions are provided in the lines and connections;

(d) Have the capacity (with respect to operating limitations established for the engine) to ensure that engine fuel system functioning is not impaired, with the fuel contaminated to a degree (with respect to particle size and density) that is greater than that established for the engine; and

(e) Have, unless there are means in the fuel system to prevent the accumulation of ice on the filter and other components susceptible to blockage by ice, means to maintain automatically the required fuel flow if ice clogging occurs.

29.999 Fuel system drains

(a) Drainage of the fuel system must be accomplished by fuel strainer drains and by the drains prescribed in section 29.971.

(b) Each drain required by paragraph (a) of this section including the drains prescribed in section 29.971 must—

(1) Discharge clear of all parts of the rotorcraft;

(2) Have manual or automatic means for positive locking in the closed position; and

(3) Have a drain valve—

(i) That is readily accessible and which can be easily opened and closed; and

(ii) That is either located or protected to prevent fuel spillage in the event of a landing with landing gear retracted.

29.1001 Fuel jettisoning system

(a) Fuel jettisoning must be demonstrated to be safe in flight under the following conditions:—

(1) Climb at the maximum rate of climb with the operating Power-units at the maximum rating Approved for the climb;

(2) Descent (see ACB 29.1001, 2);

(3) Level flight at the maximum speed for jettisoning.

(b) During the flight tests, it must also be demonstrated that:—

(1) Fuel is discharged safely, clear of all parts of the rotorcraft;

(2) Control of the rotorcraft is not adversely affected; and

(3) That jettisoning can be terminated and re-started at any time during the jettisoning operation.

(c) For Group A Rotorcraft, it must not be possible ti inadvertently reduce the available fuel during jettisoning below the quantity that will allow climb, with all engines operating, from sea-level to 1525 m (5,000 ft) followed by 30 minutes cruise, unless fuel jettisoning below this level requires the operation of a separate control after the normal jettisoning operation has been completed.

(d) Fuel jettisoning systems must be designed to comply with the Power-plant installation requirements of paragraphs 29.901(c) and 29.951(a).

29.1001 (continued)

(f) Where a fuel jettison system is installed on Group A Rotorcraft to meet operational performance requirements following a power-unit failure:—

(1) The jettisoning rate must be established, and

(2) The combined probability of Power-unit failure and a Failure precluding either:—

(i) Jettisoning of the necessary weight of fuel, or

(ii) Loss of protection against over-jettisoning, or

(iii) The system achieving the established jettisoning rate

must not be greater than Extremely Remote.

(g) A jettisoning system must be such that when jettisoning is terminated and the system is no longer in use, an explosion in any part of the jettisoning system downstream of the shut-off valve will not spread into the fuel tanks. (See ACB 29.1001 and 29.1161.)

OIL SYSTEM

29.1011 General

(a) Each engine must have an independent oil system that can supply it with an appropriate quantity of oil at temperatures and pressures within the limitations established for continuous operation.

(b) The oil system for components of the Rotor and Transmission System that require continuous lubrication must be sufficiently independent of the lubrication systems of the engines to ensure

(1) Operation with any engine inoperative; and

(2) Safe autorotation.

Such systems must supply an adequate quantity of oil at temperatures and pressures within the limitations established for continuous operation.

(c) The usable oil capacity of each system may not be less than the product of the endurance of the rotorcraft under critical operating conditions and the maximum allowable oil consumption of the engine under the same conditions, plus a suitable margin to ensure adequate circulation and cooling. Instead of a rational analysis of endurance and consumption, a usable oil capacity of one gallon for each 182 litres (40 gal) of usable fuel may be used for reciprocating engine installations.

29.1011 (continued)

(d) [*Deleted in BCAR 29*]

(e) The ability of the engine and Rotor and Transmission System oil cooling provisions to maintain the oil temperature at or below the maximum established value must be shown under the applicable requirements of sections 29.1041 through 29.1049.

(f) The oil system for the Rotor and Transmission System must be designed to satisfy the requirements of section 29.917.

(g) All atmospheric vents in the oil system must be protected against the ingress of extraneous matter and blockage by ice.

(h) Each transmission assembly must be protected so that a defective accessory cannot cause contamination of the oil supply or hazardous loss of transmission oil.

29.1013 Oil tanks

(a) *Installation.* Each oil tank installation must meet the requirements of section 29.967.

(b) *Expansion space.* Oil tank expansion space must be provided so that—

(1) Each oil tank used with a reciprocating engine has an expansion space of not less than the greater of 10% of the tank capacity or 2·27 litres (0·5 gal) and each oil tank used with a turbine engine has an expansion space of not less than 10% of the tank capacity;

(2) [*Deleted in BCAR 29*]

(3) It is impossible to fill the expansion space inadvertently with the rotorcraft in the normal ground attitude; and

(4) Each oil tank used with Transmission assemblies has an expansion space not less than 10% of the tank capacity. (See ACB 29.1013(b).)

(c) *Filler connection.* Each recessed oil tank filler connection that can retain any appreciable quantity of oil must have a drain that discharges clear of the entire rotorcraft. In addition—

(1) Each oil tank filler cap must provide an oil-tight seal under the pressure expected in operation;

(2) [*Deleted in BCAR 29*]

(3) Each oil filler must be marked under paragraph 29.1557(c)(2).

29.1013 (continued)

(d) *Vent.* Oil tanks must be vented as follows:

(1) Each oil tank must be vented from the top part of the expansion space so that venting is effective under all normal flight conditions.

(2) Oil tank vents must be arranged so that condensed water vapour that might freeze and obstruct the line cannot accumulate at any point.

(3) No vent provision may end at any point—

(i) Where the discharge of oil from the vent outlet would constitute a fire hazard, or

(ii) From which fumes could enter personnel compartments. (See ACB 29.1013(d).)

(e) *Outlet.* There must be means to prevent entrance into the tank itself, or into the tank outlet, of any object that might obstruct the flow of oil through the system. No oil tank outlet may be enclosed by a screen or guard that would reduce the flow of oil below a safe value at any operating temperature. There must be a shut-off valve at the outlet of each oil tank used with a turbine engine unless the external portion of the oil system (including oil tank supports) is Fireproof.

(f) *Flexible liners.* Each flexible oil tank liner must be Approved or shown to be suitable for the particular installation.

29.1015 Oil tank tests

Each oil tank must be designed and installed so that—

(a) It can withstand, without failure, any vibration, inertia, and fluid loads to which it may be subjected in operation; and

(b) It meets the requirements of section 29.965, except that instead of the pressure specified in paragraph 29.965(b)—

(1) For pressurised tanks used with a turbine engine, the test pressure may not be less than 35 kN/m² (5 lbf/in²) plus the maximum operating differential pressure of the tank; and

(2) 1·5 times the maximum operating differential pressure of the tank. (See ACB 29.1015 (b).)

29.1015 (continued)

(c) *Elevated temperature tests.* If the tank materials could be adversely affected by elevated temperatures, the appropriate tests must be carried out on the tank at the maximum temperature likely to be experienced in service. If the appropriate maximum temperature is not determined the test must be carried out with the fluid at a temperature of 120°C.

(d) *Cooling tests.* Cooling tests must be made under the test conditions specified in sections 29.1043 and 29.923.

29.1017 Oil lines and fittings

(a) Each oil line must meet the requirements of section 29.993.

(b) Breather lines must be arranged so that—

(1) Condensed water vapour that might freeze and obstruct the line cannot accumulate at any point;

(2) The breather discharge will not constitute a fire hazard if foaming occurs, or cause emitted oil to strike the pilot's windshield; and

(3) The breather does not discharge into the engine air induction system.

29.1019 Oil strainer or filter

(a) Each turbine engine installation must incorporate an oil strainer or filter through which all of the engine oil flows and which meets the following requirements:

(1) Each oil strainer or filter that has a bypass must be constructed and installed so that oil will flow at the normal rate through the rest of the system with the strainer or filter completely blocked.

(2) The oil strainer or filter must have the capacity (with respect to operating limitation established for the engine) to ensure that engine oil system functioning is not impaired when the oil is contaminated to a degree (with respect to particle size and density) that is greater than that established for the engine.

(3) The oil strainer or filter, unless it is installed at an oil tank outlet, must incorporate an indicator that will indicate contamination before it reaches the capacity established in accordance with subparagraph (2) of this paragraph.

29.1019(a) (continued)

(4) The bypass of a strainer or filter must be constructed and installed so that the release of collected contaminants is minimised by appropriate location of the bypass to ensure that collected contaminants are not in the bypass flow path.

(5) [*Reserved for BCAR 29*]

(b) Each oil strainer or filter in a Power-plant installation using reciprocating engines must be constructed and installed so that oil will flow at the normal rate through the rest of the system with the strainer or filter element completely blocked.

(c) Each Transmission System must have an oil strainer fitted at the suction side of each pressure and scavenge oil pump.

29.1021 Oil system drains

A drain [or drains] must be provided to allow safe drainage of the oil system. Each drain must—

(a) Be accessible; and

(b) Have manual or automatic means for positive locking in the closed position.

29.1023 Oil radiators

(a) Each oil radiator must be able to withstand any vibration, inertia, and oil pressure loads to which it would be subjected in operation.

(b) Each oil radiator air duct must be located, or equipped, so that, in case of fire, and with the airflow as it would be with and without the engine operating, flames cannot directly strike the radiator.

29.1025 Oil valves

(a) Each oil shut-off must meet the requirements of section 29.1189.

(b) [*Deleted in BCAR 29*]

(c) Each oil valve must have positive stops or suitable index provisions in the "on" and "off" positions and must be supported so that no loads resulting from its operation or from accelerated flight conditions are transmitted to the lines attached to the valve.

(d) Each engine oil shut-off means must be designed and arranged to minimise the probability of starting the engine with the shut-off means closed.

COOLING

29.1041 General

(a) The Power-plant and auxiliary Power-unit cooling provisions must be able to maintain the temperatures of Power-plant components, engine fluids, and auxiliary Power-unit components and fluids within the temperature limits established for these components and fluids, under ground, and flight operating conditions, and after normal engine or auxiliary power shutdown, or both.

(b) There must be cooling provisions to maintain the fluid temperatures in any power transmission within safe values under any critical surface (ground) and flight operating conditions.

(c) Compliance with paragraphs (a) and (b) of this section must be shown by flight tests in which the temperatures of selected Power-plant component, engine, and transmission fluids are obtained under the conditions prescribed in those paragraphs.

29.1043 Cooling tests

(a) *General.* For the tests prescribed in paragraph 29.1041(c), the following apply:

(1) If the tests are conducted under conditions deviating from the maximum ambient atmospheric temperature specified in paragraph (b) of this section, the recorded Power-plant temperatures must be corrected under paragraph (c) of this section, unless a more rational correction method is applicable.

(2) No corrected temperature determined under subparagraph (1) of this paragraph may exceed established limits.

(3) The fuel used during the cooling tests must be of the minimum grade approved for the engines, and the mixture settings must be those used in normal operation.

(4) The test procedures must be as prescribed in ACB 29.1043.

(b) The climatic conditions must be chosen in terms of the Standard Climates of BCAR 29-1, paragraph 1.4 and must not be less than the ICAO International Maximum Standard Climate of Figure 1 of BCAR 29-1.

29.1043 (continued)

(c) *Correction factor.* Unless a more rational correction applies, temperatures of engine fluids and Powerplant components for which temperature limits are established, must be corrected by adding to them the difference between the maximum ambient atmospheric temperature and the temperature of the ambient air at the time of the first occurrence of the maximum component or fluid temperature recording during the cooling test.

(d) [*Deleted in BCAR 29*]

(e) A schedule of ground and flight tests, covering all critical conditions within the range for which certification is desired must be prepared by the Applicant and must be agreed by the Authority. (See ACB 29.1043.)

29.1045 Climb cooling test procedures

[*Reserved for BCAR 29*]

29.1047 Take-off cooling test procedures

[*Reserved for BCAR 29*]

29.1049 Hovering cooling test procedures

[*Reserved for BCAR 29*]

INDUCTION SYSTEM

29.1091 Air induction

(a) The air induction system for each engine and auxiliary Power-unit must supply the air required by that engine and aixiliary Power-unit under the operating conditions for which certification is requested.

(b) Each engine and auxiliary Power-unit air induction system must provide air for proper fuel metering and mixture distribution with the induction system valves in any position.

(c) No air intake may open within the engine accessory section or within other areas of any Power-plant compartment where emergence of backfire flame would constitute a fire hazard.

(d) Each reciprocating engine must have an alternate air source.

(e) Each alternate air intake must be located to prevent the entrance of rain, ice, or other foreign matter.

(f) For turbine-engine-powered rotorcraft and rotorcraft incorporating auxiliary Power-units —

29.1091(f) (continued)

(1) There must be means to prevent hazardous quantities of fuel leakage or overflow from drains, vents, or other components of Flammable fluid systems from entering the engine or auxiliary Power-unit intake system; and

(2) The air ducts must be located or protected so as to minimise the ingestion of foreign matter during take-off, landing, and taxying.

(g) *Ingestion of parts.* All parts of the engine air intakes must be designed and arranged so that the probability of any item becoming detached and entering the engine is minimised.

29.1093 Engine intake ice protection system

(a) The requirements for de-icing and anti-icing precautions must be agreed with the Authority.

(b) *Control of engine intake ice protection systems.* A separate system for the control of the ice protection system must be provided for each engine.

29.1101 Carburettor air preheater design

Each carburettor air preheater must be designed and constructed to—

(a) Ensure ventilation of the preheater when the engine is operated in cold air;

(b) Allow inspection of the exhaust manifold parts that it surrounds; and

(c) Allow inspection of critical parts of the preheater itself.

29.1103 Induction systems ducts and air duct systems

(a) Each induction system duct upstream of the first stage of the engine supercharger and of the auxiliary power unit compressor must have a drain to prevent the hazardous accumulation of fuel and moisture in the ground attitude. No drain may discharge where it might cause a fire hazard.

(b) Engine air intake system ducts must have sufficient strength to:—

(i) For piston engine installations, prevent induction system failures resulting from backfire conditions of moderate severity; and

29.1103(b) (continued)

(ii) For turbine engine installations, withstand without failure loads arising in all conditions of engine operation, including surging and the rotorcraft design conditions, including vibration. (See ACB 29.1103.)

(c) Each duct connected to components between which relative motion could exist must have means for flexibility.

(d) Each duct within any fire zone for which a fire-extinguishing system is required must be at least—

(1) Fireproof, if it passes through any firewall; or

(2) Fire-resistant, for other ducts, except that ducts for auxiliary Power-units must be Fireproof within the auxiliary Power-unit fire zone.

(e) Each auxiliary Power-unit induction system duct must be Fireproof for a sufficient distance upstream of the auxiliary Power-unit compartment to prevent hot gas reverse flow from burning through auxiliary Power-unit ducts and entering any other compartment or area of the rotorcraft in which a hazard would be created resulting from the entry of hot gases. The materials used to form the remainder of the induction system duct and plenum chamber of the auxiliary Power-unit must be capable of resisting the maximum heat conditions likely to occur.

(f) Each auxiliary Power-unit induction system duct must be constructed of materials that will not absorb or trap hazardous quantities of Flammable fluids that could be ignited in the event of a surge or reverse flow condition.

(g) For turbine engine installations, the engine air intake arrangement must be such that no hazard will result in the event of any likely air flow reversal.

(h) The engine intake must be such as to enable the requirements of section 29.631 to be met.

29.1105 Induction system screens

If induction system screens are used—

(a) Each screen must be upstream of the carburettor;

(b) No screen may be in any part of the induction system that is the only passage through which air can reach the engine, unless it can be de-iced by heated air;

(c) No screen may be de-iced by alcohol alone; and

(d) It must be impossible for fuel to strike any screen.

29.1107 Inter-coolers and after-coolers

Each inter-cooler and after-cooler must be able to withstand the vibration, inertia, and air pressure loads to which it would be subjected in operation.

29.1109 Carburettor air cooling

It must be shown under section 29.1043 that each installation using two-stage superchargers has means to maintain the air temperature, at the carburettor inlet, at or below the maximum established value.

EXHAUST SYSTEM

29.1121 General

For Powerplant and auxiliary Power-unit installations the following apply:

(a) Each exhaust system must ensure safe disposal of exhaust gases without fire hazard or carbon monoxide contamination in any personnel compartment.

(b) Each exhaust system part with a surface hot enough to ignite Flammable fluids or vapours must be located or shielded so that leakage from any system carrying Flammable fluids or vapours will not result in a fire caused by impingement of the fluids or vapours on any part of the exhaust system including shields for the exhaust system.

(c) Each component upon which hot exhaust gases could impinge, or that could be subjected to high temperatures from exhaust system parts, must be Fireproof. Each exhaust system component must be separated by a Fireproof shield from adjacent parts of the rotorcraft that are outside the engine and auxiliary power unit compartments.

(d) No exhaust gases may discharge so as to cause a fire hazard with respect to any Flammable fluid vent or drain.

(e) No exhaust gases may discharge where they will cause a glare seriously affecting pilot vision at night.

(f) Each exhaust system component must be ventilated to prevent points of excessively high temperature.

(g) Each exhaust shroud must be ventilated or insulated to avoid, during normal operation, a temperature high enough to ignite any Flammable fluids or vapours outside the shroud.

(h) If significant traps exist, each turbine engine exhaust system must have drains discharging clear of the rotorcraft, in any normal ground and flight attitudes, to prevent fuel accumulation after the failure of an attempted engine start.

29.1121 (continued)

(i) *Exhaust-driven turbo-superchargers.* For exhaust-driven turbo-superchargers they must:—

(1) Be installed such as to permit safe use under all operating conditions;

(2) Have the turbine speed limited automatically to the maximum allowable overspeed value.

29.1123 Exhaust piping

(a) Exhaust piping must be heat- and corrosion-resistant, and must have provisions to prevent failure due to expansion by operating temperatures.

(b) Exhaust piping must be supported to withstand any vibration and inertia loads to which it would be subjected in operation.

(c) Exhaust piping connected to components between which relative motion could exist must have provisions for flexibility.

29.1125 Exhaust heat exchangers

For reciprocating-engine-powered rotorcraft the following apply:

(a) Each exhaust heat exchanger must be constructed and installed to withstand the vibration, inertia, and other loads to which it would be subjected in operation. In addition—

(1) Each exchanger must be suitable for continued operation at high temperatures and resistant to corrosion from exhaust gases;

(2) There must be means for inspecting of the critical parts of each exchanger;

(3) Each exchanger must have cooling provisions wherever it is subject to contact with exhaust gases; and

(4) No exhaust heat exchanger or muff may have stagnant areas or liquid traps that would increase the probability of ignition of Flammable fluids or vapours that might be present in case of the Failure or malfunction of components carrying Flammable fluids.

(b) If an exhaust heat exchanger is used for heating ventilating air used by personnel—

(1) There must be a secondary heat exchanger between the primary exhaust gas heat exchanger and the ventilating air system; or

(2) Other means must be used to prevent harmful contamination of the ventilating air.

POWER-PLANT CONTROLS AND ACCESSORIES

29.1141 Power-plant controls: general

(a) Power-plant controls must be located and arranged under section 29.777 and marked under section 29.1555.

(b) Each control must be located so that it cannot be inadvertently operated by persons entering, leaving, or moving normally in, the cockpit.

(c) [*Deleted in BCAR 29*]

(d) Each control must be able to maintain any set position without—

(1) Constant attention; or

(2) Tendency to creep due to control loads or vibration.

(e) Each control must be able to withstand operating loads without excessive deflection.

(f) Power-plant valve controls located in the cockpit must have—

(1) For manual valves, positive steps or in the case of fuel valves suitable index positions, in the open and closed position; and

(2) In the case of valves controlled from the cockpit other than by mechanical means, where the correct functioning of such a valve is essential for the safe operation of the rotorcraft, a valve position indicator operated by a system which senses directly that the valve has attained the position selected, unless other indications in the cockpit give the flight crew a clear indication that the valve has moved to the selected position.

(g) All Power-plant controls essential to fire fighting procedures that are located inside Designated Fire Zones must be at least Fire-resistant. (See ACB 29.1141(g).)

29.1142 Auxiliary Power-unit controls

Means must be provided on the flight deck for starting, stopping, and emergency shutdown of each installed auxiliary Power-unit.

29.1143 Engine controls

(a) There must be a separate throttle control for each engine.

(b) Throttle controls must be arranged to allow ready synchronisation of all engines by—

29.1143(b) (continued)

(1) Separate control of each engine; and

(2) Simultaneous control of all engines.

(c) Each throttle control must provide a positive and immediately responsive means of controlling its engine.

(d) Each fluid injection system control other than fuel system control must be in the throttle controls. However, the injection system pump may have a separate control.

(e) If a power or thrust control incorporates a fuel shut-off feature, the control must have a means to prevent the inadvertent movement of the control into the shut-off position. The means must—

(1) Have a positive lock or stop at the idle position; and

(2) Require a separate and distinct operation to place the control in the shut-off position.

(f) Engine power controls must also meet the requirements of paragraph 29.779(b).

29.1145 Ignition switches

(a) Ignition switches must control each ignition circuit on each engine.

(b) There must be means to quickly shut off all ignition by the grouping of switches or by a master ignition control.

(c) Each group of ignition switches, except ignition switches for turbine engines for which continuous ignition is not required, and each master ignition control must have a means to prevent its inadvertent operation. (See ACB 29.1145.)

29.1147 Mixture controls

(a) If there are mixture controls, each engine must have a separate control, and the controls must be arranged to allow—

(1) Separate control of each engine; and

(2) Simultaneous control of all engines.

(b) Each intermediate position of the mixture controls that corresponds to a normal operating setting must be identifiable by feel and sight.

29.1151 Rotor brake controls

(a) It must be impossible to apply the rotor brake inadvertently in flight.

(b) There must be means to warn the crew if the rotor brake has not been completely released before take-off.

29.1157 Carburettor air temperature controls

There must be a separate carburettor air temperature control for each engine.

29.1159 Supercharger controls

Each supercharger control must be accessible to—

(a) The pilots; or

(b) (If there is a separate flight engineer station with a control panel) the flight engineer.

29.1161 Fuel jettisoning system controls

Each fuel jettisoning system control must have guards to prevent inadvertent operation. No control may be near any fire extinguisher control or other control used to combat fire. (See section 29.1001.)

29.1163 Power-plant accessories

(a) Each engine mounted accessory must—

(1) Be Approved for mounting on the engine involved (see ACB 29.1163(2));

(2) Use the provisions on the engine for mounting; and

(3) Be sealed in such a way as to prevent contamination of the engine oil system and the accessory system.

(b) Electrical equipment subject to arcing or sparking must be installed to minimise the probability of igniting Flammable fluids or vapours.

(c) If continued rotation of an engine-driven cabin supercharger or any remote accessory driven by the engine will be a hazard if they malfunction, there must be means to prevent their hazardous rotation without interfering with the continued operation of the engine.

29.1163 (continued)

(d) Equipment drives and mountings must be designed and located to minimise the possibility of defective equipment affecting the safe functioning of the Transmission System.

(e) Accessories driven from the Transmission System must have a weak link or other means to prevent a malfunctioning accessory from applying a dangerously high torque to the system. All other parts of the Transmission System must be capable of withstanding safely the maximum torque which can result.

(f) The weak link must be designed so that its failure will not result in flailing or in loose parts causing damage to the rotorcraft.

(g) When the power absorbed by a transmission-driven accessory, e.g., electrical generator, is such as to create a hazardous condition in the event of mechanical failure of the accessory in spite of the presence of the weak link in the drive, means must be provided so that the accessory may be disengaged from the transmission while the transmission is still running.

(h) Where a means for disengagement is provided the conditions under which the accessory may be re-engaged must be established. If facilities for re-engagement in flight are provided, the technique to be employed must be declared, and demonstrated to be safe. (See ACB 29.1163.)

29.1165 Engine ignition systems

(a) Each battery ignition system must be supplemented with a generator that is automatically available as an alternate source of electrical energy to allow continued engine operation if any battery becomes depleted.

(b) The capacity of batteries and generators must be large enough to meet the simultaneous demands of the engine ignition system and the greatest demands of any electrical system components that draw from the same source.

(c) The design of the engine ignition system must account for—

(1) The condition of an inoperative generator;

(2) The condition of a completely depleted battery with the generator running at its normal operating speed; and

(3) The condition of a completely depleted battery with the generator operating at idling speed, if there is only one battery.

29.1165 (continued)

(d) Magneto ground wiring (for separate ignition circuits) that lies on the engine side of any firewall must be installed, located, or protected to minimise the probability of the simultaneous failure of two or more wires as a result of mechanical damage, electrical fault, or other cause.

(e) No ground wire for any engine may be routed through a fire zone of another engine unless each part of that wire within that zone is Fireproof.

(f) Each ignition system must be independent of any electrical circuit that is not used for assisting, controlling, or analysing the operation of that system.

(g) There must be means to warn appropriate crew members if the malfunction of any part of the electrical system is causing the continuous discharge of any battery necessary for engine ignition.

POWER-PLANT FIRE PROTECTION

29.1181 Fire precautions — general

(a) Designated Fire Zones are—

(1) The engine power section of reciprocating engines;

(2) The engine accessory section of reciprocating engines;

(3) Any complete Power-plant compartment in which there is no isolation between the engine power section and the engine accessory section, for reciprocating engines;

(4) Any auxiliary Power-unit compartment and exhaust system sections;

(5) Any fuel-burning heater and other combustion equipment installation described in section 29.859;

(6) The compressor and accessory sections of turbine engines; and

(7) The combustor, turbine, and tailpipe sections of turbine engine installations except sections that do not contain lines and components carrying Flammable fluids or gases and are isolated from the Designated Fire Zone prescribed in subparagraph (6) of this paragraph by a firewall that meets section 29.1191. (See ACB 29.1181(a).)

(b) Destruction by fire of all installations within a Designated Fire Zone must not interfere with the functioning of the remaining Power-units or their Essential Systems, or hazard the rotorcraft.

29.1181 (continued)

(c) Designated Fire Zones, regions immediately adjacent to a firewall and engine pod attachment structures must be designed and constructed to withstand without hazard any damage resulting from sudden increases in ambient pressure as a result of leakage of air or gases from defective joints or ducts (e.g. engine compressor bleed systems).

(d) Each Designated Fire Zone must meet the requirements of section 29.1183.

(e) *Fire-fighting procedures.* The procedures to be followed by the flight crew for fire fighting must be established. (See ACB 29.1181(e).)

(f) In addition to compliance with the requirements of sections 29.1183 through 29.1194, all practical measures must be taken to minimise the probability of fire both in flight and on the ground.

29.1183 Lines, fittings, and components

(a) Except as provided in paragraph (b) of this section, each line, fitting, and other component carrying Flammable fluid in any area subject to engine fire conditions and each component which conveys or contains Flammable fluid in a Designated Fire Zone, air ducts and other components the burning through of which would aggravate an existing fire, in a Designated Fire Zone, must be Fire-resistant, except that Flammable fluid tanks and supports in a Designated Fire Zone must be Fireproof or be enclosed by a Fireproof shield unless damage by fire to any non-fireproof part will not cause leakage or spillage of Flammable fluid. Components must be shielded or located so as to safeguard against the ignition of leaking Flammable fluid. For Group B rotorcraft an integral oil sump of less than 22·7 litres (5 gal) capacity on a reciprocating engine need not be Fireproof nor be enclosed by a Fireproof shield but may be Fire-resistant only. (See ACB 29.1183(a).)

(b) Paragraph (a) of this section does not apply to—

(1) Lines, fittings, and components which are already approved as part of a type certificated engine; and

(2) Vent and drain lines, and their fittings, whose failure will not result in or add to, a fire hazard.

(c) All components including air or gas ducts within a Designated Fire Zone must be Fireproof if, when exposed to or damaged or burnt through by fire, they could:—

29.1183(c) (continued)

(1) Result in fire spreading to other regions of the rotorcraft or

(2) Cause unintentional operation of, or inability to operate, Essential Services or equipment.

(3) In the case of structural members and any other parts, if failed result in a Catastrophic Effect. (See ACB 29.1183(c).)

(d) Group 2 equipment not located in Designated Fire Zones, must be so designed and installed that they will not in themselves create a risk of fire in either normal conditions or Failure conditions.

29.1185 Flammable fluids

(a) No tank or reservoir that is part of a system containing Flammable fluids or gases may be in a Designated Fire Zone unless the fluid contained, the design of the system, the materials used in the tank and its supports, the shut-off means, and the connections, lines, and controls provide a degree of safety equal to that which would exist if the tank or reservoir were outside such a zone.

(b) Each fuel tank must be isolated from the engines by a firewall or shroud.

(c) There must be at least 12·5 mm (0·5 in) of clear airspace between each tank or reservoir and each firewall or shroud isolating a Designated Fire Zone, unless equivalent means are used to prevent heat transfer from the fire zone to the Flammable fluid.

(d) Absorbent materials close to Flammable fluid system components that might leak must be covered or treated to prevent the absorption of hazardous quantities of fluids.

(e) In compartments other than Designated Fire Zones, where a Flammable mixture could occur the maximum temperature of exposed surfaces must, in either normal conditions or Failure conditions, be such as to leave an adequate margin between the temperature of the surface and the spontaneous ignition point of the fluid in question. (See ACB 29.1185.)

29.1187 Drainage and ventilation of fire zones

(a) There must be complete drainage of each part of each Designated Fire Zone and regions immediately adjacent to Designated Fire Zones and for engine pod attachment structures to minimise the hazards resulting from failure or malfunction of any component containing Flammable fluids. The drainage means must be—

(1) Effective under conditions expected to prevail when drainage is needed; and

(2) Arranged so that no discharge fluid will cause an additional fire hazard.

(b) Each Designated Fire Zone must be ventilated to prevent the accumulation of Flammable vapours.

(c) No ventilation opening may be where it would allow the entry of Flammable fluids, vapours, or flame from other zones.

(d) Ventilation means must be arranged so that no discharged vapours will cause an additional fire hazard.

(e) For Group A Rotorcraft, there must be means to allow the crew to shut off the sources of forced ventilation in any fire zone (other than the engine power section of the powerplant compartment) unless the amount of extinguishing agent and the rate of discharge are based on the maximum airflow through that zone.

(f) It must be demonstrated that the ventilation and drainage arrangements are adequate under the rotorcraft design conditions.

(g) Cooling air supply for generators and other electrical equipment must be conveyed and discharged so as not to create a fire hazard following an internal failure of the equipment (e.g. by Fireproof ducting). (See ACB 29.1187.)

29.1189 Shut-off means

(a) There must be means to shut off or otherwise prevent hazardous quantities of fuel, oil, de-icing fluid, and other Flammable fluids from flowing into, within, or through any Designated Fire Zone, except that this means need not be provided—

(1) For lines, fittings, and components forming an integral part of an engine;

(2) For oil systems for turbine engine installations in which all components of the oil system, including oil tanks, are Fireproof or located in areas not subject to engine fire conditions; or

29.1189(a) (continued)

(3) [*Deleted in BCAR 29*]

(b) The closing of any fuel shut-off valve for any engine may not make fuel unavailable to the remaining engines or auxiliary power unit capable of supplying Essential Services in flight. (See ACB 29.1189(b).)

(c) No hazardous quantity of Flammable fluid may drain into any Designated Fire Zone after shut-off has been accomplished, nor may the closing of any fuel shut-off valve for an engine make fuel unavailable to the remaining engines.

(d) The operation of any shut-off may not interfere with the later emergency operation of any other equipment, such as the means for declutching the engine from the transmission.

(e) Each shut-off must be outside of Designated Fire Zones, unless an equal degree of safety is otherwise provided.

(f) There must be means to prevent inadvertent operation of each shut-off and to make it possible for the crew to re-open it in flight after it has been closed.

(g) Controls for engine oil shut-off means which are located in a Designated Fire Zone must be Fireproof, but, if equivalent safety can be shown, may be Fire-resistant.

(h) The shut-off means prescribed in paragraph (a) of this section must:

(1) Be so located and attached so that it is unlikely to be damaged in the conditions of section 29.561; and,

(2) Be so installed so that they can be operated by the appropriate members of the flight crew as part of the engine fire drill.

29.1191 Firewalls

(a) Designated Fire Zones must be isolated by a firewall, shroud, or equivalent means, from personnel compartments, structures, controls, rotor mechanisms, and other parts that are—

(1) Essential to controlled flight and landing; and

(2) Not protected under section 29.861.

(b) Each auxiliary Power-unit, combustion heater, and other combustion equipment to be used in flight, must be isolated from the rest of the rotorcraft by firewalls, shrouds, or equivalent means.

(c) Each firewall or shroud must be constructed so that no hazardous quantity of air, fluid, or flame can pass from any Designated Fire Zones to other parts of the rotorcraft.

29.1191 (continued)

(d) Each opening in the firewall or shroud must be sealed with close-fitting Fireproof grommets, bushings, or firewall fittings.

(e) Each firewall and shroud must be Fireproof and protected against corrosion.

(f) In meeting this section, account must be taken of the probable path of a fire as affected by the airflow in normal flight and in autorotation.

(g) Precautions must be taken to prevent the possibility of hazardous distortion of the firewall under conditions of fire.

(h) Engine pod attachment structures and regions immediately adjacent to the Designated Fire Zone must be isolated by suitable means from other regions of the rotorcraft to prevent ingress of hazardous quantities of Flammable fluids and vapours. (See ACB 29.1191.)

29.1193 Cowling and engine compartment covering

(a) Each cowling and engine compartment covering must be constructed and supported so that it can resist the vibration, inertia, and air loads to which it may be subjected in operation.

(b) Cowling must meet the drainage and ventilation requirements of section 29.1187.

(c) On rotorcraft with a diaphragm isolating the engine power section from the engine accessory section, each part of the accessory section cowling subject to flame in case of fire in the engine power section of the Power-plant must—

(1) Be constructed of material at least equivalent in fire-resistance to aluminium alloy; and

(2) Meet the requirements of section 29.1191.

(d) Each part of the cowling or engine compartment covering subject to high temperatures due to its nearness to exhaust system parts or exhaust gas impingement must be Fireproof.

(e) Each rotorcraft must—

(1) Be designed and constructed so that no fire originating in any Designated Fire Zone can enter, either through openings or by burning through external skin, any other zone or region where it would create additional hazards;

(2) Meet the requirements of subparagraph (1) of this paragraph with the landing gear retracted (if applicable); and

29.1193(e) (continued)

(3) Have suitable heat-resistant skin material in areas subject to flame if a fire starts in or burns out of any Designated Fire Zone. (See ACB 29.1193.)

29.1194 Other surfaces

All surfaces aft of, and near, engine compartments and Designated Fire Zones, other than tail surfaces not subject to heat flames, or sparks emanating from a Designated Fire Zone or engine compartment, must be at least Fire-resistant.

29.1195 Fire extinguishing systems

(a) Each turbine-engined powered rotorcraft and Group A reciprocating-engine-powered rotorcraft, and each Group B reciprocating-engine-powered rotorcraft with engines of more than 0·015 m^3 (900 in^3) must have a fire extinguishing system for the Designated Fire Zones. The fire extinguishing system for a Power-plant must be able to simultaneously protect all zones of the Power-plant compartment for which protection is provided.

(b) For multi-engine-powered rotorcraft, the fire extinguishing system, the quantity of extinguishing agent, and the rate of discharge must—

(1) For each auxiliary Power-unit and combustion equipment, provide at least one adequate discharge; and

(2) For each other Designated Fire Zone, provide two adequate discharges; and

(c) For single engine rotorcraft, the quantity of extinguishing agent and the rate of discharge must provide at least one adequate discharge for the engine compartment.

(d) It must be shown by either actual or simulated flight tests that under critical airflow conditions in flight the discharge of the extinguishing agent in each Designated Fire Zone will provide an agent concentration capable of extinguishing fires in that zone and of minimising the probability of re-ignition.

(e) Fire detectors must not operate main Power-unit extinguisher systems automatically. (See ACB 29.1195.)

29.1197 Fire extinguishing agents

(a) Fire extinguishing agents must—

(1) Be capable of extinguishing flames emanating from any burning of fluids or other combustible materials in the area protected by the fire extinguishing system; and

(2) Have thermal stability over the temperature range likely to be experienced in the comartment in which they are stored.

(b) If any toxic extinguishing agent is used it must be shown by test that entry of harmful concentrations of fluid or fluid vapours into any personnel compartment (due to leakage during normal operation of the rotorcraft, or discharge on the ground or in flight) is prevented, even though a defect may exist in the extinguishing system.

(c) [Deleted in FAR]

29.1199 Extinguishing agent containers

(a) Each extinguishing agent container must have a pressure relief to prevent bursting of the container by excessive internal pressures.

(b) The discharge end of each discharge line from a pressure relief connection must be located so that discharge of the fire extinguishing agent would not damage the rotorcraft. The line must also be located or protected to prevent clogging caused by ice or other foreign matter.

(c) There must be a means for each fire extinguishing agent container to indicate that the container has discharged or that the charging pressure is below the established minimum necessary for proper functioning.

(d) The temperature of each container must be maintained, under intended operating conditions, to prevent the pressure in the container from—

(1) Falling below that necessary to provide an adequate rate of discharge; or

(2) Rising high enough to cause premature discharge.

29.1201 Fire extinguishing system materials

(a) No materials in any fire extinguishing system may react chemically with any extinguishing agent so as to create a hazard.

(b) Each system component in an engine compartment must be Fireproof.

29.1203 Fire detector systems

(a) For each turbine-engine-powered rotorcraft and Group A reciprocating-engine-powered rotorcraft, and for each Group B reciprocating-engine-powered rotorcraft with engines of more than 0·015m³ (900 in³) displacement, there must be Approved, quick-acting fire detectors in Designated Fire Zones and in the combustor turbine and tailpipe sections of turbine installations (whether or not such sections are Designated Fire Zones) in numbers and locations ensuring prompt detection of fire in those zones.

(b) Each fire detector must be constructed and installed to withstand any vibration, inertia, and other loads to which it would be subjected in operation.

(c) No fire detector may be affected by any oil, water, other fluids, or fumes and where applicable, any solar or artificial illumination that might be present.

(d) There must be means to allow crew members to check, in flight, the functioning of each fire detector system electrical circuit.

(e) The wiring and other components of each fire detector system in a Designated Fire Zone and in regions immediately behind such zones must be at least Fire-resistant.

(f) No fire detector system component for any fire zone may pass through another fire zone, unless—

(1) It is protected against the possibility of false warnings resulting from fires in zones through which it passes; or

(2) The zones involved are simultaneously protected by the same detector and extinguishing systems.

(g) The fire detection system must be of a resetting type.

(h) The fire detection system must provide the flight crew with an adequate visual and audible warning of fire.

(i) The fire detection system must be so designed and installed that:—

(1) So far as is practical, the failure of any part is more likely to render the system inoperative than to give a false warning;

(2) The system will remain operative in the event of severance of the detector system at any one point; and

(3) No environmental temperatures encountered in normal operation will cause false fire warnings. (See ACB 29.1203.)

29.1207 Compliance

Unless otherwise agreed by the Authority, fire tests must be made on components of the engine installation as necessary to demonstrate compliance with the requirements of sections 29.1181 and 29.1183. (See ACB 29.1207.)

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Subpart F — Equipment

GENERAL

29.1301 Function and installation

Each item of installed equipment must—

(a) Be of a kind and design appropriate to its intended function;

(b) Be labelled as to its identification, function, or operating limitations, or any applicable combination of these factors;

(c) Be installed according to limitations specified for that equipment;

(d) Function properly when installed; and

(e) If it is mandatory equipment, be Approved. (See ACB 29.1301.)

29.1303 Flight and navigation instruments

(a) The following are required flight and navigational instruments:

(1) An airspeed indicating system.

(2) A sensitive altimeter.

(3) A magnetic direction indicator.

(b) The following instruments are required by operational regulations:—

(1) A clock displaying hours, minutes, and seconds with a sweep-second pointer or digital presentation. (See ACB 29.1303(b).)

(2) A free-air temperature indicator.

(3) A gyroscopic bank and pitch indicator. (See section 29.1334.)

(4) A slip indicator.

(5) A gyroscopic direction indicator.

(6) A rate-of-climb (vertical speed) indicator.

29.1305 Power-plant instruments

The following are required power-plant instruments:

(a) For each Rotorcraft —

(1) A carburettor air temperature indicator for each reciprocating engine;

(2) A cylinder head temperature indicator for each air-cooled reciprocating engine, and a coolant temperature indicator for each liquid-cooled reciprocating engine;

(3) A fuel quantity indicator for each fuel tank;

29.1305(a) (continued)

(4) [*Deleted in BCAR 29*]

(5) A manifold pressure indicator, for each reciprocating engine of the altitude type;

(6) An oil pressure warning device for each pressure-lubricated system in the Transmission System to indicate when the oil pressure falls below a safe value;

(7) Means for measuring, when the Rotorcraft is in the ground attitude the quantity of oil in each oil tank and each Transmission System gearbox, if lubricant is self-contained;

(8) An oil temperature indicator for each engine;

(9) [*Deleted in BCAR 29*]

(10) A gas temperature indicator for each turbine engine;

(11) A gas producer rotor tachometer for each turbine engine;

(12) A tachometer for each engine that, if combined with the applicable instrument required by sub-paragraph (13) of this paragraph, indicates rotor rpm during autorotation;

(13) At least one tachometer to indicate, as applicable—

(i) The rpm of the single main rotor;

(ii) The common rpm of any main rotors whose speeds cannot vary appreciably with respect to each other; and

(iii) The rpm of each main rotor whose speed can vary appreciably with respect to that of another main rotor;

(14) A free power turbine tachometer for each turbine engine;

(15) A means, for each turbine engine, to indicate power for that engine;

(16) For each turbine engine, an indicator to indicate the functioning of the power-plant ice protection system;

(17) [*Reserved for BCAR 29*]

(18) [*Reserved for BCAR 29*]

(19) An indicator to indicate the proper functioning of any heater used to prevent ice clogging of fuel system components;

(20) An individual oil pressure indicator for each engine, and either an independent low oil pressure warning device for each engine or a master warning device for the engines with means for isolating the individual warning circuit from the master warning device;

29.1305(a) (continued)

(21) An individual fuel pressure indicator for each engine, unless it can be shown that fuel pressure indication is unnecessary for the particular installation, and either an independent warning device for each engine or a master warning device for the engines with means for isolating the individual warning circuit from the master warning device;

(22) Fire warning indicators to provide the flight crew with an adequate visual and audible warning of fire;

(23) Engine refrigerant quantity indicator, to indicate the quantity of useable refrigerant in each tank (see section 29.945);

(24) An oil pressure indicator for each pressure lubrication system in the Transmission System;

(25) An oil temperature indicator for each pressure lubrication system in the Transmission System;

(26) Where provision is made for the flight crew to be able to disconnect defective equipment from an engine or Transmission System while the engine or Transmission System is still running, suitable means must be provided to warn the flight crew that the equipment should be disconnected (see ACB 29.1305(a)(26);)

(27) Where an engine may be used to drive equipment whilst the engine is disconnected from the main transmission, indication of whether the engine is in main or equipment drive;

(28) Such instruments, additional to those prescribed in this section, as are necessary to enable compliance in operation with the limitations to which the engine and Transmission System are Approved. (See ACB 29.1305(a)(28).)

(b) For piston-engined Rotorcraft—

(1) For engines fitted with a turbo-supercharger,

(i) engine air inlet temperature indicator; and

(ii) exhaust gas temperature indicator.

(2) For each turbo-supercharger oil system that is separate from other oil systems:—

(i) oil pressure indicator; and

(ii) oil temperature indicator.

(c) For turbine-engined Rotorcraft—

(1) Means to indicate when an air or gas turbine starter is energised.

(2) A visual warning for each engine to indicate engine failure.

29.1305(c)(continued)

(3) For single-engined Group B Rotorcraft, an audible warning to indicate engine failure. This warning must be additional to the visual warning required by sub-paragraph (2) of this paragraph. (See ACB 29.1305(c).)

(4) For multi-engined Rotorcraft to be certificated in the Transport Category, a means of indicating to the pilot immediately any significant change in the power output of an engine as a result of fault conditions and also which engine is at fault.

(5) Such other instruments as are necessary to enable compliance in operation with limitations established during engine certification.

29.1307 Miscellaneous equipment

The following is required miscellaneous equipment:

(a) An Approved seat for each occupant.

(b) [*Deleted in BCAR 29*]

(c) Hand fire extinguishers.

(d) A windshield wiper or equivalent device for each pilot station.

(e) A two-way radio communication system as required by operational regulations.

(f) Such other equipment as the Authority may prescribe.

29.1309 Equipment, systems, and installations

[*Reserved for BCAR 29*]

INSTRUMENTS INSTALLATION

29.1321 Arrangement and visibility

(a) Each flight, navigation, and power-plant instrument for use by any pilot must be easily visible to him from his station with the minimum practicable deviation from his normal position and line of vision when he is looking forward along the flight path. (See ACB 29.1321(a).)

(b) Each instrument necessary for safe operation, including the airspeed indicator, gyroscopic direction indicator, gyroscopic bank-and-pitch indicator, slip-skid indicator, altimeter, rate-of-climb indicator, rotor tachometers, and the indicator most representative of engine power, must be grouped and centred as nearly as practicable about the vertical plane of the pilot's forward vision.

29.1321(b) (continued)

(1) [*Deleted in BCAR 29*]

(2) [*Deleted in BCAR 29*]

(3) [*Deleted in BCAR 29*]

(4) [*Deleted in BCAR 29*]

(c) Other required power-plant instruments must be conveniently grouped on the instrument panel.

(d) Identical power-plant instruments for the engines must be located so as to prevent any confusion as to which engine each instrument relates.

(e) Each power-plant instrument vital to safe operation must be plainly visible to appropriate crew members. (See ACB 29.1321(e).)

(f) Instrument panel vibration may not damage, or impair the readability or accuracy of, any instrument.

(g) If a visual indicator is provided to indicate malfunction of an instrument, it must be effective under all probable cockpit lighting conditions.

29.1322 Warning, caution, and advisory lights

If warning, caution or advisory lights are installed in the cockpit they must, unless otherwise approved by the Authority, be—

(a) Red, for warning lights (lights indicating a hazard which may require immediate corrective action);

(b) Amber, for caution lights (lights indicating the possible need for future corrective action);

(c) Green, for safe operation lights; and

(d) Any other colour including white, for lights not prescribed in paragraphs (a) through (c) of this section, provided the colour differs sufficiently from the colours prescribed in paragraphs (a) through (c) of this section to avoid possible confusion.

(e) Red warning lights must not be capable of being dimmed unless specifically approved by the Authority, and in any such cases all possible precautions must be taken to ensure that these lights are not left in the dimmed condition.

29.1323 Airspeed indicating system

For each airspeed indicating system, the following apply:

(a) Each airspeed indicating instrument must be calibrated to indicate true airspeed (at sea-level with a standard atmosphere) with a minimum practicable instrument calibration error when the corresponding pitot and static pressures are applied.

(b) Each system must be calibrated to determine the total position error of the system that is, the relation between IAS and EAS. This calibration must be determined, over an appropriate range of speeds—

(1) In flight, for the flight conditions of climb, level flight, and autorotation; and

(2) During take-off, with repeatable and readable indications that ensure—

(i) Consistent realisation of the field lengths specified in the Rotorcraft Flight Manual; and

(ii) Avoidance of the critical areas of the height-speed envelope established under section 29.79.

(c) The position error of the installation, in level flight at sea-level, at all speeds between the Take-off Safety Speed, V_2 and the normal cruising speed, must not exceed 3% or 5 knots, whichever is the greater.

(d) [*Deleted in BCAR 29*]

(e) Each system must be arranged, so far as practicable, to prevent malfunction or serious error due to the entry of moisture, dirt, or other substances, or by airflow variation.

(f) For Group A Rotorcraft each system must have a heated pitot tube or an equivalent means of preventing malfunction due to icing. (See ACB 29.1323.)

(g) The accuracy of the system must not be adversely affected by yaw effects upon static systems.

(h) Lag and the possibility of moisture blockage in pitot-static lines must be kept to acceptable minima. (See ACB 29.1323.)

(i) Sufficient moisture traps must be installed to ensure positive drainage throughout the whole of the system.

(j) A separate pitot-static system must be provided for additional instruments and equipment which—

(1) Have not been Approved, or

(2) Would introduce lag of an unacceptable order.

29.1325 Static pressure and pressure altimeter systems

(a) Each instrument with static air case connections must be vented to the outside atmosphere through an appropriate piping system.

(b) Each vent must be located where its orifices are least affected by airflow variation, moisture, or other foreign matter.

(c) Each static pressure port must be designed and located in such a manner that the correlation between air pressure in the static pressure system and true ambient atmospheric static pressure is not altered when the Rotorcraft encounters icing conditions. An anti-icing means or an alternate source of static pressure may be used in showing compliance with this requirement. If the reading of the altimeter, when on the alternate static pressure system, differs from the reading of the altimeter when on the primary static system by more than 15·2 m (50 ft), a correction card must be provided for the alternate static system.

(d) Except for the vent into the atmosphere each system must be airtight.

(e) Each pressure altimeter must be Approved and calibrated to indicate pressure altitude in a standard atmosphere with a minimum practicable calibration error when the corresponding static pressures are applied.

(f) Each system must be designed and installed so that the error in indicated pressure altitude at sea-level with a standard atmosphere, excluding instrument calibration error, does not result in an error of more than ±9·1 m (±30 ft) in the level flight speed range from 0 knots to 0·9 V_H.

(g) Except as provided in paragraph (h) of this section, if the static pressure system incorporates both a primary and an alternate static pressure source, the means for selecting one or the other source must be designed so that—

(1) When either source is selected, the other is blocked off; and

(2) Both sources cannot be blocked off simultaneously.

(h) For unpressurised Rotorcraft, paragraph (g)(1) of this section does not apply if it can be demonstrated that the static pressure system calibration, when either static pressure source is selected, is not changed by the other static pressure source being open or blocked.

(i) Each system must meet the requirements of paragraphs 29.1323(g) (h) and (j).

29.1327 Magnetic direction indicator

(a) Each magnetic direction indicator must be installed so that its accuracy is not excessively affected by the Rotorcraft's vibration or magnetic fields.

(b) The compensated installation may not have a deviation, in level flight, greater than 5° on any heading. In addition the change in deviation as a result of the movement of or interaction between other components (e.g. control movement) or the worst likely combination of electrical interference may not exceed 5°.

29.1329 Automatic pilot system

(See section 29.672 for stability augmentation systems)

(a) Each automatic pilot system must be Approved, and must be designed so that the automatic pilot can—

(1) Be quickly and positively disengaged by the pilots to prevent it from interfering with their control of the Rotorcraft (see paragraph 29.672(b)); or

(2) Be sufficiently overpowered by one pilot to let him control the Rotorcraft.

(b) Unless there is automatic synchronisation, each system must have a means to readily indicate to the pilot the alignment of the actuating device in relation to the control system it operates.

(c) Each manually operated control for the system's operation must be readily accessible to the pilots. Attitude controls (i.e. pitch, trim, etc.) must operate in the plane and direction of the required Rotorcraft response. (See ACB 29.1329(c).)

(d) The system must be designed and adjusted so that, within the range of adjustment available to the pilot, it cannot produce hazardous loads on the Rotorcraft, or create hazardous deviations in the flight path, under any flight condition appropriate to its use, either during normal operation or in the event of a malfunction, assuming that corrective action begins within a reasonable period of time. (See ACB 29.672 and 29.1329.)

(e) [*Reserved for BCAR 29*]

(f) The system must provide a positive indication that it is in operation and of the mode of operation in which it is functioning. A suitably compelling warning must be given of the system ceasing to operate correctly. (See paragraph 29.672(c).)

29.1331 Instruments using a power supply

(a) Each required flight instrument using a power supply must have—

(1) For multi-engined Rotorcraft, two independent sources of power (see ACB 29.1331(a));

(2) [*Deleted in BCAR 29*]

(3) A means to indicate the adequacy of the power being supplied; and

(b) The installation and power supply system must be such that failure of any flight or power-plant instrument connected to one source, or of the energy supply from one source, or a fault in any part of the power distribution system does not interfere with the proper supply of energy from any other source.

29.1333 Duplicate instrument systems

If duplicate flight instruments are required by any operational regulation:—

(a) Each operating system for flight instruments for the first pilot and that is required to be duplicated at other flight crew stations must be independent of the operating system for other flight crew stations;

(b) [*Deleted in BCAR 29*]

(c) [*Deleted in BCAR 29*]

(d) Duplicate instrument systems must be such that the probability of one fault impairing the operation of both systems is Extremely Remote.

29.1334 Attitude display systems

(a) The requirements of this section are applicable to the attitude display systems provided on Group A Rotorcraft for flight in Instrument Meteorological Conditions (IMC).

(b) Each pilot's station must be provided with a separate display in the form of a gyro stabilised aritificial horizon line which indicates the position of the horizon relative to a Rotorcraft reference symbol.

(c) The probability of total loss of attitude indication to the flight crew must be in the lower part of the Extremely Remote range.

(d) The probability of the indication of incorrect information likely to lead to a hazardous attitude must be Extremely Remote.

29.1334 (continued)

(e) In the event of a total failure of the main generated electrical power supply the captain's station of the Rotorcraft must be provided with uninterrupted usable attitude information for a period of time sufficient for the Rotorcraft to be landed safely assuming that any prescribed crew action necessary is taken. It is not acceptable to assume that this action is taken in less than 10 minutes after the appearance of the failure warning.

(f) Precise drills covering crew action in the event of electrical generation system failures and malfunctions must be included in the appropriate Rotorcraft manual(s), together with a statement of the battery endurance under specified load conditions.

(g) If the period of time for which attitude information is available after total failure of the main generated electrical power supply is less than the endurance of the Rotorcraft, the time must be declared in the Flight Manual. It must not, in any event, be less than half the endurance of the Rotorcraft at the representative cruising true air speed.

(h) Where a single stability augmentation system is provided to meet the stability requirements of paragraph 29.171(d) the system must have a completely separate gyro reference from the attitude indicators required by section 29.1303.

(i) *Display characteristics.* The system must be designed so that:—

(1) No misleading information is given during or after any exceedance of the range of attitudes for which the display is designed.

(2) The artificial horizon line moves in roll so as to remain parallel to the true horizon, i.e. when the Rotorcraft rolls through an angle of 30°, the artificial horizon line also rotates through 30° relative to the fixed index.

(3) The artificial horizon line remains in view over a range of pitch attitudes sufficient to cover all normal operations of the Rotorcraft plus a margin of not less than 2° in either direction. Additional 'ghost' horizon lines must be provided parallel to the main horizon line so that beyond this range, at least one such line is in view at any attitude within the range of the display.

(4) The pitch attitude scale is linear while the main horizon line is in view, but may become non-linear beyond this range, provided that indications continue to be given in the correct sense. The response and sensitivity of the display to changes in attitude must be such as to permit accurate control of the Rotorcraft.

29.1334(i) (continued)

(5) Sufficient pitch and bank angle graduations and markings are provided to allow an acceptably accurate reading of attitude and to minimise the possibility of confusion at extreme attitudes. The graduation intervals on all the attitude displays in the Rotorcraft must be sufficiently similar for there to be no risk of confusion in transferring attention from one display to another.

(6) A bank angle index and scale is provided. The index must at all times be at 90° to the horizon lines, and must be in the same position, i.e. either 90° above or 90° below, for all displays in the Rotorcraft.

(7) The 'earth' to 'sky' areas of the display are clearly distinguished by means of a distinctive colour or shade contrast. This differentiation must not be lost at any pitch or roll attitude.

(8) Any additional information (e.g. flight director commands) displayed on an attitude display does not obscure or significantly degrade the attitude information.

(9) The display is clearly visible under all conditions of daylight and artificial lighting. (See ACB 29.1334.)

29.1335 Flight director systems

If a flight director system is installed—

(a) Means must be provided to indicate to the flight crew its current mode of operation. Selector switch position is not acceptable as a means of indication.

(b) No single fault must be able to affect dangerously both the flight director system and the system (or instruments) to which the pilot would turn in the event of its failure.

(c) It must, as far as possible, be so designed that warning of fault conditions which might otherwise lead to danger will be given to the pilot.

(d) The instrument panel must be so arranged that no undue burden is placed on the flight crew in monitoring a flight director by means of other instrument indicators. (See ACB 29.1335.)

29.1337 Power-plant instruments

(a) *Instruments and instrument lines*

(1) Each Power-plant and auxiliary Power-unit instrument line must meet the requirements of sections 29.993 and 29.1183.

(2) Each line carrying Flammable fluids under pressure must—

(i) Have restricting orifices or other safety devices at the source of pressure to prevent the escape of excesssive fluid if the line fails; and

(ii) Be installed and located so that the escape of fluids would not create a hazard.

(3) Each Power-plant and auxiliary Power-unit instrument that utilises Flammable fluids must be installed and located so that the escape of fluid would not create a hazard.

(b) *Fuel quantity indicator.* There must be means to indicate to the flight-crew members the quantity, in gallons or equivalent units, of usable fuel in each tank during flight. In addition—

(1) Each fuel quantity indicator must be calibrated to read 'zero' during level flight when the quantity of fuel remaining in the tank is equal to the unusable fuel supply determined under section 29.959, and must be clearly marked (in terms of standard units of quantity and not fractions of tank capacity) on the indicator dials;

(2) [*Deleted in BCAR 29*]

(3) Tanks with interconnected outlets and airspaces may be treated as one tank and need not have separate indicators;

(4) Each exposed sight gauge used as a fuel quantity indicator must be protected against damage;

(5) For Group A Rotorcraft an independent means of checking the fuel quantity indication for gross errors must be provided for use on the ground; and

(6) The performance of the fuel quantity indicator system must be established for appropriate Rotorcraft attitudes, including cruise and refuelling conditions.

(c) *Fuel flowmeter system.* If a fuel flowmeter system is installed, each metering component must have a means for bypassing the fuel supply if malfunction of that component severely restricts fuel flow.

(d) *Oil quantity indicator.* There must be a stick gauge or equivalent means to indicate the quantity of oil—

29.1337 (d) (continued)

(1) In each tank, and

(2) In each transmission gearbox.

(e) Oil pressure indicator and low pressure warning devices for Rotor and Transmission Systems. Connections must be so arranged so that the devices indicate the pressure of the oil to the main jets. In addition—

(1) The design must be such as to ensure that the pressure sensors, the associated electrical circuits and the presentation of information on the flight deck for the indicator and warning device, are independent one from the other.

(2) There must be no relief valve or filter between the pressure indicator/warning device connections and the main jets, other than those of sub-paragraph (3) of this paragraph.

(3) Strainers necessary to protect oil jets or metering orifices must be provided and designed to reduce the possibility of blockage to a reasonable minimum.

(4) Where an auxiliary lubrication system is independent of the main system, provision must be made for the connection of an additional oil pressure indicator at the nearest practicable point to the parts being supplied with oil.

(f) All mandatory engine and transmission instruments must have independent operating systems, except where it can be shown that the failure of any system which serves more than one instrument will not jeopardise the continued safe operation of the Rotorcraft.

(g) All mandatory engine and transmission instruments requiring a power supply must have at least two independent sources of supply, except where it can be shown that the loss of information resulting from the failure of a single source of supply will not jeopardise the continued safe flight of the Rotorcraft.

(h) Means must be provided to indicate the adequacy of the power being supplied to engine and transmission instruments.

ELECTRICAL SYSTEMS AND EQUIPMENT

29.1351 General

(a) *Electrical system capacity.* The required generating capacity and the number and kind of power sources must—

(1) Be determined by an electrical load analysis; and

29.1351 (a) (continued)

(2) Meet the requirements of section 29.1309.

(b) *Generating system.* The generating system includes electrical power sources, main power busses, transmission cables, and associated control, regulation, and protective devices. It must be designed so that—

(1) Power sources function properly when independent and when connected in combination;

(2) No failure or malfunction of any power source can create a hazard or impair the ability of remaining sources to supply essential loads;

(3) The system voltage and frequency (as applicable) at the terminals of essential load equipment can be maintained within the limits for which the equipment is designed, during any probable operating condition;

(4) System transients due to switching, fault clearing, or other causes do not make essential loads inoperative, and do not cause a smoke or fire hazard;

(5) There are means accessible in flight to appropriate crew members for the individual disconnection of the electrical power sources from the main bus (see ACB 29.1351(b)(5)); and

(6) There are means to indicate to appropriate crew members the generating system quantities essential for the safe operation of the system, such as the voltage and current supplied by each generator.

(c) *External power.* If provisions are made for connecting external power to the rotorcraft, and that external power can be electrically connected to equipment other than that used for engine starting, means must be provided to ensure that no external power supply having a reverse polarity, or a reverse phase sequence, can supply power to the rotorcraft's electrical system.

(d) [*Reserved for BCAR 29*]

29.1353 Electrical equipment and installations

(a) Electrical equipment, controls, and wiring must be installed so that operation of any one unit or system of units will not adversely affect the simultaneous operation of any other electrical unit or system essential to safe operation. Any electrical interference likely to be present in the Rotorcraft must not result in hazardous effects upon the Rotorcraft or its systems except under Extremely Remote conditions. (See ACB 29.1353(a).)

29.1353 (continued)

(b) Cables must be grouped, routed, and spaced so that damage to essential circuits will be minimised if there are faults in cables, particularly heavy current-carrying cables.

(c) Storage batteries must be designed and installed as follows:

(1) Safe cell temperatures and pressures must be maintained during any probable charging and discharging condition. No uncontrolled increase in cell temperature may result when the battery is recharged (after previous complete discharge)–

(i) At maximum regulated voltage or power;

(ii) During a flight of maximum duration; and

(iii) Under the most adverse cooling condition likely in service.

(2) Compliance with sub-paragraph (1) of this paragraph must be shown by test unless experience with similar batteries and installations has shown that maintaining safe cell temperatures and pressures presents no problem.

(3) No explosive or toxic gases emitted by any battery in normal operation, or as the result of any probable malfunction in the charging system or battery installation, may accumulate in hazardous quantities within the rotorcraft.

(4) No corrosive fluids or gases that may escape from the battery may damage surrounding structures or adjacent essential equipment.

(5) Each nickel cadmium battery installation must have provisions to prevent any hazardous effect on structure or essential systems that may be caused by the maximum amount of heat the battery can generate during a short circuit of the battery or of its individual cells.

(6) Nickel cadmium battery installations that are not provided with low-energy charging means must have—

(i) A system to control the charging rate of the battery automatically so as to prevent battery overheating;

(ii) A battery temperature sensing and over-temperature warning system with a means for disconnecting the battery from its charging source in the event of an over-temperature condition; or

(iii) A battery failure sensing and warning system with a means for disconnecting the battery from its charging source in the event of battery failure.

29.1355 Distribution system

(a) The distribution system includes the distribution busses, their associated feeders, and each control and protective device.

(b) Each system must be designed so that—

(1) For Group A Rotorcraft, essential load circuits can be supplied in the event of reasonably probable faults or open circuits; and

(2) If two independent sources of electrical power for particular equipment or systems are required by BCAR 29, their energy supply is ensured. (See ACB 29.1355(b).)

29.1357 Circuit protective devices

(a) Automatic protective devices must be used to minimise distress to the electrical system and hazard to the Rotorcraft in the event of wiring faults or serious malfunction of the system or connected equipment. (See ACB 29.1357(a).)

(b) For Group A Rotorcraft, there must be means in the generating system to automatically de-energise and disconnect from the main bus any power source developing hazardous overvoltage.

(c) Each resettable circuit protective device must be designed so that, when an overload or circuit fault exists, it will open the circuit regardless of the position of the operating control.

(d) If the ability to reset a circuit breaker or replace a fuse is essential to safety in flight, that device must be located and identified so that it can be readily reset or replaced in flight.

(e) Each circuit for essential loads must have individual circuit protection.

(f) If fuses are used, there must be spare fuses for use in flight equal to 10% of the number of fuses of each rating required for complete circuit protection or 3 of each rating, whichever is the greater.

29.1359 Electrical system fire and smoke protection

(a) Components of the electrical system must meet the applicable fire and smoke protection provisions of sections 29.831 and 29.863. (See ACB 29.1359.)

(b) Electrical cables, terminals, and equipment, in Designated Fire Zones, and that are used in emergency procedures, must be at least fire resistant.

29.1359 (continued)

(c) Insulated electrical wire and cable installed in any region of the fuselage must be self-extinguishing when tested in accordance with the '60° Test' of Appendix F of BCAR 29, or other approved equivalent method. The average flame time after removal of the flame may not exceed 30 seconds, and the average length of burnt insulation may not exceed 3 in. Drippings from the test specimen may not continue to flame for more than an average of 3 seconds after falling.

29.1360 Precautions against injury

(a) *Shock.* The electrical system must be designed so as to minimise the risk of electrical shock to crew, passengers and servicing personnel and also to maintenance personnel using normal precautions. (See ACB 29.1360(a).)

(b) *Burns.* The temperature rise of any part, which has to be handled during normal operation by the flight crew, must not be such as to cause dangerous inadvertent movement, or injury to the crew member. (See ACB 29.1360(b).)

29.1362 Electrical supplies for emergency conditions

A suitable supply must be maintained to those services which are required, either by this BCAR 29 (e.g. section 29.1195) or in order that emergency drills may be carried out, after an emergency landing or ditching. The circuits to these services must be so designed and protected that the risk of their causing a fire, under these conditions, is minimised.

29.1363 Electrical system tests

(a) When laboratory tests of the electrical system are conducted—

(1) The tests must be performed on a mock-up using the same generating equipment used in the Rotorcraft;

(2) The equipment must simulate the electrical characteristics of the distribution wiring and connected loads to the extent necessary for valid test results; and

(3) Laboratory generator drives must simulate the prime movers on the Rotorcraft with respect to their reaction to generator loading, including loading due to faults.

29.1363 (continued)

(b) For each flight condition that cannot be simulated adequately in the laboratory or by ground tests on the Rotorcraft, flight tests must be made.

LIGHTS

29.1381 Instrument lights

The instrument lights must—

(a) Make each instrument, switch, and other device for which they are provided easily readable; and

(b) Be installed so that—

(1) Their direct rays are shielded from the pilot's eyes; and

(2) No objectionable reflections are visible to the pilot.

(c) For Group A Rotorcraft certificated for instrument flight, high intensity white lighting must be provided for the illumination of basic flight instruments, such that the pilot(s) are not dazzled by lightning discharge when the Rotorcraft is being flown solely by reference to instruments.

29.1383 Landing lights

(a) Each required landing or hovering light must be Approved.

(b) Each landing light must be installed so that—

(1) No objectionable glare is visible to the pilot;

(2) The pilot is not adversely affected by halation; and

(3) It provides enough light for night operation, including hovering and landing.

(c) At least one separate switch must be provided, as applicable—

(1) For each separately installed landing light; and

(2) For each group of landing lights installed at a common location.

29.1385 Position light system installation

(a) *General.* Each part of each position light system must meet the applicable requirements of this section and each system as a whole must meet the requirements of sections 29.1387 through 29.1397.

29.1385 (continued)

(b) *Forward position lights.* Forward position lights must consist of a red and a green light spaced laterally as far apart as practicable and installed forward on the Rotorcraft so that, with the Rotorcraft in the normal flying position, the red light is on the left side, and the green light is on the right side. Each light must be Approved.

(c) *Rear position light.* The rear position light must be a white light mounted as far aft as practicable and must be Approved.

(d) [*Deleted in BCAR 29*]

(e) *Light covers and colour filters.* Each light cover or colour filter must be at least flame-resistant and may not change colour or shape or lose any appreciable light transmission during normal use.

29.1387 Position light system dihedral angles

(a) Except as provided in paragraph (e) of this section, each forward and rear position light must, as installed, show unbroken light within the dihedral angles described in this section.

(b) Dihedral angle L (left) is formed by two intersecting vertical planes, the first parallel to the longitudinal axis of the Rotorcraft, and the other at 110° to the left of the first, as viewed when looking forward along the longitudinal axis.

(c) Dihedral angle R (right) is formed by two intersecting vertical planes, the first parallel to the longitudinal axis of the Rotorcraft, and the other at 110° to the right of the first, as viewed when looking forward along the longitudinal axis.

(d) Dihedral angle A (aft) is formed by two intersecting vertical planes making angles of 70° to the right and to the left, respectively, to a vertical plane passing through the longitudinal axis, as viewed when looking aft along the longitudinal axis.

(e) If the rear position light, when mounted as far aft as practicable in accordance with paragraph 29.1385(c), cannot show unbroken light within dihedral angle A (as defined in paragraph (d) of this section), a solid angle or angles of obstructed visibility totalling not more than 0·04 steradians is allowable within that dihedral angle, if such solid angle is within a cone whose apex is at the rear position light and whose elements make an angle of 30° with a vertical line passing through the rear position light. (See ACB 29.1387.)

29.1389 Position light distribution and intensities

(a) *General.* The intensities prescribed in this section must be provided by new equipment with light covers and colour filters in place. Intensities must be determined with the light source operating at a steady value equal to the average luminous output of the source at the normal operating voltage of the Rotorcraft. The light distribution and intensity of each position light must meet the requirements of paragraph (b) of this section.

(b) *Forward and rear position lights.* The light distribution and intensities of forward and rear position lights must be expressed in terms of minimum intensities in the horizontal plane, minimum intensities in any vertical plane, and maximum intensities in overlapping beams, within dihedral angles, L, R, and A, and must meet the following requirements:

(1) *Intensities in the horizontal plane.* Each intensity in the horizontal plane (the plane containing the longitudinal axis of the Rotorcraft and perpendicular to the plane of symmetry of the Rotorcraft), must equal or exceed the values in section 29.1391.

(2) *Intensities in any vertical plane.* Each intensity in any vertical plane (the plane perpendicular to the horizontal plane) must equal or exceed the appropriate value in section 29.1393 where I is the minimum intensity prescribed in section 29.1391 for the corresponding angles in the horizontal plane.

(3) *Intensities in overlaps between adjacent signals.* No intensity in any overlap between adjacent signals may exceed the values in section 29.1395, except that higher intensities in overlaps may be used with the use of main beam intensities substantially greater than the minima specified in sections 29.1391 and 29.1393 if the overlap intensities in relation to the main beam intensities do not adversely affect signal clarity.

29.1391 Minimum intensities in the horizontal plane of forward and rear position lights

Each position light intensity must equal or exceed the applicable values in the following table:

29.1391 (continued)

Dihedral angle (light included)	Angle from right or left of longitudinal axis, measured from dead ahead	Intensity (candles)
L and R (forward red and green)	0° to 10°	40
	10° to 20°	30
	20° to 110°	5
A (rear white)	110° to 180°	20

(See ACB 29.1391.)

29.1393 Minimum intensities in any vertical plane of forward and rear position lights

Each position light intensity must equal or exceed the applicable values in the following table:

Angle above or below the horizontal plane:	Intensity
0°	1·00 I.
0° to 5°	0·90 I.
5° to 10°	0·80 I.
10° to 15°	0·70 I.
15° to 20°	0·50 I.
20° to 30°	0·30 I.
30° to 40°	0·10 I.
40° to 90°	0·05 I.

(See ACB 29.1393.)

29.1395 Maximum intensities in overlapping beams of forward and rear position lights

No position light intensity may exceed the applicable values in the following table, except as provided in paragraph 29.1389(b)(3).

Overlaps	Maximum intensity	
	Area A (candles)	Area B (candles)
Green in dihedral angle L	10	1
Red in dihedral angle R	10	1
Green in dihedral angle A	5	1
Red in dihedral angle A	5	1
Rear white in dihedral angle L	5	1
Rear white in dihedral angle R	5	1

Where—

(a) Area A includes all directions in the adjacent dihedral angle that pass through the light source and intersect the common boundary plane at more than 10° but less than 20°; and

(b) Area B includes all directions in the adjacent dihedral angle that pass through the light source and intersect the common boundary plane at more than 20°.

29.1397 Colour specifications

Each position light colour must have the applicable International Commission on Illumination chromaticity co-ordinates as follows:

(a) *Aviation red*—

y is not greater than 0·335; and

z is not greater than 0·002.

(b) *Aviation green*—

x is not greater than $0{\cdot}440-0{\cdot}320y$;

x is not greater than $y-0{\cdot}170$; and

y is not less than $0{\cdot}390-0{\cdot}17x$.

(c) *Aviation white*–

x is not less than 0·300 and not greater than 0·540;

y is not less than '$x-0{\cdot}040$' or '$y_o-0{\cdot}010$', whichever is the smaller; and

y is not greater than '$x+0{\cdot}020$' nor '$0{\cdot}636-0{\cdot}400x$';

Where y_o, is the y co-ordinate of the Planckian radiator for the value of x considered.

29.1399 Riding light

[*Reserved for BCAR 29*]

29.1401 Anti-collision light system

(a) *General.* If certification for night operation is requested, the Rotorcraft must have an anti-collision light system that—

(1) Consists of one or more Approved anti-collision lights located so that their emitted light will not impair the crew's vision or detract from the conspicuity of the position lights; and

(2) Meets the requirements of paragraphs (b) through (f) of this section.

(b) *Field of coverage.* The system must consist of enough lights to illuminate the vital areas around the Rotorcraft, considering the physical configuration and flight characteristics of the Rotorcraft. The field of coverage must extend in each direction within at least 30° above and 30° below the horizontal plane of the Rotorcraft, except that there may be solid angles of obstructed visibility totalling not more than 0·5 steradians.

29.1401 (continued)

(c) *Flashing characteristics.* The arrangement of the system, that is, the number of light sources, beam width, speed of rotation, and other characteristics, must give an effective flash frequency of not less than 40, nor more than 100, cycles per minute. The effective flash frequency is the frequency at which the Rotorcraft's complete anti-collision light system is observed from a distance, and applies to each sector of light including any overlaps that exist when the system consists of more than one light source. In overlaps, flash frequencies may exceed 100, but not 180, cycles per minute.

(d) *Colour.* Each anti-collision light must be aviation red and must meet the applicable requirements of section 29.1397.

(e) *Light intensity.* The minimum light intensities in any vertical plane, measured with the red filter (if used) and expressed in terms of 'effective' intensities, must meet the requirements of paragraph (f) of this section. The following relation must be assumed:

$$Ie = \frac{\int_{t_1}^{t_2} I(t)dt}{0{\cdot}2 + (t_2 - t_1)}$$

where:

I_e = effective intensity (candles).
$I(t)$ = instantaneous intensity as a function of time.
$t_2 - t_1$ = flash time interval (seconds).

Normally, the maximum value of effective intensity is obtained when t_2 and t_1 are chosen so that the effective intensity is equal to the instantaneous intensity at t_2 and t_1.

(f) *Minimum effective intensities for anti-collision lights.* Each anti-collision light effective intensity must equal or exceed the applicable values in the following table:

Angle above or below the horizontal plane:	Effective intensity (candles)
0° to 5°	100
5° to 10°	60
10° to 20°	20
20° to 30°	10

SAFETY EQUIPMENT

29.1411 General

(a) *Accessibility.* Required safety equipment to be used by the crew in an emergency, such as automatic liferaft releases, must be readily accessible and plainly marked as to its method of operation. Where safety equipment is carried in compartments or containers, such compartments and containers must be marked to identify the contents.

(b) *Stowage provisions.* Stowage provisions for required emergency equipment must be furnished and must—

(1) Be arranged so that the equipment is directly accessible and its location is obvious;

(2) Protect the safety equipment from inadvertent damage; and

(3) For the stowage of all liferafts;

(i) Be such that the probability of unintentional inflation or release is not greater than Extremely Remote, unless it can be shown that such inflation or release will not hazard the rotorcraft;

(ii) Be such that the liferafts (including valise-types) will not be disturbed except for inspection purposes;

(iii) For internal stowages, be so arranged that adequate space is available for access to and easy manipulation of the liferaft package prior to launching;

(iv) Be such as to prevent damage or deterioration of the liferaft package due to spillage of or contact with any likely contaminants, including deleterious quantities of water;

(v) For stowage covers opening outside the Rotorcraft, be secured by mechanical locks adequate to prevent spontaneous opening of the stowage cover during any condition of flight, including Emergency Alighting on water. The security of stowage covers must be readily ascertainable by visual inspection when the Rotorcraft is on the ground;

(vi) For stowages, covers and locks, comply with the strength requirements for the Rotorcraft as a whole as prescribed in Subpart C. In addition, due allowance must be made for the loads resulting from pre-loading, altitude effects due to residual gas in the liferafts, aerodynamic forces and vibration;

29.1411(b) (continued)

(vii) For external stowage compartments, be substantially weather-tight, and yet designed to drain completely both in flight and in ground attitudes;

(viii) For all stowages, be free from any sharp edges or projections liable to damage a liferaft whilst stowed or during launching, and must provide positive location for inflation cylinders and any other articles which might shift and damage or disarrange the liferaft or the release and operating mechanism; and

(ix) For all equipment essential for the operation of the liferaft after its release and such other equipment and provisions as may be prescribed, either be attached to the liferaft, or its stowage in relation to the liferaft must be such as to ensure that, so far as possible, each liferaft will be launched with its required equipment.

(c) *Emergency exit descent device.* The stowage provisions for the emergency exit descent device required by paragraph 29.809(f) must be at the exits for which they are intended.

(d) *Liferaft installation.* Where liferafts are required by operational regulations their installation must comply with the requirements of this paragraph.

(1) *General.* The location of liferafts and their method of release must be suitably chosen in relation to the ditching and flotation characteristics of the Rotorcraft, the escape facilities of the Rotorcraft, and the disposition of the occupants. (See section 29.801 and paragraph 29.807(b)(2).)

(2) Liferaft installations must be designed so as to ensure that the liferafts, together with any equipment, provisions etc., which are required to be carried, will be serviceable when needed and that, so far as is practical, the installations will not be damaged by any defect likely to necessitate an Emergency Alighting on water (e.g. engine fire or fuel leakage) or by any damage liable to occur during such an alighting.

(3) The design and location of liferaft installations must be such that, under emergency conditions, and in all sea states and wave height/length ratios up to the maximum demonstrated to comply with the requirements of section 29.801, the liferafts can be launched quickly and made ready for use from any of the ditching emergency exits, the right way up, and clear of any obstructions liable to foul or damage them during launching and during boarding.

29.1411(d) (continued)

(4) Liferafts automatically or remotely released outside the Rotorcraft must be attached to the Rotorcraft by the static line prescribed in section 29.1415.

(5) *Remotely-controlled release.* Where a liferaft installation has a remotely-controlled release:—

(i) The release systems must be safeguarded against spontaneous or inadvertent operation in any conditition of flight, and must be so designed that it is impossible to operate the release partially and return the control to its normal position, without it being obvious that the release has been partially operated.

(ii) A manual release must be provided at the liferaft position for each liferaft normally intended to be released by remote control. Jamming of the remote control must not prevent functioning of the manual release.

(iii) The means of releasing liferafts must be rapid and obvious and the location of such means must be adequately marked.

(iv) There must be at least one convenient release means inside the Rotorcraft by which all remotely controlled liferafts can be released (also see subparagraph (4) of this paragraph and ACB 29.1411(d)).

(6) *Automatic release.* Where a liferaft installation has an automatic release system, the requirements must be decided in consultation with the Authority.

(7) *Launching.* After launching it must be possible to attach liferafts in such a position that the likelihood of the occupants of the Rotorcraft being immersed while boarding them is reduced to a minimum.

(8) *Manual launching*

(i) Where launching is by hand, the necessary actions must be within the capacity of an untrained person of average strength, and must not require exceptional agility or skill (see also paragraph (a) of this section).

(ii) The overall dimensions of the liferaft package must be such that it can be easily passed through any emergency exit likely to be used for launching. (See ACB 29.1411(d).)

29.1411 (continued)

(e) *Long-range signalling device.* The stowage provisions for the long-range signalling device required by section 29.1415 must be near an exit available during an unplanned ditching.

(f) *Life-preservers.* Each life-preserver must be within easy reach of each occupant while seated.

29.1413 Safety belts: passenger warning device

(a) If there are means to indicate to the passengers when safety belts should be fastened, they must be installed to be operated from either pilot seat. (See paragraph 29.853(c)(2).)

(b) Each safety belt must be equipped with a metal to metal latching device.

29.1415 Ditching equipment

(a) Emergency flotation and signalling equipment required by operational regulations must meet the requirements of this section.

(b) Each liferaft and each life-preserver must be Approved. In addition—

(1) Unless excess liferafts of enough capacity are provided, the buoyancy and seating capacity beyond the rated capacity of the liferafts must accommodate all occupants of the Rotorcraft in the event of a loss of one liferaft of the largest rated capacity; and

(2) Each liferaft must have a trailing line, and must have a static line designed to hold the liferaft near the Rotorcraft but to release it if the Rotorcraft becomes totally submerged.

(c) Approved survival equipment must be attached to each liferaft.

(d) There must be an Approved survival type emergency locator transmitter for use in one liferaft.

29.1416 Emergency flotation gear

(a) *Applicability.* Where the carriage of emergency flotation gear is required by operational regulations, the equipment and its installation must meet the requirements of this section.

(b) *General.* The design and installation of the emergency flotation gear must be such that during and after an Emergency Alighting on water, the requirements of section 29.801 are met.

29.1416 (continued)

(c) *Buoyancy.* The buoyancy of each float must not be less than 125% of that proportion of the Maximum Weight of the Rotorcraft normally supported by the float in fresh water.

(d) *Stability*

(i) The arrangement of the floats must be such as to provide a margin of positive stability for the rotorcraft in the conditions of section 29.801.

(ii) The number of separate watertight compartments must be such that a margin of positive stability in conditions up to Sea State 2 (as defined in ACB 29.801(c)) is provided with any single compartment flooded. (See ACB 29.1416(d).)

(e) *Strength.* The emergency flotation gear and its attachments must comply with section 29.563.

(f) *Installation.* For both normally inflated and normally deflated emergency flotation gear installations—

(1) The installation must be designed so, as far as practicable, it will not be damaged by any defect likely to necessitate ditching (e.g. engine fire and fuel leakage), or by any damage likely to occur during an Emergency Alighting.

(2) The location of floats and, where applicable, their means of inflation must be suitably chosen in relation to the ditching characteristics of the Rotorcraft, the escape facilities and the location of personnel inside the Rotorcraft.

(3) Any limitations imposed by the design of floats (e.g. speed, altitude, temperature) must be established.

(g) *Normally deflated floats.* For normally deflated emergency flotation gear installations, in addition to those requirements of paragraph (f) of this section, the following are also required:—

(1) *Attachments.* Attachments of stowages and protective covers must meet the requirements of section 29.303 with allowance for pre-loading, inertia, aerodynamic pressures and altitude effects resulting from residual gas in stowed floats.

(2) *Security.* The security of protective covers must be readily apparent by visual inspection when the Rotorcraft is on the ground.

(3) *Inflation*

(i) The probability that floats will not inflate correctly when required or inflate asymmetrically must not be more than Remote. (See ACB 29.1416(g)(3).)

29.1416(g) (continued)

(ii) Inflation systems must be safeguarded against spontaneous or inadvertent operation in all conditions of flight. (See ACB 29.1416(g)(3).)

(iii) The probability of hazard to the Rotorcraft in the event of inadvertent inflation in any normal condition of flight must not be more than Remote.

(iv) Where flotation gear is intended to be inflated in flight, an envelope of flight conditions must be established as safe for the inflation.

(v) The time of inflation, i.e. that time from initiation to full inflation, must be sufficiently small to prevent the Rotorcraft becoming more than partially submerged, and must be such that occupants may be expected to remain dry. (See ACB 29.1416(g)(3).)

(vi) Suitable means must be provided for checking the pressure in gas storage cylinders.

(vii) A means must be provided to guard against the possibility of over-inflation.

(h) *Tests.* Compliance with the requirements of paragraphs (g)(3)(iii) and (g)(3)(iv) of this section must be demonstrated by flight tests and those of (g)(3)(v) by suitable tests on prototype installations.

29.1419 Ice protection

[*Reserved for BCAR 29*]

MISCELLANEOUS EQUIPMENT

29.1431 Electronic equipment

(a) Radio communication and navigation installations must be free from hazards in themselves, in their method of operation, and in their effects on other components, under any critical environmental conditions.

(b) Radio communication and navigation equipment, controls, and wiring must be installed so that operation of any one unit or system of units will not adversely affect the simultaneous operation of any other radio or electronic unit, or system of units, required by BCAR.

29.1433 Vacuum systems

(a) There must be means, in addition to the normal pressure relief, to automatically relieve the pressure in the discharge lines from the vacuum air pump when the delivery temperature of the air becomes unsafe.

(b) Each vacuum air system line and fitting on the discharge side of the pump that might contain Flammable vapours or fluids must meet the requirements of section 29.1183 if they are in a Designated Fire Zone.

(c) Other vacuum air system components in Designated Fire Zones must be at least fire-resistant.

29.1435 Hydraulic systems

Hydraulic systems used for any Essential Service must comply with the requirements of this section. Hydraulic systems used for any other services need only comply with the requirements of this section to the extent necessary for compliance with section 29.1301.

(a) *Design.* Each applicable hydraulic system must be designed as follows:

(1) Each element of the hydraulic system must be designed to withstand, without detrimental, permanent deformation, limit structural loads that may be imposed simultaneously with the maximum operating hydraulic loads.

(2) *Loads.* Each element of the hydraulic system must be designed to withstand without leakage or permanent deformation, the loads prescribed in this paragraph for proof conditions and without fracture or bursting, the loads prescribed in this paragraph for ultimate conditions.

(i) *Proof Loads.* For components pipes and couplings, loads resulting from pressures of 1·5 Pw or 1·0 Pr, whichever is the greater.

(ii) *Ultimate Loads.* For components only, loads resulting from pressures of 2·0 Pw or 1·5 Pr, whichever is the greater. For pipes and couplings, loads resulting from pressures of 3·0 Pw or 2·25 Pr whichever is the greater. (See ACB 29.1435(a)(2).)

29.1435 (a) (continued)

(3) *Indication*

(i) In each main system, indication of the pressure, or warning of inadequate pressure, or a means of positively checking for adequate pressure before operation of the system must be given to the appropriate member of the flight crew. When the emergency operation of Essential Services is dependent on energy stored in accumulators, indication must be provided in the flight-crew compartment of the available pressure in each source.

(ii) On hydraulic systems associated with power-operated or power-assisted primary flight control systems, a means of indicating to the pilot the failure of each system, and, if appropriate, each power-source, must be provided.

(4) *Pressure*

(i) There must be means provided for limiting, without loss of fluid, the maximum steady pressures achievable during operation (e.g. by one or more short-circuiting relief valves). These means must ensure that the transient pressures realised in any possible condition of operation do not exceed 1·33 Pw, except that, if transient pressures greater than 1·33 Pw would arise from the system being suddenly arrested, these will be acceptable provided that the design of the system takes account of the stresses thereby imposed;

(ii) Means must be provided to safeguard all parts of the system against pressures which might be set up owing to any abnormal cause (e.g. by extremely rapid temperature changes or failure of a pressure reducing valve). Fluid released in meeting this requirement must either be returned to the system or be discharged to some safe place. The system must, however, be so designed as to ensure that fluid is not lost to an extent which might prejudice the operation of any Essential Service; and

(iii) The possibility of detrimental transient (surge) pressures during operation must be considered.

(5) Each hydraulic line, fitting, and component must be installed and supported to prevent excessive vibration and to withstand inertia loads. Each element of the installation must be protected from abrasion, corrosion, and mechanical damage.

29.1435(a) (continued)

(6) Means for providing flexibility must be used to connect points, in a hydraulic fluid line, between which relative motion or differential vibration exists under normal and emergency conditions.

(7) *Output.* The output of the pumps and hydraulic accumulators together must be sufficient to operate the most adverse combination of Essential Services and other services which may be operated at the same time, against the appropriate external loads, and within any minimum times prescribed. Where part of this output is from an accumulator, the required number of operations of the services, and the time intervals between operations, must be such as to be adequate for safety in relation to the services operated.

(8) *Abnormally high temperatures.* The system must be designed to avoid hazard to the Rotorcraft arising from the effects of abnormally high temperatures which may occur in certain parts of the system under fault conditions. (See ACB 29.1435(a)(8).)

(9) *Filters.* Filters of appropriate rating and capacity must be provided in the system where necessary to safeguard the Rotorcraft against the effects of damage or malfunctioning of components as a result of contamination of the fluid. (See ACB 29.1435(a)(9).)

(b) *Tests*

(1) Each element of the system must be tested to a proof pressure of 1·5 times the maximum pressure to which that element will be subjected in normal operation, without failure, malfunction, or detrimental deformation, of any part of the system.

(2) Complete prototype systems must be submitted to such tests as are necessary in the light of previous experience, to prove them to be satisfactory. (See ACB 29.1435(b).)

(c) *Fire protection.* Each hydraulic system using Flammable hydraulic fluid must meet the applicable requirements of sections 29.861, 29.1183, 29.1185, and 29.1189.

(d) *Hydraulic fluid.* Hydraulic fluid which is suitable to be used in the Rotorcraft must be specified in the appropriate manual. (See ACB 29.1435(d).)

29.1439 Protective breathing equipment

[*Deleted in BCAR 29*]

29.1457 Cockpit voice recorders

(a) Each cockpit voice recorder required by operational regulations must be approved and must meet the requirements of CAA Specification No. 11.

(b) [*Deleted in BCAR 29*]

(c) [*Deleted in BCAR 29*]

(d) [*Deleted in BCAR 29*]

(e) [*Deleted in BCAR 29*]

(f) [*Deleted in BCAR 29*]

(g) [*Deleted in BCAR 29*]

29.1461 Equipment containing high energy rotors

(a) Equipment containing high energy rotors must meet paragraph (b), (c), or (d) of this section. (Also see section 29.908.)

(b) High energy rotors contained in equipment must be able to withstand damage caused by malfunctions, vibration, abnormal speeds, and abnormal temperatures. In addition—

(1) Auxiliary rotor cases must be able to contain damage caused by the failure of high energy rotor blades; and

(2) Equipment control devices, systems, and instrumentation must reasonably ensure that no operating limitations affecting the integrity of high energy rotors will be exceeded in service.

(c) It must be shown by test that equipment containing high energy rotors can contain any failure of a high energy rotor that occurs at the highest speed obtainable with the normal speed control devices inoperative.

(d) Equipment containing high energy rotors must be located where rotor failure will neither endanger the occupants nor adversely affect continued safe flight.

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Subpart G — Operating Limitations and Information

29.1501 General

(a) Each operating limitation specified in sections 29.1503 through 29.1533 and other limitations and information necessary for safe operation must be established.

(b) The operating limitations and other information necessary for safe operation must be made available to the crew members as prescribed in sections 29.1541 through 29.1589.

OPERATING LIMITATIONS

29.1503 Airspeed limitations: general

(a) An operating speed range must be established.

(b) When airspeed limitations are a function of weight, weight distribution, altitude, rotor speed, power, or other factors, airspeed limitations corresponding with the critical combinations of these factors must be established.

29.1505 Never-Exceed Speed

(a) The Never-Exceed Speed, VNE, must be established so that it is —

(1) Not less than 40 knots (CAS); and

(2) Not more than the lesser of —

(i) 0·9 times the maximum forward speeds established under section 29.309; or

(ii) 0·9 times the maximum speed shown under sections 29.251 and 29.629; and

(3) Such that the probability of inadvertently exceeding the Maximum Demonstrated Flight Speed, VDF, is Remote.

(b) VNE may vary with altitude, rpm, temperature, and weight, if—

(1) [*Deleted in BCAR 29*]

(2) The ranges of these variables (or of the indications on instruments integrating more than one of these variables) are large enough to allow an operationally practical and safe variation of VNE.

29.1505(continued)

(c) For helicopters, a stabilised power-off VNE denoted as VNE (power-off) may be established at a speed less than VNE established pursuant to paragraph (a) of this section, if the following conditions are met:

(1) VNE (power-off) is not less than a speed midway between the power-on VNE and the speed used in meeting the requirements of—

(i) paragraph 29.67(a)(3) for Group A helicopters;

(ii) 29.65(a) for Group B helicopters, and

(iii) 29.67(b) for multi-engine Group B helicopters meeting the requirements of 29.67(b).

(2) VNE (power-off) is—

(i) A constant airspeed;

(ii) A constant amount less than power-on VNE; or

(iii) A constant airspeed for a portion of the altitude range for which certification is requested, and a constant amount less than power-on VNE for the remainder of the altitude range.

29.1506 Normal Operating Limit Speed

The Normal Operating Limit Speed VNO, must be established for rotorcraft with VH exceeding 0·9 VNE and must be sufficiently below VNE to ensure that the probability of exceeding VNE in a moderate upset occurring at VNO is not more than Reasonably Probable. In the absence of an investigation substantiating another value, VNO must not exceed 0·9 VNE.

29.1507 Maximum Demonstrated Flight Speed

The Maximum Demonstrated Flight Speed VDF, must not be greater than VD.

29.1509 Rotor speed

(a) *Rotor Maximum rpm (Power Off).* The Rotor Maximum RPM (Power Off) must be established so that it does not exceed 95% of the lesser of—

(1) The maximum design rpm determined under paragraph 29.309(b); and

(2) The maximum rpm shown during the type tests.

(b) *Rotor Minimum RPM (Power Off).* The Rotor Minimum RPM (Power Off) must be established so that it is not less than 105% of the greater of—

(1) The minimum shown during the type tests; and

(2) The minimum determined by design substantiation.

(c) *Rotor Minimum RPM (Power On).* The Rotor Minimum RPM (Power On) must be established so that it is—

(1) Not less than the greater of—

(i) The minimum shown during the type tests; and

(ii) The minimum determined by design substantiation; and

(2) Not more than a value determined under paragraph 29.33(a)(1) and (c)(1).

29.1513 Minimum control airspeed

Information must be given of any minimum airspeeds for the control of the rotorcraft, the observance of which is found, as the result of flight tests, to be necessary in particular circumstances.

29.1515 Landing gear speeds

For retractable landing gear, the Landing Gear Operating Speed, V_{LO} and the landing gear extended speed, if different from V_{LO}, must be established, and must not be greater than the maximum airspeed at which compliance with section 29.729 is established.

29.1517 Height-speed envelope

If a range of heights exists at any speed, including zero, within which it is not possible to make a safe landing following power failure, the range of heights and its variation with forward speed must be established, together with any other pertinent information, such as the kind of landing surface. (See section 29.79.)

29.1518 Automatic control system

The minimum height above terrain for the operation of any automatic control system, together with any other limitations on its use must be established. (See ACB 29.1518.)

29.1519 Weight and centre of gravity

(a) The weight and centre of gravity limitations determined under sections 29.25 and 29.27, respectively, must be established as operating limitations.

(b) *Cargo and baggage compartment loading.* The maximum total load and the maximum load per unit area of cargo and baggage compartments must not exceed those at which compliance with section 29.787 has been established.

(c) Any other weight and balance limitations which are necessary must also be established.

29.1521 Power-plant limitations

(a) *General.* The Power-plant limitations prescribed in this section must be established so that they do not exceed the corresponding limits for which the engines are type certificated.

(b) *Take-off operation.* The Power-plant take-off operation must be limited by—

(1) The maximum rotational speed which may not be greater than—

(i) The maximum value determined by the rotor design; or

(ii) The maximum value shown during the type tests;

(2) The maximum allowable manifold pressure (for reciprocating engines);

(3) The maximum allowable turbine inlet or turbine outlet gas temperature (for turbine engines);

29.1521(b) (continued)

(4) The maximum allowable power or torque for each engine, considering the power input limitations of the transmission with all engines operating;

(5) The maximum allowable power or torque for each engine considering the power input limitations of the transmission with one engine inoperative;

(6) The time limit for the use of the power corresponding to the limitations established in subparagraphs (1) through (5) of this paragraph; and

(7) If the time limit established in subparagraph (6) of this paragraph exceeds 2 minutes—

(i) The maximum allowable cylinder head or coolant outlet temperature (for reciprocating engines);

(ii) The maximum allowable engine and transmission oil temperatures;

(iii) The minimum allowable engine and transmission oil pressures and the conditions of rotational speeds and associated oil temperatures; and

(iv) The maximum allowable rate of engine and transmission oil consumption (if applicable).

(c) *Continuous operation.* The continuous operation must be limited by—

(1) The maximum rotational speed, which may not be greater than-

(i) The maximum value determined by the rotor design; or

(ii) The maximum value shown during the type tests;

(2) The minimum rotational speed shown under the rotor speed requirements in paragraph 29.1509(c);

(3) The maximum allowable manifold pressure (for reciprocating engines);

(4) The maximum allowable turbine inlet or turbine outlet gas temperature (for turbine engines);

(5) The maximum allowable power or torque for each engine, considering the power input limitations of the transmission with all engines operating;

(6) The maximum allowable power or torque for each engine, considering the power input limitations of the transmission with one engine inoperative;

29.1521(c) (continued)

(7) The maximum allowable temperatures for—

(i) The cylinder head or coolant outlet (for reciprocating engines);

(ii) The engine oil; and

(iii) The transmission oil;

(8) The minimum allowable engine and transmission oil pressures and the conditions of rotational speeds and associated oil temperatures; and

(9) The maximum allowable rate of engine and transmission oil consumption (if applicable).

(d) *Fuel grade or designation.* The minimum fuel grade (for reciprocating engines) or fuel designation (for turbine engines) must be established so that it is not less than that required for the operation of the engines within the limitations in paragraphs (b) and (c) of this section.

(e) *Ambient temperature.* Ambient temperature limitations (including limitations for winterisation installations if applicable) must be established as the maximum ambient atmospheric temperature at which compliance with the cooling provisions of sections 29.1041 through 29.1043 is shown.

(f) *Maximum Contingency Power operation.* For helicopters for which compliance with the Maximum Contingency Power requirements of BCAR 29 is shown, the established time limit for the use of Maximum Contingency Power must be 2½ minutes for any period in which that power is used. The use of Maximum Contingency Power must also be limited by—

(1) The maximum rotational speed, which may not be greater than—

(i) The maximum value determined by the Rotor design; or

(ii) The maximum value shown during the type tests;

(2) The maximum allowable gas temperature;

(3) The maximum allowable torque;

(4) The maximum allowable oil temperature.

(5) The minimum allowable engine and transmission oil pressures and the conditions of rotational speeds and associated oil temperatures; and

(6) The maximum allowable rate of engine and transmission oil consumption (if applicable).

29.1521 (continued)

(g) *Intermediate Contingency Power operation.* For helicopters for which compliance with the Intermediate Contingency Power requirements of BCAR 29 is shown, the use of Intermediate Contingency Power must also be limited by—

(1) The maximum rotational speed which may not be greater than—

(i) The maximum value determined by the rotor design; or

(ii) The maximum value shown during the type tests;

(2) The maximum allowable gas temperature;

(3) The maximum allowable torque; and

(4) The maximum allowable oil temperature;

(5) The minimum allowable engine and transmission oil pressures and the conditions of rotational speeds and associated oil temperatures; and

(6) The maximum allowable rate of engine and transmission oil consumption (if applicable).

(h) *Oil specification.* The approved oil specifications, brands and types, together with any associated temperature limitations, must be established.

(i) *Starting.* The established information must include the following:—

(1) Limitations to be observed in the starting of an engine or transmission system on the ground or restarting an engine in flight.

(2) Limitations to be observed following an unsuccessful attempt to start an engine on the ground or to restart an engine in flight.

(j) *Fuel system.* The established information must include the following:—

(1) The minimum fuel temperature.

(2) The minimum fuel pressure.

(k) *Miscellaneous limitations.* The established information must include the following:—

(1) Limitations associated with the use of the fuel/air mixture control system and fuel injection system and, for piston engines, limitations associated with weak mixture operation.

(2) Limitations on, and procedures for the use of Powerplant ice-protection systems.

(3) Limitations on the use of turbine engine bleeds.

29.1522 Auxiliary Power-unit limitations

If an auxiliary Power-unit that meets the requirements of JAR-APU is installed in the rotorcraft, the limitations established for that auxiliary Power-unit under the JAR including the categories of operation must be specified as operating limitations for the rotorcraft.

29.1523 Minimum flight crew

The minimum flight crew must be established so that it is sufficient for safe operation, considering—

(a) The workload on individual crew members;

(b) The accessibility and ease of operation of necessary controls by the appropriate crew member; and

(c) The kinds of operation authorised under section 29.1525.

29.1525 Kinds of operation

The kinds of operation to which the rotorcraft is limited are established by the flight characteristics and installed equipment.

29.1527 Maximum operating altitude

The maximum altitude up to which operation is allowed, as limited by flight, structural, powerplant, functional, or equipment characteristics, must be established.

29.1529 Instructions for Continued Airworthiness

The applicant must prepare Instructions for Continued Airworthiness in accordance with Appendix A of BCAR 29 that are acceptable to the Authority.

29.1533 Additional operating limitations

The following operating limitations must be established. Any other information which is necessary must also be established, in particular that associated with unconventional design, operating or handling features.

29.1533 (continued)

(a) *Rotor Torques – Single-engined Helicopters (where applicable)* The following must be established:—

(1) A Rotor Maximum One-Hour Torque.

(2) A Rotor Maximum Continuous Torque.

(3) A Rotor Maximum Over-Torque.

(b) *Rotor Torques – Twin-engined Helicopters (where applicable)* The following must be established:—

(1) A Rotor Maximum Contingency Torque.

(2) A Rotor Intermediate Contingency Torque.

(3) A Rotor Maximum Continuous Torque.

(4) A Rotor Maximum Over-Torque.

(c) *Interrelated limitations.* Some limitations may, on the basis of their being unique and independent, have more than one value and be interrelated provided that the combined limitations are readily remembered and complied with. (See ACB 29.1533(c).)

(d) *Miscellaneous.* If, as a result of flight tests, it is found that certain conditions in respect of the following items must not be exceeded if hazardous conditions are to be avoided, limitations must be established to control these conditions. Where no limitation is established for an item, information must be given on the most adverse conditions encountered during tests.

(1) *Maximum speed on the surface of the ground.* This speed, for take-off, landing and taxying, must be related to specific ground conditions.

(2) *Most adverse cross-wind for take-off and landing.* This must include Emergency Landing.

(3) *Maximum sideways speed and maximum backward speed.*

(4) *Maximum wind speed for Rotor starting and stopping.*

(5) *Maximum speeds on tow with the engine(s) stopped (if applicable).*

(6) *Emergency alighting on water.* The limitations prescribed in paragraph 29.801(h). (See ACB 29.1533(d).)

MARKINGS AND PLACARDS

29.1541 General

(a) The rotorcraft must contain—

(1) The markings and placards specified in sections 29.1545 through 29.1565; and

(2) Any additional information, instrument markings, and placards required for the safe operation of the rotorcraft if it has unusual design, operating or handling characteristics.

(b) Each marking and placard prescribed in paragraph (a) of this section—

(1) Must be displayed in a conspicuous place; and

(2) May not be easily erased, disfigured, or obscured. (See ACB 29.1541.)

29.1543 Instrument markings: general

For each instrument—

(a) When markings are on the cover glass of the instrument there must be means to maintain the correct alignment of the glass cover with the face of the dial; and

(b) Each arc and line must be wide enough and located to be clearly visible to the pilot. (See ACB 29.1543.)

29.1545 Airspeed indicator

(a) Each airspeed indicator must be marked as specified in paragraph (b) of this section, with the marks located at the corresponding indicated airspeeds.

(b) The following markings must be made:

(1) A red radial line at VNE.

(2) [*Deleted in BCAR 29*]

(3) For the caution range, a yellow arc.

(4) For the normal operating range, a green arc from zero extending to an upper limit at VNO. (See ACB 29.1545.)

29.1547 Magnetic direction indicator

(a) A placard meeting the requirements of this section must be installed on or near the magnetic direction indicator.

29.1547 (continued)

(b) The placard must show the calibration of the instrument in level flight with the engines operating.

(c) The placard must state whether the calibration was made with radio receivers on or off.

(d) Each calibration reading must be in terms of magnetic heading in not more than 45° increments.

(e) The placard must show the deviations of the instrument under all normal and emergency combinations of generator and equipment utilisation.

29.1549 Power-plant instruments

For each required Power-plant instrument, as appropriate to the type of instruments—

(a) Each maximum and, if applicable, minimum safe operating limit must be marked with a red radial or a red line;

(b) Each normal operating range must be marked with a green arc or green line, not extending beyond the maximum and minimum safe limits;

(c) Each take-off and precautionary range must be marked with a yellow arc or yellow line; and

(d) Each engine range that is restricted because of excessive vibration stresses must be marked with red arcs or red lines.

29.1551 Oil quantity indicator

Each oil quantity indicator must be marked with enough increments to indicate readily and accurately the quantity of oil.

29.1553 Fuel quantity indicator

If the unusable fuel supply for any tank exceeds 5% or 4·5 litres (1 gal), of the tank capacity, whichever is greater, a red arc must be marked on its indicator extending from the calibrated zero reading to the lowest reading obtainable in level flight.

29.1555 Control markings

(a) Each cockpit control, other than primary flight controls or control whose function is obvious, must be plainly marked as to its function and method of operation.

29.1555 (continued)

(b) For Power-plant fuel controls—

(1) Each fuel tank selector valve control must be marked to indicate the position corresponding to each tank and to each existing cross feed position;

(2) If safe operation requires the use of any tanks in a specific sequence, that sequence must be marked on, or adjacent to, the selector for those tanks; and

(3) Each valve control for any engine of a multi-engine rotorcraft must be marked to indicate the position corresponding to each engine controlled.

(c) Usable fuel capacity must be marked as follows:—

(1) [*Reserved for BCAR 29*]

(2) For fuel systems having selector controls, the usable fuel capacity available at each selector control position must be indicated near the selector control.

(d) For accessory, auxiliary, and emergency controls—

(1) Each essential visual position indicator, such as those showing rotor pitch or landing gear position, must be marked so that each crew member can determine at any time the position of the unit to which it relates; and

(2) Each emergency control must be red and must be marked as to method of operation.

(e) For rotorcraft incorporating retractable landing gear where the Landing Gear Operating Speed, V_{LO}, or the Landing Gear Extended Speed, V_{LE}, is lower than V_{NO}, a placard must be displayed as close as practicable to the landing gear control stating in terms of IAS V_{LO} and, if different, V_{LE}.

29.1557 Miscellaneous markings and placards

(a) *Baggage and cargo compartments, and ballast location.* Each baggage and cargo compartment, and each ballast location must have a placard stating any limitations on contents, including weight, that are necessary under the loading requirements.

(b) *Seats.* If the maximum allowable weight to be carried in a seat is less than 77 kg (170 lb), a placard stating the lesser weight must be permanently attached to the seat structure.

29.1557 (continued)

(c) *Fuel and oil filler openings.* The marking in subparagraphs (1) and (2) must be marked on or near to the filler cap or filling point. If it is not practicable to so mark the specification and/or brands of the Approved liquids the information must be made available in the flight-crew compartment in a form suitable for immediate reference during replenishment. A reference to where this information can be found must be marked on or near to the filler cap or filler point.

(1) Fuel filler openings must be marked with —

(i) The word 'fuel';

(ii) For reciprocating-engine-powered rotorcraft, the minimum fuel grade (where practicable);

(iii) For turbine-engine-powered rotorcraft, the permissible fuel designations (where practicable);

(iv) For pressure fuelling systems, the maximum persmissible fuelling supply pressure and the maximum permissible defuelling pressure; and

(v) The useable tank capacity.

(2) Oil filler openings must be marked with

(i) The word 'oil';

(ii) The tank capacity; and

(iii) The brands of the Approved oils for the engines (where practicable).

(d) *Normal and emergency exit placards*

(1) *External placards.* Each placard and operating control for each emergency exit must differ in colour from the surrounding fuselage surface as prescribed in paragraph 29.811(h)(2). A placard must be near each emergency exit control and must clearly indicate the location of that exit and its method of operation.

(2) *Internal placards.* Operating controls for normal and emergency exits must be marked to indicate their function. The markings for emergency exits must be in red.

(e) *Centre of gravity.* Markings must be provided to identify the datum to which the centre of gravity limitations established by paragraph 29.1519(a) are related, unless some well-defined feature of the rotorcraft (e.g. rotor mast) is used.

29.1557 (continued)

(f) Levelling marks must be provided. (See section 29.871.)

(g) *Airspeed indicator.* A placard must be installed as close as practicable to each airspeed indicator, or a suitable indicating means must be provided, stating in terms of IAS:—

(1) Any permitted variations with altitude temperature and weight limitations which have been marked on the airspeed indicator in accordance with section 29.1545, and

(2) Any speed limitation which is not marked on the airspeed indicator in accordance with section 29.1545.

(h) Jettison controls, installed under section 29.1001, must be clearly marked to indicate their functions and methods of use.

(i) *Maximum Weight.* The Maximum Weight defined in section 29.25, must be placarded, together with a caution that this does not necessarily ensure a safe performance, for which the Flight Manual should be consulted. This placard need not be readily visible in flight, but must be readily visible when entering the cockpit.

(j) *Automatic control system operation.* A placard must be provided stating all limitations regarding the use of the automatic control system established in accordance with section 29.1518.

(k) *Smoking.* If required by paragraph 29.853(c) a placard stating that smoking in the compartment is not permitted must be provided.

(l) *Use of rotor brake and clutch.* Any necessary limitations or information regarding the use of the rotor brake and clutch, established by section 29.921, must be placarded where it is visible to the pilot in flight.

(m) *Hydraulic fluid.* The word 'hydraulic' or its equivalent in other languages and the specification of the Approved fluids must be marked on, or adjacent to, all system filling points and unit filling points.

(n) Flammable fluid emergency controls must be clearly marked to indicate their functions and method of use.

(o) For rotorcraft approved for carrying external loads, the placards of paragraphs 29.865(c) and (d).

29.1559 Limitations placard

There must be a placard in a clear view of the pilot that specifies the kinds of operations (VFR, IFR, day, night, or icing) for which the rotocraft is Approved. (See ACB 29.1559.)

29.1561 Safety equipment

(a) Each safety equipment control to be operated by the crew in emergency, such as controls for automatic liferaft releases, must be plainly marked as to its method of operation.

(b) Each location, such as a locker or compartment, that carries any fire extinguishing, signaling, or other life saving equipment, must be so marked.

(c) Stowage provisions for required emergency equipment must be conspicuously marked to identify the contents and facilitate removal of the equipment.

(d) Each liferaft must have obviously marked operating instructions.

(e) Approved survival equipment must be marked for identification and method of operation.

(f) Instructions for the use of extinguishing apparatus fitted in compliance with paragraph 29.855(d) must be placarded at the appropriate crew member's station.

29.1565 Tail rotor

Each tail rotor must be marked so that its disc is conspicuous under normal daylight ground conditions.

ROTORCRAFT FLIGHT MANUAL

29.1581 General

(a) *Furnishing information.* A Rotorcraft Flight Manual must be furnished with each rotorcraft, and it must contain the following:

(1) Information required by sections 29.1583 through 29.1589.

(2) Other information that is necessary for safe operation because of design, operating, or handling characteristics. (See ACB 29.1581(a).)

29.1581 (continued)

(b) *Approved information.* Each part of the manual listed in sections 29.1583 through 25.1589 that is appropriate to the rotorcraft, must be furnished, verified, and Approved, and must be segregated, identified, and clearly distinguished from each unapproved part of that manual to the satisfaction of the Authority. (See ACB 29.1581(b).)

(c) [Reserved for FAR]

(d) *Table of contents.* Each Rotorcraft Flight Manual must include a table of contents if the complexity of the manual indicates a need for it.

(e) *Contents.* The information provided in accordance with paragraph (a) of this section must be divided into numbered sections in the following order:—

(1) General (see ACB 29.1581(e)(1)),

(2) Limitations (see section 29.1583),

(3) Emergency procedures (see section 29.1585),

(4) Normal procedures (see section 29.1585),

(5) Performance (see section 29.1587),

(6) Supplements (see ACB 29.1581(e)(6)).

(f) *Units.* The units used in the Flight Manual must be the same as those marked on the appropriate rotorcraft instruments. (See ACB 29.1581(f).)

29.1583 Operating limitations

(a) *Airspeed and rotor limitations.* Information necessary for the marking of airspeed and rotor limitations on or near their respective indicators must be furnished. The significance of each limitation and of the colour coding must be explained.

(b) *Power-plant limitations.* The following information must be furnished:

(1) Limitations required by section 29.1521.

(2) Explanation of the limitations, when appropriate.

(3) Explanation of the significance of any instrument colour markings provided in accordance with paragraph 29.1541(a).

(4) The engines to which the Flight Manual relates.

29.1583(b) (continued)

(5) Limitations, where applicable, on the use of the rotor brake.

(c) *Weight and loading distribution.* The following limits must be furnished:—

(1) *Weights*

(i) Maximum Take-off Weight.

(ii) Maximum Landing Weight.

(2) *Baggage and freight loading.* A Statement of the maximum loads and intensity of load of all cargo and baggage compartments. (See ACB 29.1583(c)(2).)

(3) *Centre of gravity*

(i) A statement of the centre of gravity limits longitudinally, laterally and, where appropriate, vertically in terms of distance from a datum, together with a definition of that datum.

(ii) Where any of the limits vary with weight, a graph showing the variations.

(d) *Flight crews.* When a flight crew of more than one is required, the number and functions of the minimum flight crew determined under section 29.1523 must be furnished.

(e) *Kinds of operation.* Each kind of operation for which the rotorcraft and its equipment installations are Approved must be listed.

(f) [*Deleted in BCAR*]

(g) [Reserved for FAR]

(h) *Altitude.* The altitude established under section 29.1527 and an explanation of the limiting factors must be furnished.

(i) *Ambient temperature.* Maximum and minimum ambient temperature limitations must be furnished. (See ACB 29.1583(i).)

(j) *Number of occupants.* The maximum permissible number of occupants, together with a statement that children under the age of three years when carried in the arms of an adult need not be taken into account must be furnished. (See ACB 29.1583(j).)

(k) *Certification category.* The certification category or categories must be furnished.

(l) *Systems.* Any limitations on the use of the systems in the rotorcraft must be furnished, with particular reference to the electrical system and equipment.

(m) *Smoking.* Any restrictions on smoking in the rotorcraft must be furnished.

29.1583 (continued)

(n) *Markings and placards.* The inscription on, and location of, each placard which is required to be displayed, together with an explanation of the significance of any instrument colour markings must be furnished.

(o) *Declared time interval.* For Group A rotorcraft which have a declared time interval, this declared time interval must be furnished. (See paragraphs 29.601(e) and 29.917(b).)

29.1585 Operating procedures

(a) The parts of the manual containing operating procedures must have information concerning any normal and emergency procedures, and other information necessary for safe operation, including the applicable procedures, such as those involving minimum speeds, to be followed if an engine fails. Reference to airspeed must be made in terms of IAS. At least the items prescribed in paragraphs (1) and (2) of this section must be furnished. (See ACB 29.1585(a).)

(1) *Normal procedures*

(i) Preparing the rotorcraft for flight (including unfolding of rotor blades, removing of covers, locks, etc).

(ii) Engine starting procedures.

(iii) Rotor starting procedures.

(iv) Engine run-up, control functioning and related checks.

(v) Ground taxying procedure.

(vi) Pre-take-off cockpit check.

(vii) Take-off procedure.

(viii) Significance of limitations — warning characteristics.

(ix) In-flight procedures.

(x) Use of special equipment.

(xi) Flight in ice-forming conditions, where applicable.

(xii) Use of fuel systems; control of centre of gravity in flight.

(xiii) Flight in turbulence.

(xiv) Use of automatic flight control or stability augmentation system.

(xv) Pre-landing cockpit check.

(xvi) Approach and landing procedures for varying visibilities, with and without power.

29.1585(a) (continued)

(xvii) Balked landing procedure.

(xviii) Stopping the rotor.

(xix) Stopping the engine(s).

(xx) Towing.

(xxi) Parking and picketing.

(xxii) External load carrying procedures, where applicable. (See ACB 29.1585(a)(3).)

(2) *Emergency procedures*

(i) Fire on the ground (engine, cabin, electric, or other possible types).

(ii) Fire in the air (engine, cabin, electric, or other possible types including smoke clearance).

(iii) Partial and complete power failure, at various conditions of height and airspeed, during take-off, approach and other flight conditions.

(iv) Actual or suspected damage or malfunctioning of rotor systems and auxiliary systems, (fuel, electrical, power-operated controls, automatic flight control or stability augmentation system, etc.)

(v) Emergency alighting, including ditching.

(vi) Severe static or lightning strikes.

(vii) Procedure for restarting an engine in flight.

(viii) External load carrying procedures, where applicable. (See ACB 29.1585(a)(3).)

(ix) Fuel jettisoning procedure.

(b) [*Reserved for BCAR 29*]

(c) [*Reserved for BCAR 29*]

(d) For each rotorcraft showing compliance with paragraphs 29.1353(c)(6)(ii) or (c)(6)(iii), the operating procedures for disconnecting the battery from its charging source must be furnished.

(e) *Unusable fuel*

(1) If the unusable fuel supply in any tank exceeds 5% of the tank capacity, or 4·5 litre (1 gal), whichever is greater, information must be furnished which indicates that when the fuel quantity indicator reads 'zero' in level flight, any fuel remaining in the fuel tank cannot be used safely in flight.

(2) A statement of the effect on the unusable fuel quantity resulting from the failure of any pump must be furnished.

29.1585(e) (continued)

(3) A statement giving conditions (e.g. flight attitudes) corresponding to the unusable fuel quantity must be furnished.

(f) Information on the total quantity of usable fuel for each fuel tank must be furnished.

(g) The appropriate fuel quantity indicator system performance information established by paragraph 29.1337(b)(6) must be furnished.

(h) For Group B rotorcraft, the airspeeds and corresponding rotor speeds for minimum rate of descent and best glide angle as prescribed in section 29.71 must be provided.

29.1587 Performance information (See ACB 29.1587)

(a) *Group A.* For each Group A Rotorcraft, the Rotorcraft Flight Manual must contain a summary of the performance data, including data necessary for the application of any operating rule, together with descriptions of the conditions, such as airspeeds, under which this data was determined, and must contain —

(1) The indicated airspeeds corresponding with those determined for take-off, and the procedures to be followed if the critical engine fails during take-off;

(2) The airspeed calibrations;

(3) The techniques, associated airspeeds, and rates of descent for autorotative landings;

(4) The Rejected Take-off Area determined under paragraph 29.59(b) and the Take-off Space Required determined under paragraph 29.59(c);

(5) The landing data determined under sections 29.75 and 29.77;

(6) *Wind.* The wind conditions for which the rotorcraft is permitted to operate;

(7) *Cruising speeds*

(i) A representative cruising true air speed for use in showing compliance with operational performance rules relating to flight over water.

(ii) A representative cruising true air speed relating to one-Power-unit-inoperative en-route data (see ACB 29.1587(a)(7); and,

29.1587(a) (continued)

(8) *Series and renewal data.* The Gross Performance agreed with the Authority to be necessary for the evaluation of series and renewal flight tests. (See BCAR Section A, Chapter A5—2.)

(b) *Group B.* For each Group B rotorcraft, the Rotorcraft Flight Manual must contain —

(1) The Take-off Space Required and the climbout speed together with the pertinent information defining the flight path with respect to autorotative landing if an engine fails, including the calculated effects of altitude and temperature;

(2) The steady rates of climb and hovering ceiling, together with the corresponding airspeeds and other pertinent information, including the calculated effects of altitude and temperature;

(3) The Landing Space Required appropriate glide airspeed, and kind of Landing Surface, together with any pertinent information that might affect this distance, including the calculated effects of altitude and temperature;

(4) *Wind.* The wind conditions for which the rotorcraft is permitted to operate;

(5) The airspeed calibrations;

(6) The height-speed envelope;

(7) Glide distance as a function of altitude when autorotating at the speeds and conditions for minimum rate of descent and best glide angle, as determined in section 29.71;

(8) [*Reserved for BCAR 29*]

(9) A representative cruising true airspeed for use in showing compliance with operational performance rules relating to flight over water.

(10) *Series and renewal data.* The Gross Performance agreed with the Authority to be necessary for the evaluation of series and renewal flight tests (see BCAR Section A, Chapter A5—2); and

(11) Any additional performance data necessary for the application of any operating rule. (See ACB 29.1587.)

29.1589 Loading information

There must be loading instructions for each possible loading condition between the Maximum and Minimum Weights determined under section 29.25 that can result in a centre of gravity beyond any extreme prescribed in section 29.27, assuming any probable occupant weights.

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Appendix A

Instructions for Continued Airworthiness

A29.1 . *General*

(a) This Appendix specifies requirements for the preparation of Instructions for Continued Airworthiness as required by section 29.1529.

(b) The Instructions for Continued Airworthiness for each rotorcraft must include the Instructions for Continued Airworthiness for each engine and rotor (hereinafter designated 'products'), for each appliance required by this chapter, and any required information relating to the interface of those appliances and products with the rotorcraft. If Instructions for Continued Airworthiness are not supplied by the manufacturer of an appliance or product installed in the rotorcraft, the Instructions for Continued Airworthiness for the rotorcraft must include the information essential to the continued airworthiness of the rotorcraft.

(c) The applicant must submit to the Authority a programme to show how changes to the Instructions for Continued Airworthiness made by the applicant or by the manufacturers of products and appliances installed in the rotorcraft will be distributed.

A29.2 *Format*

(a) The Instructions for Continued Airworthiness must be in the form of a manual or manuals as appropriate for the quantity of data to be provided.

(b) The format of the manual or manuals must provide for a practical arrangement.

A29.3 *Content*

The contents of the manual or manuals must be prepared in the English language. The Instructions for Continued Airworthiness must contain the following manuals or sections, as appropriate, and information:

(a) *Rotorcraft maintenance manual or section*

(1) Introduction information that includes an explanation of the rotorcraft's features and data to the extent necessary for maintenance or preventive maintenance.

(2) A description of the rotorcraft and its systems and installations including its engines, rotors, and appliances.

(3) Basic control and operation information describing how the rotorcraft components and systems are controlled and how they operate, including any special procedures and limitations that apply.

(4) Servicing information that covers details regarding servicing points, capacities of tanks, reservoirs, types of fluids to be used, pressures applicable to the various systems, location of access panels for inspection and servicing, locations of lubrication points, the lubricants to be used, equipment required for servicing, tow instructions and limitations, mooring, jacking, and levelling information.

(b) *Maintenance instructions*

(1) Scheduling information for each part of the rotorcraft and its engines, auxiliary power units, rotors, accessories, instruments, and equipment that provides the recommended periods at which they should be cleaned, inspected, adjusted, tested, and lubricated, and the degree of inspection, the applicable wear tolerances, and work recommended at these periods. However, the applicant may refer to an accessory, instrument, or equipment manufacturer as the source of this information if the applicant shows that the item has an excceptionally high degree of complexity requiring specialised techniques, test equipment, or expertise. The recommended overhaul periods and necessary cross references to the Airworthiness Limitations section of the manual must also be included. In addition, the applicant must include an inspection programme that includes the frequency and extent of the inspections necessary to provide for the continued airworthiness of the rotorcraft.

(2) Troubleshooting information describing probable malfunctions, how to recognise those malfunctions, and the remedial action for those malfunctions.

(3) Information describing the order and method of removing and replacing products and parts with any necessary precautions to be taken.

(4) Other general procedural instructions including procedures for system testing during ground running, symmetry checks, weighing and determining the centre of gravity, lifting and shoring, and storage limitations.

Appendix A (continued)

A29.3 (continued)

(5) *Control system characteristics.* In the course of establishing compliance with the handling requirements of Subpart B, sufficient observations must be made of the friction (and other significant rigging characteristics) of the primary flight control systems, to enable such maintenance instructions to be formulated as will ensure that there will be no undue variation between the handling characteristics of the prototype rotorcraft at the time of official trials, and those of series rotorcraft, or of the same rotorcraft, during its service life.

(c) Diagrams of structural access plates and information needed to gain access for inspections when access plates are not provided.

(d) Details for the application of special inspection techniques including radiographic and ultrasonic testing where such processes are specified.

(e) Information needed to apply protective treatments to the structure after inspection.

(f) All data relative to structural fasteners such as identification, discard recommendations, and torque values.

(g) A list of special tools needed.

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A29.4 *Airworthiness Limitations section*

The Instructions for Continued Airworthiness must contain a section titled Airworthiness Limitations that is segregated and clearly distinguishable from the rest of the document. This section must set forth each mandatory replacement time, structural inspection interval, and related structural inspection procedure. If the Instructions for Continued Airworthiness consist of multiple documents, the section required by this paragraph must be included in the principal manual. This section must contain a legible statement in a prominent location that reads: "The Airworthiness Limitations section and variations have been approved by the Authority".

Appendix B

Airworthiness Criteria for Helicopter Instrument Flight

I *General.* A transport category helicopter may not be type certificated for operation under the instrument flight rules (IFR) of BCAR 29 unless it meets the design and installation requirements contained in this Appendix.

II *Definitions.*

(a) VYI means instrument climb speed, utilised instead of VY for compliance with the climb requirements for instrument flight.

(b) VNEI means instrument flight never exceed speed, utilised instead of VNE for compliance with maximum limit speed requirements for instrument flight.

(c) VMINI means instrument flight minimum speed, utilised in complying with minimum limit speed requirements for instrument flight.

III *Trim.* It must be possible to trim the cyclic, collective, and directional control forces to zero at all approved IFR airspeeds, power settings, and configurations appropriate to the type.

IV *Static longitudinal stability.* (See ACB 29.171,(1).)

(a) *General.* The helicopter must possess positive static longitudinal control force stability at critical combinations of weight and centre of gravity at the conditions specified in paragraphs IV(b) through (f) of this Appendix. The stick force must vary with speed so that any substantial speed change results in a stick force clearly perceptible to the pilot. The airspeed must return to within 10% of the trim speed when the control force is slowly released for each trim condition specified in paragraphs IV(b) through (f) of this Appendix.

(b) *Climb.* Stability must be shown in climb throughout the speed range 20 knots either side of trim with—

(1) The helicopter trimmed at VYI;

(2) Landing gear retracted (if retractable); and

(3) Power required for limit climb rate (at least 1000 ft/min) at VYI or maximum continuous power, whichever is less.

(c) *Cruise.* Stability must be shown throughout the speed range from 0·7 to 1·1 VH or VNEI, whichever is lower, not to exceed ±20 knots from trim with—

(1) The helicopter trimmed and power adjusted for level flight at 0·9 VH or 0·9 VNEI, whichever is lower; and

(2) Landing gear retracted (if retractable).

(d) *Slow cruise.* Stability must be shown throughout the speed range from 0·9 VMINI to 1·3 VMINI or 20 knots above trim speed, whichever is greater, with—

(1) The helicopter trimmed and power adjusted for level flight at 1·1 VMINI; and

(2) Landing gear retracted (if retractable).

(e) *Descent.* Stability must be shown throughout the speed range 20 knots either side of trim with—

(1) The helicopter trimmed at 0·8 VH or 0·8 VNEI (or 0·8 VLE for the landing gear extended case), whichever is lower;

(2) Power required for 1000 ft/min descent at trim speed; and

(3) Landing gear extended and retracted, if applicable.

(f) *Approach.* Stability must be shown throughout the speed range from 0·7 times the minimum recommended approach speed to 20 knots above the maximum recommended approach speed with—

(1) The helicopter trimmed at the recommended approach speed or speeds;

(2) Landing gear extended and retracted, if applicable; and

(3) Power required to maintain a 3° glide path and power required to maintain the steepest approach gradient for which approval is requested.

V *Static lateral-directional stability*

(a) Static directional stability must be positive throughout the Approved ranges of airspeed, power, and vertical speed. In straight, steady sideslips up to ±10° from trim, directional control position must increase in approximately constant proportion to angle of sideslip. At greater angles up to the maximum sideslip angle appropriate to the type, increased directional control position must produce increased angle of sideslip.

(b) During sideslips up to ±10° from trim throughout the Approved ranges of airspeed, power, and vertical speed there must be no negative dihedral stability perceptible to the pilot through lateral control motion or force. Longitudinal cycle movement with sideslip must not be excessive.

Appendix B (continued)

VI *Dynamic stability.* It should be demonstrated that at least the following criteria are met:—

(a) Any oscillation having a period of less than 5 seconds must damp to ½ amplitude in not more than one cycle.

(b) Any oscillation having a period of 5 seconds or more but less than 10 seconds must damp to ½ amplitude in not more than two cycles.

(c) Any oscillation having a period of 10 seconds or more but less than 20 seconds must be damped.

(d) Any oscillation having a period of 20 seconds or more may not achieve double amplitude in less than 20 seconds.

(e) [*Deleted in BCAR 29*]
(See ACB for Appendix B.)

VII *Stability augmentation system (SAS)*
See section 29.672 (as contained in Subpart D).

VIII *Equipment, systems, and installations*
See Subpart F.

IX *Rotorcraft Flight Manual*
See Subpart G.

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Appendix F

An Acceptable Test Procedure for Showing Compliance with BCAR Sections 29.853 and 29.1359

(a) *Conditioning.* Specimens must be conditioned to 70°F, ±5°, and at 50%, ±5%, relative humidity until moisture equilibrium is reached or for 24 hours. Only one specimen at a time may be removed from the conditioning environment immediately before subjecting it to the flame.

(b) *Specimen configuration.* Except as provided for materials used in electrical wire and cable insulation and in small parts, materials must be tested either as a section cut from a fabricated part as installed in the rotorcraft or as a specimen simulating a cut section, such as a specimen cut from a flat sheet of the material or a model of the fabricated part. The specimen may be cut from any location in a fabricated part; however, fabricated units, such as sandwich panels, may not be separated for the test. The specimen thickness must be no thicker than the minimum thickness to be qualified for use in the rotorcraft, except that: (1) thick foam parts, such as seat cushions, must be tested in ½ inch thickness; (2) when showing compliance with paragraph 29.853(a)(4) for materials used in small parts that must be tested, the materials must be tested in no more than ⅛ inch thickness; (3) when showing compliance with paragraph 29.1359(c) for materials used in electrical wire and cable insulation, the wire and cable specimens must be the same size as used in the rotorcraft. In the case of fabrics, both the warp and fill direction of the weave must be tested to determine the most critical flammability condition. When performing the tests prescribed in paragraphs (d) to (e) of this Appendix, the specimen must be mounted in a metal frame so that; (1) in the vertical tests of paragraph (d), the two long edges and the upper edge are held securely; (2) in the horizontal test of paragraph (e), the two long edges and the edge away from the flame are held securely; (3) the exposed area of the specimen is at least 2 inches wide and 12 inches long, unless the actual size used in the rotorcraft is smaller; and (4) the edge to which the burner flame is applied must not consist of the finished or protected edge of the specimen but must be representative of the actual cross-section of the material or part installed in the rotorcraft.

(c) *Apparatus.* Except as provided in paragraph (h) of this Appendix, tests must be conducted in a draught-free cabinet in accordance with Federal Test Method Standard 191 Method 5903 (revised Method 5902) for the vertical test, or Method 5906 for horizontal test or other approved equivalent methods. Specimens which are too large for the cabinet must be tested in similar draught-free conditions.

(d) *Vertical test, in compliance with paragraphs 29.853(a)(1) and (a)(2).* A minimum of three specimens must be tested and the results averaged. For fabrics, the direction of weave corresponding to the most critical flammability conditions must be parallel to the longest dimension. Each specimen must be supported vertically. The specimen must be exposed to a Bunsen or Tirrill burner with a nominal ⅜ inch inside diameter tube adjusted to give a flame of 1½ inches in height. The minimum flame temperature measured by a calibrated thermocouple pyrometer in the centre of the flame must be 1550°F. The lower edge of the specimen must be ¾ inch above the top edge of the burner. The flame must be applied to the centreline of the lower edge of the specimen. For materials covered by paragraph 29.853(a)(1), the flame must be applied for 60 seconds and then removed. For materials covered by paragraph 29.853(a)(2) the flame must be applied for 12 seconds and then removed. Flame time, burn length, and flaming time of drippings, if any, must be recorded. The burn length determined in accordance with paragraph (g) of this Appendix must be measured to the nearest 1/10 inch.

(e) *Horizontal test in compliance with paragraphs 29.853(a)(3) and (a)(4).* A minimum of three specimens must be tested and the results averaged. Each specimen must be supported horizontally. The exposed surface when installed in the aircraft must be face down for the test. The specimen must be exposed to a Bunsen burner or Tirrill burner with a nominal ⅜ inch inside diameter tube adjusted to give a flame of 1½ inches in height. The minimum flame temperature measured by a calibrated thermocouple pyrometer in the centre of the flame must be 1550°F. The specimen must be positioned so that the edge being tested is ¾ inch

above the top of, and on the centreline of, the burner. The flame must be applied for 15 seconds and then removed. A minimum of 10 inches of the specimen must be used for timing purposes, approximatley 1½ inches must burn before the burning front reaches the timing zone, and the average burn rate must be recorded.

(f) [*Deleted in BCAR 29*]

(g) *60° test in compliance with paragraph 29.1359(c).* A minimum of three specimens of each wire specification (make and size) must be tested. The specimen of wire or cable (including insulation) must be placed at an angle of 60° with the horizontal in the cabinet specified in paragraph (c) of this Appendix with the cabinet door open during the test or must be placed within a chamber approximately 2 ft high x 1 ft x 1 ft, open at the top and at one vertical side (front), and which allows sufficient flow of air for complete combustion, but which is free from draughts. The specimen must be parallel to and approximately 6 inches from the front of the chamber. The lower end of the specimen must be held rigidly clamped. The upper end of the specimen must pass over a pulley or rod and must have an appropriate weight attached to it so that the specimen is held tautly throughout the flammability test. The test specimen span between lower clamp and upper pulley or rod must be 24 inches and must be marked 8 inches from the lower end to indicate the central point for flame application. A flame from a Bunsen or Tirrill burner must be applied for 30 seconds at the test mark. The burner must be mounted underneath the test mark on the specimen, perpendicular to the specimen and at an angle of 30° to the vertical plane of the specimen. The burner must have a nominal bore of ⅜ inch, and must be adjusted to provide a 3 inch high flame with an inner cone approximately one-third of the flame height. The minimum temperature of the hottest portion of the flame, as measured with a calibrated thermo-couple pyrometer, may not be less than 1750° F. The burner must be positioned so that the hottest portion of the flame is applied to the test mark on the wire. Flame time, burn length, and flaming time of drippings, if any, must be recorded. The burn length determined in accordance with paragraph (h) of this Appendix must be measured to the nearest 1/10 inch. Breaking of the wire specimens is not considered a failure.

(h) *Burn length.* Burn length is the distance from the original edge to the farthest evidence of damage to the test specimen due to flame impingement, including areas of partial or complete consumption, charring, or embrittlement, but not including areas sooted, stained, warped, or discoloured, nor areas where material has shrunk or melted away from the heat source.

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BCAR 29—1

ACB 29—1, 1 General

BCAR 29—1 gives definitions essential to the accurate interpretation of the requirements of BCAR 29 as a whole. Other definitions appropriate to particular Subparts and sections are given at appropriate places. Definitions of other terms are, in the main, consistent with the Glossary of Aeronautical Terms published by the British Standards Institution as BS 185*.

ACB 29—1, 1.4 Climatic conditions

(1) The standard climatic conditions are intended primarily for use in designing rotorcraft structure and equipment which should remain airworthy when subjected to the appropriate conditions.

(2) Rotorcraft performance will vary considerably within the defined climates. It is not intended that any one stated performance should be achievable throughout the whole envelope of conditions but rather that sufficient performance data should be scheduled for an operator to determine the performance which will be achieved in particular conditions.

(3) The climatic conditions given are conditions of the free atmosphere. The temperatures achieved in a rotorcraft in these atmospheric conditions may be considerably higher. In the absence of precise information as to surface finish, ventilation and type of engine, etc., the following maximum ambient temperatures should be assumed:—

		Temperate and Arctic	Tropical
(a)	in the interior of a rotorcraft	45°C	60°C
(b)	for portions of the outer covering liable to be in the sun and parts attached directly to such covering	55°C	80°C
(c)	in an engine compartment for parts not attached directly to the engine	100°C	100°C

NOTE: Parts connected to the engine may attain higher temperatures.

*Obtainable from the British Standards Institution.

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ACB—SUBPART A

ACB 29.1 Applicability

BCAR 29 does not specifically make reference to the following features because it is considered unlikely that rotorcraft with such features would be submitted for certification under BCAR 29:—

(1) Rotorcraft other than helicopters (e.g. gyroplanes).

(2) Rotorcraft equipped for water operations.

(3) Rotorcraft equipped for agricultural operations.

(4) Rotorcraft equipped with skis.

(5) Rotorcraft equipped with propellers.

ACB 29.3 Rotorcraft Groups

(1) Traditionally aeroplane group classifications are determined by performance considerations alone. However, for Rotorcraft, engineering standards also result in operational constraints. Thus Rotorcraft Groups defined in section 29.3 determine both the performance and engineering standards required.

(2) The attainment of a probability less than Very Remote is limited by the state of the art on the design of certain parts of the Rotor and Transmission Systems. It is however intended that other systems affecting safe continuation of flight, including, where possible, the Rotor and Transmission Systems, should attain the level of Extremely Remote in order not to reduce the safety below that reasonably achievable.

(3) The safe flight and landing referred to in paragraph 29.3(a) is continued flight followed by a controlled power-on landing at a suitable site.

(4) See also paragraphs 29.601(d), 29.601(e), 29.917(b) and 29.1583(o).

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SUBPART B

ACB 29.21 Proof of compliance

(1) Demonstration of compliance in less complex test conditions than those implied by the form of the requirements, will be acceptable provided that the standard established is in no case lower than the standard prescribed.

(2) Compliance with the requirements will normally be established for prototype Rotorcraft by means of comprehensive flight trials, and for series rotorcraft by abbreviated flight trials. The administrative procedures to be followed are given in BCAR Section A.

ACB 29.27 Weight and centre of gravity

These terms refer to the Rotorcraft weight and centre of gravity unless otherwise specified, the centre of gravity position being quoted in three dimensions, in Cartesian co-ordinates, relative to any convenient set of mutually perpendicular axes intersecting near the centre of gravity.

NOTES: (1) Where there is a fundamental set of reference axes the relationship of these to the axes should be established.

(2) This does not preclude the presentation in the Flight Manual of loading limitations in terms more convenient to the operator, provided that equivalent values in the terms specified above, are also included.

ACB 29.29 Empty weight and corresponding centre of gravity

(1) The weight and the longitudinal and lateral locations of the centre of gravity position should be determined either by weighing the complete Rotorcraft or by weighing the complete Rotorcraft less items weighed in accordance with paragraph (2), and deriving the weight and centre of gravity of the complete Rotorcraft from the combined data.

(2) For each rotor, the weight of the blades (and the minimum number of parts normally detached with them) should be determined by a separate weighing.

(3) The vertical location of the centre of gravity of the complete Rotorcraft should be determined by weighing the Rotorcraft, less the main rotor blades (and, if necessary, considering the attitude in which the Rotorcraft is weighed, the auxiliary rotor blades) and less any items such as accumulators which it may be necessary to remove to permit weighing in the attitude chosen. The vertical location of the centre of gravity should then be derived from the weight so obtained considered in conjunction with the weights and moment arms of the items removed, which items should be weighed separately.

(4) The condition of the Rotorcraft, to which the empty weight and centre of gravity so obtained are applicable, should be recorded and should be one which can be easily repeated and easily defined, particularly as regards rotorcraft attitude, position of the rotor blades, the contents of the fuel, oil, and coolant tanks, and the items of equipment installed.

ACB 29.33(e) Main rotor low speed warning

With reference to paragraph 29.33(e)(2) with the Rotorcraft initially in steady unaccelerated cruising flight at Rotor Minimum RPM (Power-On), it should be possible to prevent the rotor speed from falling below the Rotor Minimum RPM (Power-Off) after any sudden loss of engine power. Pilot reaction will be considered critical if, with the rotorcraft initially in steady unaccelerated cruising flight at Rotor Minimum RPM (Power-On), the time which elapses between the sudden loss of power and the rotor speed falling to the Rotor Minimum RPM (Power-Off), assuming no pilot intervention, is less than 5 seconds.

ACB 29.45 Performance — general

(1) *OPERATING REGULATIONS.* The level of safety intended by the airworthiness performance requirements will only be achieved by relating the flight characteristics of the Rotorcraft to the characteristics of the aerodrome, the aerodrome surroundings and the route. This level of safety will be achieved when rotorcraft certificated in accordance with these requirements are operated using information contained in the Flight Manual in conjunction with the appropriate operational performance rules.

(2) An Applicant may establish take-off and landing data using non-mandatory techniques providing that the extent and implications of the differences in technique are clearly and explicitly stated.

(3) *NON-STANDARD DATA.* Where the Applicant has elected to establish take-off and landing data as described in paragraph (2) it should be determined and scheduled for the same weight-altitude-temperature conditions.

ACB 29.45(g) Use of devices — power augmentation

The Authority will decide in consultation with the Applicant what performance credit may be taken for power augmentation in meeting requirements, and in doing so will take account of the duration that such power is available and the method of using it.

ACB 29.45(h) Landing gear

(1) For Group A Rotorcraft there is no corresponding maximum time and the performance requirements provide for this in paragraph 29.45(j)(2).

(2) For Rotorcraft the approach and landing characteristics of which are conventional, the Authority may agree to an air speed lower than that defined in paragraph 29.45(h) but not lower than 75 knots EAS.

ACB 29.45(j)(2) Gross performance

(1) It is necessary to make performance measurements in both high and low performance conditions. The extent to which performance measurements are repeated in different conditions of altitude and temperature, and the extrapolation of test data will depend, among other things, on the amount of reliable test data which is available on closely comparable Rotorcraft and/or Power-plant installations.

NOTE: Tests in a wide range of atmospheric conditions are necessary in any case to establish the correct functioning of components and to reveal any otherwise unanticipated difficulties of operation of the Rotorcraft.

(2) When establishing the performance of a Rotorcraft type, due allowance should be made for any differences which exist between the condition of the test Rotorcraft and that expected in service.

(3) In order to obtain the Gross Performance it is usually necessary to adjust the Measured Performance.

(4) The power or thrust used when correcting the Measured Performance to obtain Gross Performance should be the Engine Fleet Mean Performance or the Minimum Acceptance Power or Thrust.

NOTES: (1) The methods for establishing the installed power to be assumed in establishing the Gross Performance are contained in JAR—E; in Chapter C2—5 for piston engines, and in Chapters C4—5 and C4—7 for turbine engines.

(2) Should the check testing of engine power required by the Authority reveal a reduction in mean engine power below the value used in establishing the Gross Performance a revision of the performance data scheduled in the Flight Manual may have to be made depending upon the actual flight performance of the Rotorcraft type(s) concerned.

ACB 29.45(k) Means of simulating Power-unit failure

Sudden complete failure of a power-unit may be simulated in accordance with the following:—

(1) Where the Rotor System is disengaged and remains disengaged from the Power-unit when the throttle is in the idling position the appropriate throttle should be moved to the idling position as rapidly as possible without, however, moving the corresponding rotor or propeller control.

(2) Where the conditions of paragraph (1) are not obtainable the procedure of sub-paragraph (a) or (b) as appropriate may be adopted, provided that such action does not result in the operation of any device which would be unaffected by an actual complete failure.

(a) *Piston Engines.* The appropriate throttle should be moved to the closed position as rapidly as possible without, however, moving the corresponding rotor or propeller control. In this case the Power-unit should be so adjusted that, when the Rotorcraft is stationary on the ground with engine temperatures approximately normal, it is possible readily to stop it solely by moving the appropriate throttle lever or grip to the fully closed position.

(b) *Turbine Engines.* The engine fuel cock should be closed.

(3) Any other method agreed in consultation with the Authority.

ACB 29.51(b) Take-off performance — general

(1) *GROUND EFFECT.* Account should be taken of ground effect in determining the Gross Performance from which the Take-off Space Required and Rejected Take-off Area are derived. No account should be taken of ground effect in establishing the take-off flight paths.

(2) *WIND*

(a) *General.* Except where otherwise stated, the winds referred to when determining and scheduling the effect of wind on take-off data, are those wind speeds which would be measured at a height of 33 ft above the Take-off Surface; for the purpose of these requirements they are assumed to be steady.

NOTE: The data and limitations included in the Flight Manual which provide for account to be taken of wind are intended to be used in conjunction with the wind which would be measured at a height of 33 ft above the Take-off Surface.

(b) *Cross wind.* In determining Gross Performance from which take-off data are derived, the effect of cross wind is usually ignored, and no provision is made for scheduling the effect of cross-wind components. However, should take-off performance prove to be sensitive to cross wind the Authority may require that account is taken of cross-wind components.

(c) *Scheduling of data.* The operational performance rules specify that factors of 50% and 150% should be applied to the head-wind and tail-wind components respectively when assessing the Take-off Space Required and the Rejected Take-off Area. The information scheduled in the Flight Manual should incorporate the effect of these factors so as to enable the direct use of the reported wind.

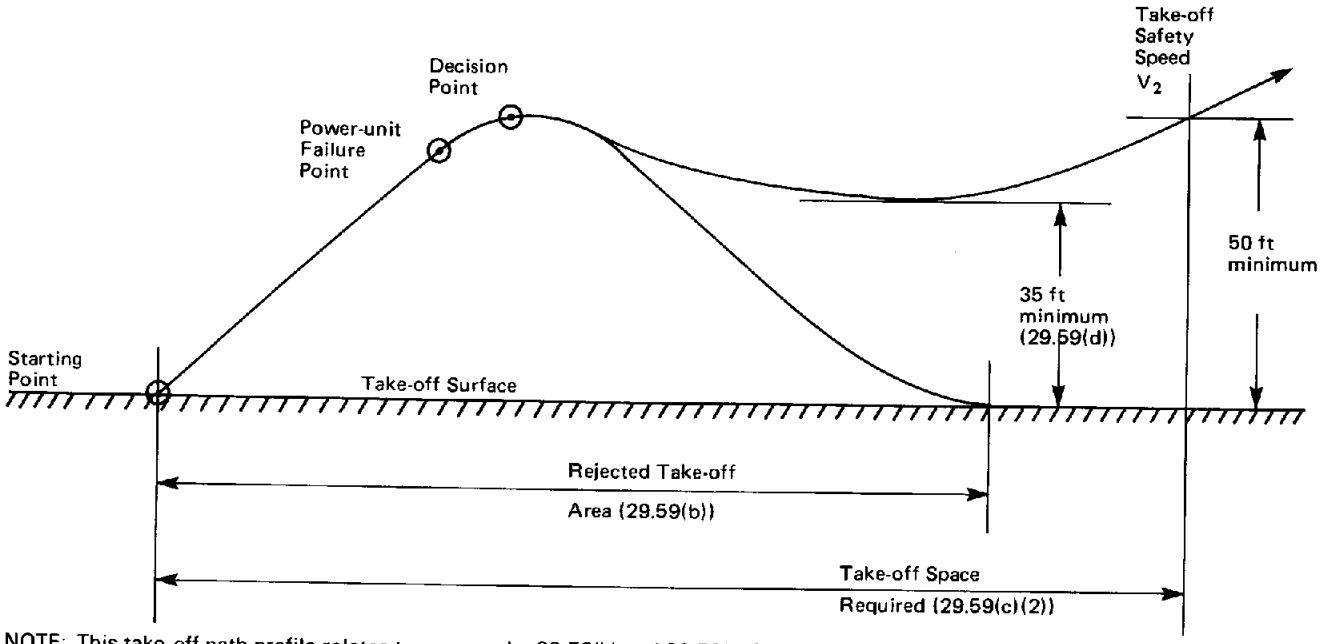
(d) *Wind gradient.* The Gross Performance from which the take-off flight paths are derived should be determined in such a way that no effects of wind gradient are present. In scheduling take-off flight path data no provision should be made for taking account of wind gradient.

ACB 29.51(b)(4) Spaces and areas

When scheduling the Take-off Space Required in accordance with paragraph 29.59(c) or 29.63, the margin to be applied will be decided taking into account the most adverse rational combination of at least the following variables — power, propulsive efficiency, drag, air speed, weight and pilot handling.

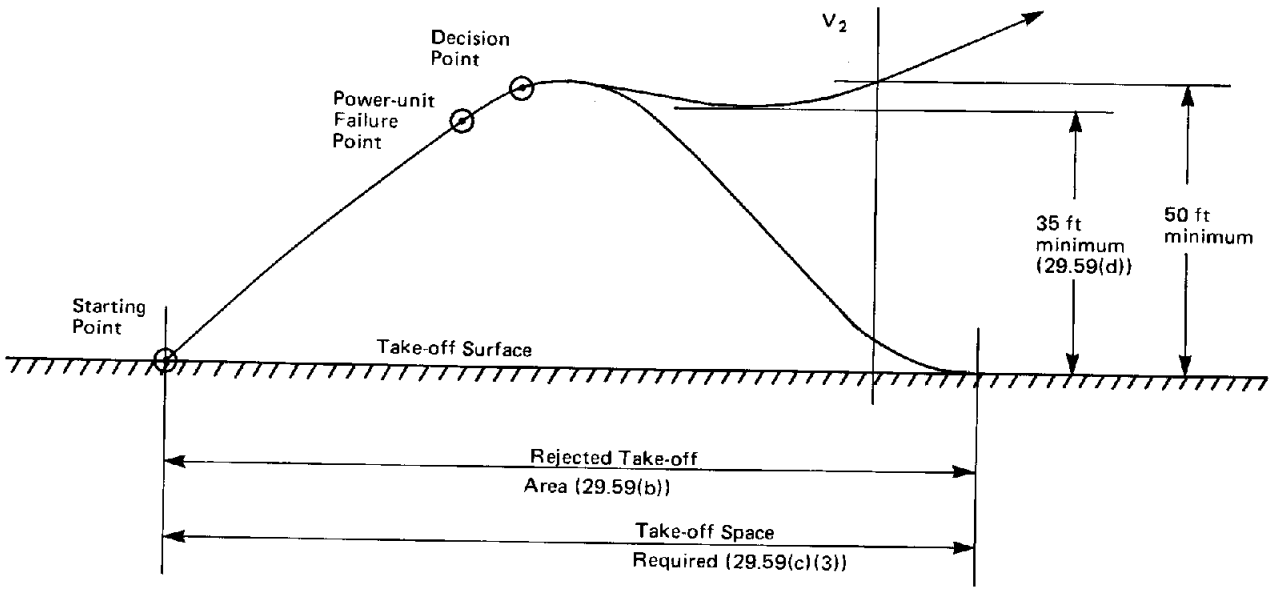
ACB 29.53(a) Take-off: Group A

Figures 1 and 2 show Group A Rotorcraft take-off profiles for the cases where the Critical Power-unit fails at the Power-unit Failure Point.



NOTE: This take-off path profile relates to paragraphs 29.59(b) and 29.59(c)(2).

FIGURE 1



NOTE: This take-off path profile relates to paragraphs 29.59(b) and 29.59(c)(3).

FIGURE 2

ACB 29.53(b) Decision Point

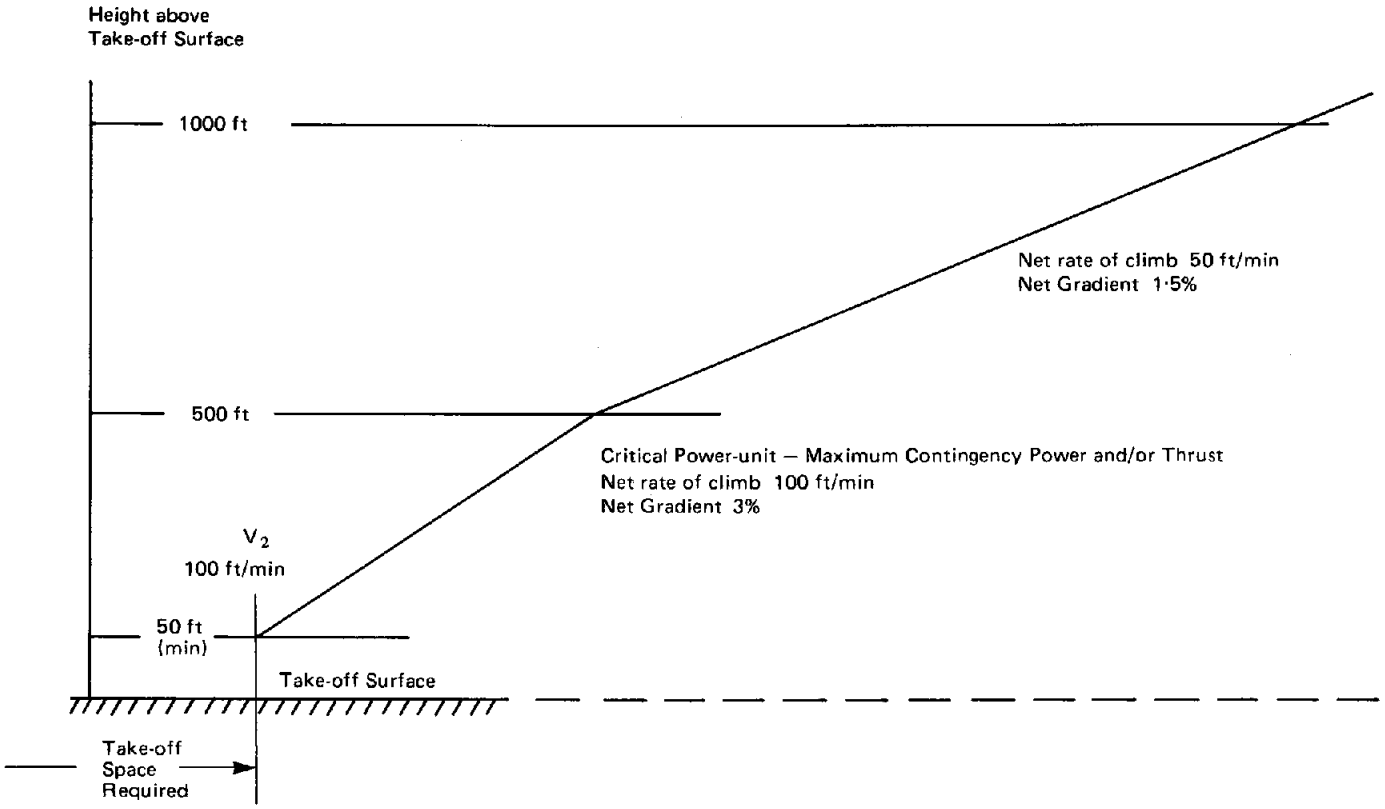
(1) The Decision Point may be chosen by the Applicant except that it should follow the assumed Power-unit Failure Point by a time interval which allows for appreciating that a Power-unit Failure has occurred. The possible need for varying the Decision Point to suit different operating sites should be considered, and where necessary take-off performance may be scheduled for a range of Decision Points.

(2) An air-speed indicator reading, possibly combined with a height reading, may provide an acceptable means of identifying the Decision Point.

ACB 29.59(c) Take-off Space Required

The Applicant may choose whether to present the all-Power-units-operating and one-Power-unit-inoperative net spaces separately or as a single space which is based on the more severe case as appropriate. If the former choice is adopted a statement should appear in the Flight Manual stating that the Take-off Space Required is the greater of the two spaces scheduled.

ACB 29.61(a) Take-off Climb-out path: Group A



NOTE: This Net Take-off Climb-out Path relates to sections 29.61 and 29.67.

FIGURE 1

ACB 29.61(a)(5) Net Take-off Climb-out Path

The amount by which the gross take-off flight path will be diminished will be decided taking into account the most adverse rational combinations of at least the following variables — power, propulsive efficiency, drag, air speed, weight and pilot handling.

ACB 29.63 Take-off Space Required

The Applicant may define the Take-off Space Required up to a height of 100 ft separately.

ACB 29.67 General

(1) *ROTORCRAFT WITH PISTON ENGINES.* In establishing the climb data with the Critical Power-unit inoperative, up to Maximum One-hour Power may be drawn from the operating Power-unit(s).

(2) *CLIMB, EN ROUTE (ALL POWER-UNITS OPERATING).* In the case of Rotorcraft with engines having Maximum One-hour Power ratings, it is at the discretion of the Applicant whether the Flight Manual should include the en-route climb data associated with this power.

(3) *WIND.* The climb minima are related to conditions of zero wind and zero wind gradient. It is left to the disretion of the Applicant whether or not to schedule the effect of wind on en-route data.

ACB 29.67(a) Climb performance

The amount by which the gross rate of climb will be diminished will be decided taking into account the most adverse rational combination of at least the following variables — power, propulsive efficiency, drag, air speed, weight and pilot handling.

ACB 29.75 Landing — general conditions

(1) *WIND* (see paragraph 29.75(a)(4)(iii)).

(a) *General.* Except where otherwise stated, the winds referred to when determining and scheduling the effect of wind on landing data, are those wind speeds which would be measured at a height of 33 ft above the Landing Surface; for the purpose of these requirements they are assumed to be steady.

NOTE: The data and limitations included in the Flight Manual which provide for account to be taken of wind are intended to be used in conjunction with the wind which would be measured at a height of 33 ft above the Landing Surface.

(b) *Scheduling of Data.* The operational performance rules specify that factors of 50% and 150% should be applied to the head-wind and tail-wind components respectively when assessing the Landing Space Required. The information scheduled in the Flight Manual should incorporate the effect of these factors so as to enable the direct use of the forecast wind.

(c) *Cross Wind.* In determining Gross Performance from which landing spaces are derived, the effect of cross wind is usually ignored, and no provision is made for scheduling the effect of cross-wind components. However, should landing performance prove to be sensitive to cross wind the Authority may require that account be taken of cross-wind components.

(2) *GROUND EFFECT.* Account should be taken of ground effect in determining the Gross Performance from which the Landing Space Required is derived.

ACB 29.75 (continued)

(3) *LANDING GEAR.* The landing gear should be fully extended throughout.

(4) *RETARDATION*

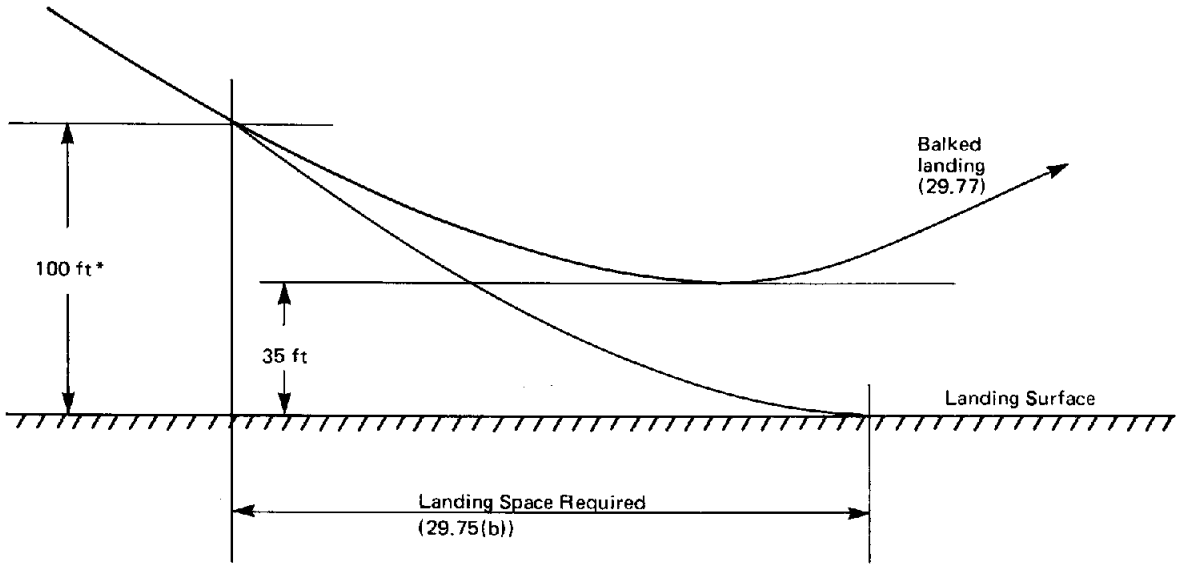
(a) *Wheel brakes.* Wheel brakes should not be applied before the Rotorcraft has settled on to the ground in its initial ground run attitude. They should not be used in such a manner as to produce a retardation which would necessitate excessive servicing of the brakes and tyres. Emergency braking systems should not be used.

NOTE: This paragraph is not intended to prevent operation in the normal way of automatic braking systems which, for instance, permit brakes to be selected on before touchdown.

(b) *Skids.* The technique should not be such as to necessitate excessive servicing of the skids.

ACB 29.75 Landing profile

The landing profile relates to the rotorcraft with the Critical Power-unit inoperative.



*Or the minimum height from which a balked landing can be made, whichever is higher.

FIGURE 1 GROUP A ROTORCRAFT LANDING PROFILE

ACB 29.141 Flight characteristics — general

Definitions. The following definitions are applicable throughout the handling requirements of Subpart B.

(1) *TRIMMING AND TRIMMED SPEED.* For the purpose of these requirements "trimming" means "the reduction to zero of the mean control forces needed to maintain straight flight at a given speed without the aid of an automatic-pilot". The words "trimmed speed" are consistent with the foregoing definition, with the proviso that where the effect of friction would render the definition applicable to a band of speeds, the speed intended is that to which the definition would apply in the absence of control friction.

ACB 29.141 (continued)

(2) *CONTROL FORCE AND CONTROL MOVEMENT.* Except where otherwise prescribed, these refer to the longitudinal control. The terms "stick-force" and "pedal-force" signify the forces applied to the control specified, longitudinal stick-force being regarded as positive when the force applied by the pilot tends to move the top of the control column forward, such forward movement also being regarded as positive.

(3) *EXCESSIVE CONTROL FORCES.* The assessment of whether a control force is excessive, apart from a maximum figure which may be prescribed, may be influenced by the ease of applying it and the general level of control forces for the rotorcraft.

ACB 29.141(a)(1) Altitude and temperature

This requirement is intended to cover such effects as freezing of control system lubricants, and differential contraction, as well as aerodynamic effects. Tests at extreme conditions will normally not be required unless there is reason to believe that these conditions are likely to be critical.

ACB 29.141(a)(2) Handling — general

(1) In showing compliance with each handling requirement, sufficient data should be obtained to enable the variation in behaviour with centre of gravity position to be reliably predicted in the region of the centre of gravity limits for which certification is desired.

(2) The margin by which the demonstrated centre of gravity envelope exceeds the envelope for which certification is desired will be not less than 5% of the total range at each end of the range about each of the three axes.

ACB 29.143(a) Controllability and manoeuvrability

(1) Compliance with paragraph 29.143(a)(2) should be shown with accelerated manoeuvres including steep turns and straight pull-outs at all points within the forward-positive flight envelope for which strength is provided in accordance with section 29.337, except that compliance need not be demonstrated in conditions such that the loads occurring in the structure exceed 75% of the design Limit Loads.

(2) *FORCES AND MOVEMENT*

(a) From trimmed initial conditions, the control forces required for executing normal operational manoeuvres should not exceed —

(i) a stick force of 27 N (6 lbf) for light rotorcraft*, 45 N (10 lbf) for other rotorcraft, and

(ii) a pedal force of 90 N (20 lbf) for light rotorcraft*, and 225 N (50 lbf) for other rotorcraft.

(b) The force required for operation of the collective pitch control should be —

(i) not less than 9 N (2 lbf) and not more than 45 N (10 lbf) for light rotorcraft*, and

(ii) not less than 9 N (2 lbf) and not more than 70 N (15 lbf) for other rotorcraft.

(c) It should be possible to leave the trimming controls untouched throughout take-off and landing, without excessive control forces being generated, whether or not a Power-unit failure occurs. Consideration should be given to any likely error in the initial settings of trimming controls.

*For the purposes of this ACB, a rotorcraft, the Maximum Weight of which is less than 1150 kg, is considered as a light rotorcraft.

ACB 29.143(a) (continued)

(d) *Interaction of controls*

(i) There should be the minimum of coupling between the longidutinal and other control planes. The lateral travel of the control stick with speed change in straight steady flight should be not more than 20% of the longitudinal movement at any part of the range, and corresponding lateral stick forces should not exceed 20% of the longitudinal forces. Induced rudder pedal forces should not exceed 75% of the longitudinal stick forces.

(ii) Lateral control displacement should not produce longitudinal stick forces greater than 40% of the lateral stick forces or rudder pedal forces in excess of 100% of the lateral stick force. Directional control displacements should not produce longitudinal stick forces in excess of 8% of the rudder pedal forces or lateral control forces in excess of 6% of the rudder pedal force.

(iii) Movement of the collective pitch control should not produce any objectionable forces in the cyclic control.

(e) *Powered controls.* In the event of a failure in the power-control system it should be possible to continue steady flight and execute a normal landing without exceeding the following control forces:—

(i)	for longitudinal controls	111 N (25 lbf)
(ii)	for lateral controls	70 N (15 lbf)
(iii)	for directional controls	360 N (80 lbf)
(iv)	for collective controls	160 N (35 lbf)

(f) Changes of flow state. The rotorcraft should not exhibit dangerous characteristics when the rotorcraft enters and is in the autorotative state, or when the pitch on the main rotors is suddenly reduced in vertical flight. Sufficient information should be provided to enable the pilot to avoid any combination of forward speed and rate of descent likely to result in a condition of flight where control response is inadequate.

(g) *Control of heading*

(i) If the recommended technique for take-off and/or re-landing includes a minimum airborne speed (e.g. for the purpose of avoiding uncontrollable swing), it should be demonstrated that over a reasonable range of speed above and below this speed, adequate control is available both on the ground and in flight.

(ii) If the recommended landing technique is associated with a minimum airborne speed a positive indication should be given to the flight crew when speed is reduced below this minimum in circumstances likely to lead to loss of yawing control. The method of complying with this requirement should be decided in consultation with the Authority.

NOTE: The reason for this requirement is that an unintentional loss of speed during the last part of a power-off flare-out might lead to the touchdown being made during an uncontrollable swing.

(h) *Flight in turbulence.* Any special techniques for flight in turbulence should be established and scheduled. These techniques should be chosen to give the optimum protection against loss of control and against structural damage either occurring directly as the result of turbulence, or occurring in the recovery from any disturbance of the flight path. The technique should distinguish between the procedures to be followed when deliberately entering an area of known turbulence, and that to be followed when the encounter is unexpected.

ACB 29.143(d) Power-unit failures

(1) The transition between normal powered flight and that existing after a failure of the Critical Power-unit should be accomplished safely allowing for a pilot reaction time compatible with the characteristics of the rotorcraft. In no case should the delay period be less than 2 seconds when the rotorcraft is under manual control or less than 5 seconds when the rotorcraft is under automatic-pilot control. The rotor speed should not fall below the safe minimum auto-rotative speed during this manoeuvre, nor should it exceed the safe maximum within 2 seconds after the pilot has applied the minimum likely pitch.

(2) The technique for landing the rotorcraft following loss of power may include cases where there is a likelihood of damage to the rotorcraft up to, but not exceeding, that assumed in stressing the rotorcraft for the emergency landing case of section 29.561, but it is not intended that the technique should be demonstrated for those conditions for which the rotorcraft is liable to be damaged. Sufficient experience is required, however, to enable the behaviour in more adverse conditions to be forecast with reasonable accuracy.

ACB 29.161(a) Trim control

In straight flight it should be possible for Group B Rotorcraft, at all engine powers (including the case of one Power-unit inoperative) to reduce the mean control loads to zero at all speeds between the Normal Operating Limit Speed, V_{NO}, and the speed for best rate of climb, V_Y, and to less than 25 N (5 lbf) at all lower speeds, including hovering.

ACB 29.171 Stability — general

(1) *CONDITIONS OF FLIGHT.* Stability characteristics should be investigated throughout the range of speeds and conditions given in Table 1.

TABLE 1

Initial Trim and Power Condition	Speed Range
(a) Hovering	−37 to +56 km/h (−20 to +30 knots)
(b) Level flight at V_{mp}	V_{mp} ± 37 km/h (± 20 knots)
(c) Level flight at 80% V_H	60% V_{NO} to V_{NO}
(d) Level flight at V_H	80% V_{NO} to V_{DF}
(e) Climb at best rate of climb	V_Y ± 28 km/h (± 15 knots)
(f) Autorotation with trim as in (c)	60% V_{NO} to maximum speed in autorotation
(g) Autorotation, speed for minimum rate of descent	Speed for minimum rate of descent — ± 37 km/h (± 20 knots)

NOTE: Where V_H is less than V_{NO}, V_H may be used in place of V_{NO}.

(2) *LONGITUDINAL STABILITY.* In steady trimmed flight the controls should possess a self-centring force gradient of at least 175 N/m (1 lbf/in) for the first inch of travel from trim. There should be no undesirable discontinuities in the stick force/displacement curves and their gradients should be positive at all times; failing this a rotorcraft may be considered satisfactory for flight in visual contact with the terrain if it is not noticeably unstable in a qualitative test and the general flying qualities of the rotorcraft are otherwise satisfactory.

ACB 29.171 (continued)

(3) *DIRECTIONAL STABILITY*

(a) Assuming the yawing controls to be left free* and other controls held fixed,

(i) in trimmed flight the rotorcraft should tend to correct automatically moderate disturbances in yaw,

(ii) for rotorcraft able to hover at zero air speed (even if only under favourable conditions) any angular velocity in yaw imparted to the rotorcraft when it is initially trimmed for zero air speed, constant height, and constant heading should tend to diminish.

NOTE: If the standard trimming device is inadequate, other means of trimming may be used in establishing compliance with this recommendation.

(b) The directional stability should be sufficient to prevent objectionable or dangerous flight conditions following abrupt pedal displacements.

(c) In steady trimmed flight the controls should possess a self-centring force gradient of approximately 1·75 kN/m (10 lbf/in) for the first 12·5 mm (0·5 in) of travel from trim. There should be no undesirable discontinuities in the control force displacement curves, and their gradients should be positive at all times.

(4) *LATERAL STABILITY.* In steady trimmed flight the lateral controls should possess a self-centring force gradient of at least 88 N/m (0·5 lbf/in) for the first 25 mm (1·0 in) of travel from trim. There should be no undesirable discontinuities in the control force/displacement curves, and their gradients should be positive at all times.

ACB 29.252 External load operation

(1) *FLIGHT CHARACTERISTICS*

(a) *General.* The flight envelope of any rotorcraft/load combination should not exceed that laid down in the Flight Manual for the rotorcraft when not carrying external loads.

(b) *Load configuration.* Load densities and shapes should be so selected that the flight characteristics of the rotorcraft/load combination are satisfactory within the flight envelope for which certification is sought for the rotorcraft/load combination(s).

NOTES: (1) The maximum air speed may need to be varied with the selected load densities and shapes.

(2) Limits on strop length (i.e. distance of load from rotorcraft external load attaching means) may have to be specified.

(3) Resonant frequencies of suspended loads should be considered in relation to any dynamic inputs, including rotorcraft forcing frequencies, and it may be necessary to specify the material and type of strop.

(c) *Tests.* For the purpose of demonstrating acceptable flight characteristics, tests should be made with a load selected from each of the following general categories:—

(i) High density low volume (e.g. full drums of liquid, plant, machinery).

(ii) Low density high volume (e.g. large empty containers).

(iii) Long loads (e.g. telegraph poles, pipes, timber).

Any peculiarities of in-flight behaviour applicable to any category of load should be included in the Flight Manual.

(d) A maximum windspeed for any particular type of rotorcraft/load combination may need to be determined.

*For test purposes, it would probably be necessary to disturb the control, return it to its original position and then effectively free it.

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ACB — SUBPART C

ACB 29.301(e) Specific weights of fuels and oils

In the absence of more appropriate limits the following ranges of specific weights should be considered when calculating design loads:—

Petrol	0·66—0·75 kg/litre	(6·616—7·518 lb/Imp gal.)
Kerosene	0·72—0·85 kg/litre	(7·217—8·520 lb/Imp gal.)
Lubricating oil	0·83—0·97 kg/litre	(8·320—9·723 lb/Imp gal.)

ACB 29.303 Factor of safety (strength)

Where there is uncertainty about the absolute strength of parts of the structure or about their variability or where inspection in service is difficult, such parts should be designed with additional factors of safety, to be agreed with the Authority, which can reasonably be expected to make them as reliable as the rest of the structure.

Main causes of uncertainty may be the absence of tests, variability of strength and possible deterioration in service.

ACB 29.307(a) Proof of structure

(1) For structures having more than one critical design case, it will usually be acceptable for tests to be made up to a proportion of Ultimate Load to be agreed with the Authority, provided that structural analysis supported by experimental data obtained in these tests indicates that the strength is sufficient for the Ultimate Load, and that the structure is tested to full Ultimate Load for one critical design case, which is chosen in consultation with the Authority.

(2) Evidence to satisfy the Authority that structural analysis alone gives sufficient assurance in the case of rotorcraft which are developments of certificated rotorcraft types should take into account:—

(a) the overall increases in load compared with the previous structure,

(b) the changes in stress and stress distribution compared with the previous structure,

(c) the scope and type of test work carried out on the previous structure.

(3) The use of simplified design criteria will be acceptable where there are supporting data to justify them and provided that they will ensure a level of safety not less than that obtainable by a rational investigation of the prescribed conditions.

ACB 29.307(c) Correction of test results

(1) For simple elements the dimensions and material properties of the test specimen should be measured and the test results adjusted to give the load corresponding to the minimum strength permitted by the material specification and the drawing limits.

ACB 29.307(c) (continued)

(2) For other structures in which failure of a particular element results in a redistribution of the load through alternative structural paths, either,

(a) the dimensions and material properties of the test structure should be measured and the test results adjusted to correspond to the use of materials of average dimensions and with the minimum strength properties permitted by the material specification, or

(b) the correction should be determined by the designer in consultation with the Authority.

ACB 29.309 Flight envelope

The flight envelope which is based on the estimated performance of the rotorcraft should be declared by the designer and submitted to the Authority at an early stage in the design of the rotorcraft.

At this juncture it is not possible to envisage the appropriate form of the design flight envelope for rotorcraft. The envelope will involve the parameters of forward speed, vertical speed, rotor rotational speed and the acceleration initiated by control movements.

If during the progress of the design, the estimated performance of the rotorcraft is changed, then the flight envelope should be correspondingly altered and the design cases reconsidered.

ACB 29.341(a) Sharp-edged gusts

A sharp-edged gust is where the air velocity is suddenly and uniformly increased over the rotor in the direction of the gust. (The assumption is thus made of unit alleviating factor for this gust velocity.)

ACB 29.361 Torque loads

If a torsiograph is fitted, then the maximum indicated torque values may be used for design purposes.

ACB 29.395(b) Control systems

The loads assumed in paragraph 29.395(b) should, in any case, be sufficient to ensure a robust system to provide for excess loading arising as a result of jarring, taxying and parking in a wind, control inertia, friction, and gusts encountered by the rotorcraft while on the ground.

ACB 29.398(b) Automatic control systems

When, in order to continue safe flight a mechanical disconnect is required to isolate the automatic control system (see section 29.672), from the primary flight controls in the event of Failure, the strength of any such connection should be agreed with the Authority.

ACB 29.547(d)(1) Rotor structure

For skid landing gear, the rotorcraft is assumed to be standing on ground handling wheels.

ACB 29.561(c) Equipment and seat attachments

It is recommended that inertia forces corresponding to higher accelerations than those prescribed in paragraph 29.561(b)(3) should be used for the design of seat and equipment attachments, etc., since, in the event of a crash involving such higher accelerations, it is desirable to protect occupants from injury by detached equipment and seats.

ACB 29.563(b) Emergency alighting on water

The requirement of paragraph 29.563(b) is intended to cover the strength of any emergency flotation gear and its attachment to the aircraft structure. However, where no such gear is required it may be assumed that rotor lift is equal to rotorcraft weight.

ACB 29.571(a) Fatigue evaluation of flight structures

(1) Where there are two parts in a rotorcraft, the double failure of which could affect the rotorcraft in the same way as the failure of a Class 1 Part, their Safe Fatigue Lives shall be established as being sufficient to ensure that the possibility of a double failure is acceptably remote. In assessing the possibility of a double failure the ease with which a part can be inspected and the frequency of inspection should be considered.

(2) In demonstrating Safe Fatigue Life the Authority will expect that, at the time of initial certification, the Safe Fatigue Life which can be substantiated will be such as to give reasonable assurance as to the soundness of the structure (see ACB 29.571(b)(1)).

(3) In demonstrating fail-safe characteristics, information should be provided in the relevant manual as to the frequency and extent of the repeated inspection of the structure necessary to ensure that any failure will be found within a reasonable period.

(4) In order that vibratory stresses can be kept low, great care should be given to the detailed design of:—

(a) the main and auxiliary rotors including retaining hubs and controls;

(b) the Transmission System;

(c) certain parts of the main control system;

particularly with a view to reducing stress concentrations.

ACB 29.571(b)(1) Safe Fatigue Life

(1) *EVALUATION OF SAFE FATIGUE LIFE.* Safe Fatigue Life may be evaluated in accordance with this ACB.

NOTE: Although it would be desirable to standardise on a method of resolving fatigue problems, it is realised that new design features and differing methods of fabrication may require variations and deviations from the recommendations contained in this ACB.

ACB 29.571(b)(1) (continued)

(2) *GENERAL*

(a) The evaluation of Safe Fatigue Life should be carried out on the lines summarised in (i) to (iv).

(i) The determination of the components considered to be critical from fatigue aspects. (See (3).)

(ii) The determination of the magnitude and frequency of the stress variations in the critical components under ground and flight conditions, together with the determination of the relative time spent in the ground and flight conditions. (See (4).)

(iii) The determination of the fatigue strength characteristics of the components. (See (5).)

(iv) The establishment of Safe Fatigue Life by a method acceptable to the Authority. (See (6).)

(b) As minor discrepancies in manufacture may result in large variations in fatigue life, assemblies and parts used in testing should be of the same quality and made to the same drawings as the components used in the rotorcraft.

(3) *DETERMINATION OF COMPONENTS CRITICAL FROM FATIGUE ASPECTS*

(a) In assessing the possibility of fatigue failure (see (5)(a)(ii)) for a new rotorcraft type, use should be made of the structural analysis and those parts which are considered to need investigation should be checked by strain gauging under critical alternating stress conditions. (See (4).)

(b) Prior to conducting ground and flight strain-gauge tests it may be possible to determine approximately the critical stress areas, and this will assist in determining the appropriate distribution of the strain gauges. A qualitative study for this purpose could be made by means of brittle coatings. Photo-elastic methods may be used for assisting in determining points of high stress concentration.

(c) The strain gauging and measurement should be conducted in a manner compatible with the system to be used in laboratory testing in order that the loads and critical vibratory stresses can be accurately reproduced in those parts or sections of parts where measurement of actual stresses is difficult or impossible.

(4) *DETERMINATION OF THE PATTERN OF ALTERNATING STRESS AND THE RELATIVE TIME SPENT IN THE GROUND AND FLIGHT CONDITIONS.* The method for determining the pattern of alternating stress expected in service is detailed in this paragraph (4). Alternating stresses of a relatively high frequency of occurrence (e.g. associated with rotating parts) are dealt with in (a); those of a relatively low frequency of occurrence (e.g. fixed aerodynamic surfaces, landing gear) are dealt with in (b).

(a) *Parts subjected to alternating stress of a relatively high frequency of occurrence.* The parts subjected to alternating stress of a relatively high frequency of occurrence and requiring investigation in accordance with this paragraph (a) should be agreed with the Authority and will normally include such parts as main rotor blades, rotor head, auxiliary rotors, primary control systems (both rotating and static) together with such other components, e.g. rotor pylons, transmission, engine mountings, the failure of which could be catastrophic.

(i) *Strain gauging*

(A) In view of the approximations used in the stress analysis of rotor and Transmission Systems, it is not possible to determine analytically, with the necessary accuracy, the stresses throughout the systems. Rotor and transmission stress levels should therefore be determined by means of carefully controlled instrumented ground and

ACB 29.571(b)(1) (continued)

flight strain-gauge testing. These tests should determine the magnitude of the mean (see (5)(a)(v)(C)) and alternating stresses associated with the likely operation of the rotorcraft and in particular should determine the critical alternating stresses associated with specific manoeuvres or operating conditions. In some cases the information might lead to limitations of operating conditions or manoeuvres, but in other cases the critical data obtained can be used as a basis for a test programme required to determine the fatigue life of the various individual assemblies.

(B) When conducting flight strain-gauge measurements, in addition to obtaining alternating stress data on the hubs, blades, control members, pylons and certain parts of the Transmission, it may be advisable to record the control movements of the rotor blades and the accelerations of the rotorcraft, at its centre of gravity, during manoeuvres. This record should provide the data on which to estimate safe control movements and manoeuvres encountered during normal service operation.

(C) Corresponding flight parameters (air speed, rotor speeds, centre of gravity, rotorcraft weight, etc.) should also be recorded simultaneously by suitable methods.

(ii) *Conditions to be investigated.* The parts agreed should be investigated in accordance with this paragraph (a)(ii) for all practical combinations of the conditions prescribed in (C); where the combination of extreme conditions is incompatible, agreement with the Authority on limitations is necessary. For the purposes of fatigue assessment those flight and ground parameters of weight, centre of gravity, rotor speed and altitude producing the most critical stresses should be used.

(A) The severity and rapidity of control movement used in reversing the controls and the extent of blade stall investigated during the investigation should be at least as severe as that which is likely to occur in service, consideration being given to inadvertent overshoot and pilot training as well as normal operation.

(B) When the Primary Structure is used to carry hot compressed air internally the effect of both this internal pressure occurring on every flight in addition to variations during flight and the temperature effects of the hot gases should also be assessed.

(C) *Range of conditions*

— Rotorcraft Weight: Minimum Design Weight to Maximum Design Weight.

— Centre of gravity: the most adverse position appropriate to each weight.

— Rotorcraft speed: all speeds between declared maximum backward speed and 1·11 V_{NE} and between declared maximum sideways speed in each direction.

— Rotor rotational speeds: all speeds between Rotor Minimum RPM (Power On) or Rotor Minimum RPM (Power Off), whichever is the lesser and the Rotor Never Exceed RPM.

— Altitude: sea-level to declared maximum altitude.

— Engine power: full range of engine power covering the speeds from Ground Idling to Maximum Engine Overspeed.

— Engine failure: each engine-out condition for multi-engined rotorcraft.

(iii) *Frequency of different manoeuvres*

(A) A factor of importance in determining the Safe Fatigue Life of the various components is the assessment of the percentage of total operating time associated with each manoeuvre. This evaluation will be largely a statistical one and will vary according to the purpose for which a particular helicopter is used.

ACB 29.571(b)(1) (continued)

(B) Table 1 (ACB 29.571(b)(1)) is a typical distribution of the different manoeuvres for a single-engined single-main-rotor helicopter and also represents a typical range for a strain-gauge survey. If any particular manoeuvre or combination of operating conditions (e.g. a condition producing resonance) has critical effects on fatigue life it will be necessary either to impose restrictions to ensure that the effects on fatigue life are within acceptable limits or to prohibit the manoeuvre or particular combinations of operating conditions. The Table is only a guide and the distribution of the particular manoeuvres should be declared by the Applicant for consideration by the Authority and, if necessary, for inclusion in the Flight Manual.

(C) For those manoeuvres which occur infrequently it is permissible to consider them on a number of manoeuvres per flight basis, e.g. one flare out per flight. For overall operation an average of two flights per hour may be assumed.

NOTE: For specific operations where there is reason to assume that this figure is too low then a higher figure should be declared by the Applicant and agreed by the Authority.

(D) In assessing the life of a component due allowance should be made for the effect of the ground-flight-ground cycle of stresses on the fatigue life.

(E) For multi-engined helicopters Table 1 (ACB 29.571(b)(1)) will require modification. There is some evidence to suggest that Autorotation (Part 4) should be considerably decreased and the appropriate parts of the powered flight spectrum increased accordingly. Further it is necessary to add a Power-unit inoperative section. The distribution of powers for this condition of flight should be declared by the Applicant and agreed by the Authority.

TABLE 1 (ACB 29.571(b)(1))

Condition	Occurrence (%)	Condition	Occurrence (%)
PART 1 GROUND CONDITIONS			
(a) Rapid increase of rpm on ground to quickly engage clutch	0·5	(c) Take-off	0·5
(b) Taxying with full cyclic control	0·5		
PART 2 VERY LOW SPEED FLIGHT			
(a) Steady hovering	0·5	(d) Longitudinal reversal	1·0
(b) Lateral reversal	0·5	(e) Backward flight	0·5
(c) Sideways flight	0·5	(f) Directional reversal	1·0
PART 3 FORWARD FLIGHT — POWER ON			
(a) Level flight at 20% VNE	5·0	(l) Cyclic and collective pull-ups from level flight	0·5
(b) Level flight at 40% VNE	10·0	(m) Change to autorotation from power-on flight	0·5
(c) Level flight at 60% VNE	18·0	(n) Partial power descent (including zero flow through rotor)	2·0
(d) Level flight at 80% VNE	18·0	(o) Landing, including approach	3·0
(e) Maximum level flight (but not greater than VNE)	10·0	(p) Lateral reversals at VNE	0·5
(f) VNE	3·0	(q) Longitudinal reversals at VNE	0·5
(g) 111% VNE	0·5	(r) Directional reversals at VNE	0·5
(h) Right turns	3·0	(s) Climb (Maximum One-hour Power)	2·0
(j) Left turns	3·0		
(k) Climb (Maximum Continuous Power)	4·0		
PART 4 AUTOROTATION — POWER OFF			
(a) Steady forward flight	2·5	(e) Longitudinal reversals	0·5
(b) Right turns	1·0	(f) Directional reversals	0·5
(c) Left turns	1·0	(g) Cyclic and collective pull-ups	2·0
(d) Lateral reversals	0·5	(h) Landings (including flares)	2·5

ACB 29.571(b)(1) (continued)

(iv) *Factors.* In determining the fatigue strength characteristics of components subjected to alternating stress, it is necessary to introduce a factor to cover variations in stress from one rotorcraft to another, therefore all measured alternating stresses of this nature should be factored by 1·2.

NOTE: This factor is for general use. Where in a particular application there is evidence to show that this factor is too high or too low such evidence should be made available to the Authority and any consequent change will have to be agreed with the Authority.

(b) *Parts subjected to alternating stresses of a relatively low frequency of Occurrence*

(i) The investigation of the wing, tail plane and fin should take into account the provisions of (A) to (F).

(A) The effect of the rotor aerodynamic and forced vibratory loads on the auxiliary surfaces.

(B) The general average gust frequency and magnitude and the variation of these with terrain and geographical location appropriate to the route over which the rotorcraft is to be operated, as obtained from data on this and other aircraft types.

(C) A scatter factor of 1·5 on gust frequency to cover the possibility of one rotorcraft in the fleet experiencing a greater frequency of these loads than the average rotorcraft in the fleet.

NOTE: To avoid the necessity of assumptions which overestimate the gust intensities it is desirable to fit a sufficient number of rotorcraft with load recording instruments, approved by the Authority, in order to provide adequate comparative data if varying types of operation are carried out especially in different parts of the world. The Authority will consider the reduction of the scatter factor of 1·5 if this is justified by the records obtained.

(D) The best possible assessment of the comparative effects of gust loading and forced vibration from the rotors on auxiliary surfaces.

(E) The expected average flight plan involving climb, cruise, descent, flight times, speeds and altitudes.

(F) Any additional loads such as the effect of the repeated change from the condition of zero-lift to steady flight on take-off and return to the zero-lift condition on landing and the possible effect of ground loads in ground handling, taxying, take-off and landing.

(ii) The investigation of such parts as landing gear, hydraulic and control system components, fuel systems, etc., should be carried out.

NOTE: In many cases it will be necessary to check the frequency and corresponding magnitude of the loads in the components by appropriate means, e.g. during ground steering for hydraulic components and during flight (under automatic-pilot conditions if appropriate) for servo controlled mechanisms.

(5) *FATIGUE STRENGTH CHARACTERISTICS.* The determination of the fatigue strength characteristics of those parts indicated by the investigations of (3), should be carried out in accordance with this paragraph (5) which is written in terms of rotorcraft the expected service life of which is of the order of 10,000 hours or more.

(a) *General*

(i) The Authority will require tests on a complete rotorcraft airframe under the critical alternating stress conditions, unless, as a result of the structural analysis and strain gauging, the indicated alternating stresses both at critical regions and in the general structure are of such a low order that past experience indicates the possibility of fatigue failure to be Extremely Remote during the anticipated operational lifetime of the rotorcraft type. In any event, sufficient testing of the most critical details of the rotorcraft will be necessary.

ACB 29.571(b)(1) (continued)

(ii) The main purpose of the complete rotorcraft airframe tests is to establish for the first and subsequent failures, the components involved and their corresponding fatigue lives. It is intended that, if possible, the component be repaired after each failure until a stage is reached when further repair is impracticable or it is agreed not to continue the testing. In addition, laboratory testing of a number of components, similar to those which failed in the complete rotorcraft tests, should be made at the corresponding critical conditions of alternating stress both to obtain an estimate of the scatter of fatigue life and to establish the average fatigue life.

(iii) Experience has shown that data on the fatigue characteristics of simple material specimens cannot be directly applied to built-up structures. Although material data modified by appropriate stress concentration factors can be used as a guide in design, experience indicates that the fatigue strength of a built-up structure is below that of material specimens for which allowance has been made for estimated stress concentration. It is therefore necessary that endurance tests of an adequate number of specimens of the critical parts be conducted by applying steady and alternating loads, in a manner simulating the loading actually encountered in service.

(iv) Parts that may be subject to high temperature, e.g. hot air ducts in rotor blades and parts subject to turbine exhaust impingement, should have the effect of such high temperatures on the fatigue strength of the structure evaluated by a method to be agreed with the Authority.

(v) *Definitions.* The definitions of this paragraph (v) are applicable throughout this ACB.

(A) *S/N Curve.* A mean curve constructed from the results of those tests carried out to determine the relationship between the magnitude of alternating stress and the number of cycles of such stress required to cause the failure of a part.

(B) *Fatigue Limit.* The alternating stress at or below which a part sustains no fatigue damage.

NOTES: (1) The Fatigue Limit is associated with a steady (mean) stress level.
(2) Acceptable assumptions on Fatigue Limit are prescribed in paragraph (6)(b).

(C) *Mean Stress.* The steady stress in a part when the part is in a state of dynamic equilibrium.

(vi) *Methods of endurance testing*

(A) Since neither of the two current methods of fatigue endurance testing is completely adequate by itself, it is essential to make the methods complementary to each other.

— *Testing of complete assemblies.* This method consists of either the testing on the ground of the complete rotorcraft, or the testing of complete assemblies on a suitable rig.

— *Testing of components.* This method consists of the testing of components, or critical sections of components, using fatigue testing machines.

(B) Both the methods described in (A) suffer from the disadvantage that it is not practical to simulate all the atmospheric conditions (temperature and humidity) which will be encountered in service and in addition the effects of corrosion, which appreciably reduce the fatigue life cannot be simulated. A further disadvantage associated with the second method of (5)(vi)(A) is that it is not possible to simulate, with existing fatigue testing machines, the pattern of the alternating stress that is estimated to occur during the service life of the rotorcraft, both in regard to the sequence of occurrence and the rate at which the stresses are applied. In view of the deficiencies of these testing methods, it may be necessary to take steps to ensure that the effects of these deficiencies are kept to a minimum. (See (6)(f).)

ACB 29.571(b)(1) (continued)

(b) *Establishment of mean Fatigue Limit*

(i) The establishment of the mean Fatigue Limit of a component will usually necessitate the production of an S/N Curve for the component. The critical range of stress cycles for the component (probably 10^5 to 10^8) should be determined and an S/N Curve should be obtained by testing a sufficient number of identical specimens at different magnitudes of alternating stress within the envelope of stress expected in service determined in accordance with (4).

(ii) The curve obtained by the method of (i) should be adequate to give an assurance that a mean Fatigue Limit obtained by extrapolation or comparison with S/N Curves for similar materials will be valid.

(iii) Where there are a number of Mean Stress levels for any one part it will not normally be necessary to investigate more than two of them and, accordingly, the results from two S/N Curves may be suitably modified for the other Mean Stress levels without further testing. Alternatively, it can be assumed that all the alternating stress variations occur about the higher Mean Stress level unless this assumption is known to be optimistic. Such assumptions should be agreed with the Authority as the testing proceeds.

(6) *ESTABLISHMENT OF SAFE FATIGUE LIFE.* Having established the pattern and frequency of stress levels by the method of (4) and the mean Fatigue Limit by the method of (5)(b) the Safe Fatigue Life should be established in accordance with one or more methods described in this paragraph (6).

(a) *Use of the pattern of alternating stress to establish Safe Fatigue Life*

(i) The loads can be directly applied in units representative of the pattern of alternating stress. The units should represent a convenient time period, say 50 or 100 hours each, during which time the number of alternating stress cycles corresponding to each critical alternating stress level should be applied in a regular sequence; should the Mean Stress for any particular alternating stress level vary, this may be fed into the pattern.

(ii) Suppose that two flight or ground conditions (Condition 1 and Condition 2) are critical from a fatigue standpoint to the exclusion of all other conditions, and that the following parameters apply,

	Condition 1	Condition 2
Mean Stress	X_1	X_2
Alternating Stress about Mean Stress	Y_1	Y_2
Cycles of Stress Y per minute	n_1	n_2
Percentage of life spent in this condition (from Table 1 ABC 29.571(b)(1))	l_1	l_2

together with a load unit time of 100 hrs then the following total mean and alternating stress cycles would be applied during each load unit,

$$60\ n_1\ l_1 \text{ at } X_1 \pm FY_1{}^*$$
$$\text{plus } 60\ n_2\ l_2 \text{ at } X_2 \pm FY_2$$

and repeated in this sequence until failure occurred. The estimated safe life in hours would then normally be assumed to be the geometric mean of the numbers of load units completed on the specimens multiplied by 100.

NOTE: Where the scatter of experimental results is unusually large for the number of specimens tested it may be necessary to reconsider whether the mean value gives an adequate margin of safety.

*For values of F see (6)(a)(iii).

ACB 29.571(b)(1) (continued)

(iii) The value of the factor F will depend on the number of specimens tested in accordance with this paragraph (6)(a) and should be applied to the alternating stress as follows:—

1 specimen	3·0
2 specimens	2·5
3 specimens	2·25
4 or more specimens	2·0

the factor on the Mean Stress, X, being 1·0 in all cases.

NOTES: (1) For a single specimen all those cases giving rise to stresses higher than the mean Fatigue Limit divided by 3·0 will need to be considered. For two specimens only those cases giving rise to stress higher than the mean Fatigue Limit divided by 2·5 need be considered and so on. If initially it is decided to test more than three specimens then only those cases giving rise to stresses greater than the mean Fatigue Limit divided by 2·0 need be considered.

(2) Where there is sufficient evidence to justify the use of factors other than those quoted in (6)(a)(iii) then such evidence should be made available to the Authority and such factors as are used will have to be agreed with the Authority.

(3) Where there is sufficient evidence to suggest that the factor required under (4)(a)(v) can be combined with the factors of this paragraph as amended by Note (2), then the resultant factors will have to be agreed with the Authority.

(b) *Unlimited fatigue life and reduced testing time*

(i) In establishing unlimited fatigue life it is necessary to demonstrate that the alternating stresses anticipated in service lie below the working Fatigue Limit of the material of the component in its assembled condition.

NOTE: By working Fatigue Limit is meant the mean Fatigue Limit divided by a similar factor to that required in (6)(a)(iii).

(ii) In the absence of better information the following assumptions may be made:—

(A) for aluminium alloys, that the Fatigue Limit is the maximum alternating stress that the material can sustain for 10^9 cycles,

(B) for alloy steels, free from attrition and corrosion, that the Fatigue Limit is the maximum alternating stress that the material can sustain in accordance with Table 2 (ACB 29.571(b)(1)).

(iii) In order to reduce testing time to establish the mean Fatigue Limit, it will be permissible to test to less than the number of cycles prescribed in (ii) and to extrapolate the results using suitable factors. The extrapolation factor to be used, which should be agreed with the Authority, will depend on the material and it is permissible to use factors appropriate to established S/N Curves for the material.

TABLE 2 (ACB 29.571(b)(1))

Ultimate Tensile Strength (tons/sq. in.)	Cycles (10^6)
up to 50	5
51— 60	20
61— 80	40
81—110	100

ACB 29.571(b)(1) (continued)

(c) *Use of life factors only to establish finite Fatigue Life.* The provisions of this paragraph (c) are applicable to those parts subjected to alternating cycles of stress which are not likely to occur more than 10^5 times during the life of the rotorcraft, for parts subjected to a greater number of cycles of stress, the provisions of (a) or (b) should be applied.

(i) If no alternating stress factor other than that of (4)(a)(iv) is used it will be necessary to use the Life Factors of Table 3 (ACB 29.571(b)(1)) which are applicable to light alloys. Life Factors for steel and other materials should be agreed with the Authority.

(ii) If, in any other case where more than one specimen is tested, the result obtained for any one specimen is less than 1·5 times the Safe Fatigue Life which would be obtained by using the factors of Table 3 (ACB 29.571(b)(1)), the assessment of the Safe Fatigue Life will have to be agreed in consultation with the Authority.

TABLE 3 (ACB 29.571(b)(1))

Life Factors for Light Alloy Components

No. of Specimens	Life Factor
1	6·0 on the result
3	4·5 on the average of the results
6	3·5 on the average of the results

NOTE: These factors may be used in conjunction with results of repeated load tests in which a single level of alternating stress is applied, this level of stress is usually chosen to correspond with the level of maximum fatigue damage; the level of maximum fatigue damage being determined by superimposing the pattern of alternating stress on the best estimate of the shape of the S/N Curve for the particular component. If tests are carried out to cover the repeated application of more than one level of alternating stress, then the Authority may review the magnitude of the factors.

(d) *Acceptance of calculations.* In special circumstances the Authority may, in consultation with the Applicant, accept calculations based on measured stresses obtained as in (4) in place of fatigue tests on certain components. A condition of acceptance of such calculations is that a safety factor on fatigue stresses, high enough to satisfy the Authority, be used for design purposes. Normally a fatigue safety factor of 3·0 will be acceptable after agreed stress concentration factors have been applied. Stress concentration factors should be obtained from the best available information or derived from tests.

(e) *Safe Fatigue Life at initial certification*

(i) The factors specified in this ACB for the determination of Safe Fatigue Life are based on certain assumptions as to the absolute value of the average result of tests and as to the scatter. Where there is sufficient evidence to suggest that the factors assumed in this ACB are too high or too low then such evidence should be made available to the Authority and any consequent change in factors will have to be agreed with the Authority.

(ii) If the results available when certification is required have established a relatively low value of fatigue life or if the testing has only been carried to a relatively low number of cycles, there would be doubt as to the adequacy of the specified factors and there would, therefore, be doubt as to whether a value of Safe Fatigue Life could be quoted at all. For those parts where the major alternating stresses are predominantly:—

(A) of engine order frequency, the established Safe Fatigue Life should be appreciably greater than the anticipated life of the rotorcraft,

ACB 29.571(b)(1) (continued)

(B) of rotor order frequency, the established Safe Fatigue Life at the time of initial certification will depend on the type, rotor speed and normal duration of the rotorcraft concerned; for a conventional transport type rotorcraft a minimum figure of 1,000 hours should be established.

(f) *Overhaul and re-testing of components.* As mentioned in (5)(a)(vi)(B) the deficiencies in the methods of testing require special procedures to ensure that the fatigue properties of the components are adequately maintained throughout the life of the rotorcraft. It will therefore be necessary for the Applicant to declare and institute methods to achieve this purpose. Such methods will usually take the form of:—

(i) adequate inspection (including overhaul),

(ii) specimen fatigue testing of components or parts at periodic intervals, and

(iii) limiting lives of components or parts for reasons other than fatigue where these reasons are likely to affect the fatigue properties.

(g) *Type development.* For new variants of rotorcraft types, the necessity for additional testing on the complete rotorcraft and/or details of the rotorcraft will be assessed on the basis of comparing the results of:—

(i) analysis of the estimated stresses in the critical parts of the re-designed rotorcraft, and

(ii) a check of the analysis by suitable means (e.g. stress lacquer technique and strain gauging of the critical re-designed parts of the rotorcraft),

with the results of the original tests of the rotorcraft covering the measured stresses and correspondingly achieved fatigue life.

(h) *Repairs.* Where a repair has been carried out as a result of damage in service, the possible effect of the repair on the fatigue strength of the structure should be considered. Further tests may be necessary to substantiate the fatigue strength of the repair.

(j) *Change of operation.* If the type of operation of the rotorcraft is altered, the Authority reserves the right to check whether the scope of the proposed new operation is satisfactorily covered by the tests for the original operation.

ACB 29.571(b)(2) Evaluation of Fail-Safe Structure characteristics

After failure of a part or parts of the Primary Structure (as in the definition of a Fail-Safe Structure in BCAR 29-1) the remaining Primary Structure should have sufficient strength and stiffness to withstand the loads which are reasonably expected to occur after the failure during the maximum period which may elapse before the failure can be assumed to have been found by inspection. The loads which should be assumed in cases where the failure can be assumed to be found by inspection within a very short period, are those specified in (1). In cases where longer periods may elapse before the part is inspected, more severe load conditions should be provided for in the remaining structure; the conditions to be assumed should be agreed with the Authority.

NOTES: (1) It is recommended in Fail-Safe Structures to avoid the use of parts which are difficult to inspect or which it is only convenient to inspect at infrequent intervals.

(2) It is recommended that the Primary Structure in addition to having fail-safe characteristics should be such as to provide long fatigue life of its constituent parts.

(1) *LOAD CONDITIONS TO BE APPLIED AFTER FAILURE OF THE PARTS.* Subsequent to the failure of a part which can be assumed to be found by inspection within a very short period of time, the remainder of the structure should be capable of supporting the Limit Loads with an Ultimate Factor of 1·0.

ACB 29.571(b)(2) (continued)

(2) In addition to meeting the requirements of section 29.307, load tests should be carried out to substantiate the fail-safe characteristics. The nature and extent of such tests will depend upon previous experience on similar types of structure both as regards tests of this nature and characteristics in operation.

(3) In cases where a repair has been carried out on parts damaged in service, the possible effect of the repair on the fail-safe characteristics previously established should be considered. Further tests may be necessary to substantiate the repair.

ACB 29.572(a) Fatigue testing of gearboxes

(1) In considering general fatigue testing, ACB 29.571(b)(1) calls for a fatigue limit stress factor of not less than 2·0 times the maximum loading that is likely to occur in service, unless evidence justifying a different factor is available.

(2) From evidence in relation to the strength of steel gears of conventional design, the Authority is prepared to accept that adequate fatigue strength of such gears can be demonstrated by the use of a stress factor of 1·4 for a single test, or 1·3 for four or more tests. In the latter case the specimens tested should be selected so that the gears do not have common batch origins, or heat treatments, and are not tested in the same gearbox.

(3) In carrying out the test, the maximum loading should be adjusted to compensate for the differences in vibratory loading experienced in the rotorcraft (as measured in the vibration survey of paragraph 29.907(d) as appropriate) and on the rig.

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ACB — SUBPART D

ACB 29.601(d)(1) Failure conditions

Failure of Primary Structures and other high integrity parts is dealt with in section 29.571. Failures in the Rotor and Transmission System are dealt with in section 29.917.

ACB 29.601(d)(2) Declared time interval

(1) The period of 10 minutes has been set as a minimum to allow reasonable time for detection, decision making and effecting a controlled landing.

(2) A rotorcraft with a specified period of time will have to be operated so that a suitable landing site is always available within that period and the Flight Manual annotated accordingly. (See paragraph 29.1583(o).)

ACB 29.602(a)(2)(i) Operation of Essential Services (Group A Rotorcraft)

One Power-unit inoperative. It is intended that in the one-Power-unit-inoperative condition the rotorcraft should not suffer the loss, or unacceptable reduction, of performance of any Essential Service. The following are examples of Essential Services which, if installed, should provide an acceptable level of performance in the one-Power-unit-inoperative condition:—

(1) main flying controls and trimmers,

(2) landing gear lowering system,

(3) transmission lubrication,

(4) essential instruments as required by Subpart F,

(5) communication and emergency equipment,

(6) de-icing equipment,

(7) landing lamps.

In cases where the one-Power-unit-inoperative performance of any particular Essential Service is lower than that provided in the all Power-units-operating condition, the lower value will be used for the purpose of scheduling the appropriate performance of the rotorcraft.

ACB 29.602(a)(2)(ii) Operation of Essential Services (Group B Rotorcraft)

Power-unit Failure necessitating an Emergency Landing. The intention of the requirements of paragraphs 29.602(a) and (b) is to ensure the provision of sufficient facilities to enable an Emergency Landing to be made. The following Essential Services should be provided as a minimum; others may have to be included for particular rotorcraft:—

(1) main flying controls and trimmers,

(2) landing gear lowering system,

ACB 29.602(a)(2)(ii) (continued)

(3) transmission lubrication,

(4) essential instruments for a limited period of time, the instruments and the period to be agreed with the Authority,

(5) communication and emergency equipment appropriate to the rotorcraft situation,

(6) landing lamps.

ACB 29.602(a)(3) Operation of Essential Services

The requirement of subparagraph 29.602(a)(3) is intended to cover, for example, the case of a double Power-unit failure in a rotorcraft having three Power-units.

ACB 29.602(b) Accessory drive failure

It is not intended that the requirement of paragraph 29.602(b) should be applied in combination with any Power-unit Failure.

ACB 29.603(b) Materials and fabrication processes

For the purposes of paragraphs 29.603(b) and 29.605(a), in addition to specifications specifically Approved by the Authority, British Standard Specifications in the Aircraft Series and DTD Specifications are accepted as Approved. Other specifications accepted by an Approved Design Organisation (with the necessary technical capabilities for this purpose) for a material or fabrication process to be used in a part designed within the terms of their approval, are accepted as Approved (unless the Authority has notified non-approval) provided that:—

(1) the specification is such that materials or fabrication processes accepted as complying with it will have the essential properties assumed in the design,

(2) the Approved Design Organisation maintains a record of each specification accepted in this way, together with its means of identification (date, title and/or number) and of any amendments thereto, this record being available for inspection by the Authority at any reasonable time.

ACB 29.604 Reduction of normal acceleration

The requirement of section 29.604 does not prohibit those temporary malfunctions or failures to function under reduction of normal acceleration which would not hazard the safety of the rotorcraft.

ACB 29.605(b) Flaw detection

The need for a flaw detection test on each part should be considered and the drawings endorsed accordingly. The technique to be employed in conducting such tests should be agreed, where necessary, between the designer and the manufacturer.

ACB 29.609 Protection against corrosion and other effects of the presence of fluids

(1) *INTRODUCTION.* It is intended that this ACB should be used for guidance purposes in meeting the requirements of sections 29.609 and 29.611.

(2) *GENERAL.* In assessing the design for inspection and maintenance provisions and protection, particular attention should be given to:—

(a) the effects of leaks from systems containing fluids (e.g. hydraulic, water);

(b) the effects of rain, sleet, snow, ice, hail, slush, sea-spray etc.;

(c) the effects of liquids spilt in cargo compartments, galleys, toilets and from batteries;

NOTE: The liquids assumed to be spilt should be appropriate to the intended use of the rotorcraft, e.g. carriage of special liquids.

(d) the effects of condensation especially where it may drip (e.g. on to the top side of roof panels) and where it may collect in underfloor regions and belly;

(e) the effects of gassing from batteries and condensation contaminated by such gassing;

(f) the effects of cleaning of, or ground or airborne de-icing of, the outside of the rotorcraft (the liquids for which could gain access to the inside of the rotorcraft); cleaning of the inside of the rotorcraft;

(g) the effects of changes of rotorcraft attitude in operation;

(h) those parts of the rotorcraft in which liquids and vapours could collect:—

(i) in the normal course of events,

(ii) as a result of a drain, or drain hole becoming blocked, and

(iii) as a result of a system leaking.

NOTES: (1) It should be borne in mind that as time passes a liquid could bring down with it certain solids such as swarf (which cannot always be entirely removed from the structure during manufacture), dirt, dust, sand, mud, flakes of paint, sealant, grease, as well as chemicals from lagging, etc.

(2) See ACB 29.853(a)(7) for advisory material dealing with the testing for corrosive impurities in textiles.

(3) *FLUIDS.* The design of the rotorcraft should be such as to minimise the possibility that any fluid which may leak from a system or may be spilled in the accommodation (e.g. in galleys and toilets) will result in a direct or indirect danger to the rotorcraft or its occupants, or an immediate or eventual loss of airworthiness to a serious extent.

NOTE: The effects of corrosion as a result of spilled fluids should be given particular consideration.

(a) Particular attention should be given to the design of those compartments where the spilling of liquids is likely to occur. Sealed floors with suitable drainage should be provided for galleys and toilets.

(b) Particular attention should be given to the location of pipes, tanks and apparatus containing fluids which are installed in or near compartments containing critical electrical equipment, or critical mechanical parts, the operating temperature of which is likely to be below the freezing point of the particular fluids.

NOTES: (1) Care should be taken to avoid pockets where liquids could freeze and so jam mechanisms.

(2) It is recommended that joints and unions in pipe lines should not be located in closed portions of the structure.

(3) See paragraphs 29.799 and 29.863(e) for requirements for water systems and location of pipes and tanks for other considerations.

ACB 29.609 (continued)

(4) *RAIN.* The effects of rain on the rotorcraft should be considered. Where sealing is not practical, precautions should be taken to ensure that any rain that does gain access to the interior of the rotorcraft does not constitute a direct or indirect danger. Particular attention should be given to the results of the wetting of equipment, the possibility of jamming by freezing (especially if water can collect in pockets) of mechanisms (especially control systems), exits, emergency exits and latches.

NOTE: See also BCAR Section J, Chapter J1—3, 5 for protection of electrical equipment.

(5) *DRAINAGE.* All compartments in the structure, including those in control surfaces, should be adequately drained both on the ground and in flight.

(a) Each drainage system should be considered separately and drains and drain holes should be so located that the blockage of any one drain or drain hole in any one drainage system will not prevent compliance with paragraph (5).

NOTE: Particular attention should be given to the location of internal drain holes so as to minimise the possibility of fluids being trapped in the structure and being prevented from running to a drain.

(6) *VENTS.* All compartments in the structure should be adequately vented. Vents should be located, constructed and (if necessary) drained so as to preclude the possibility of their becoming obstructed:—

(a) by fluid or other foreign matter when the rotorcraft is in the ground attitude and when it is in any steady flight attitude,

(b) by ice, when the rotorcraft is in any ground or flight attitude.

(7) *CLOSED SECTIONS.* Where closed sections (e.g. tubes) are employed as load carrying members the design organisation should be satisfied that adequate inspection schemes have been established for checking on the presence and extent of any corrosion that may occur in these regions and that corrosion will be detected before an unacceptable loss of airworthiness has taken place.

NOTES: (1) Particular attention should be given to those closed sections which constitute tension members.

(2) See also section 29.303 for additional factors of safety.

(8) *CORROSION*

(a) Contact between fluids and materials likely to result in detrimental corrosive action should be kept to a minimum and, so far as is practical, the juxtaposition of dissimilar metals should be avoided.

NOTE: With regard to electrolytic action in cases where juxtaposition is unavoidable, the best available data should be used; where no such data are available then the Authority should be consulted.

(b) Where contact between fluids and materials likely to result in detrimental corrosive action cannot otherwise be avoided, adequate protection should be given to parts (particularly those made up of dissimilar metals) likely to come into contact with such fluids. In particular closed sections which are employed in structural members, especially tension members (e.g. tubes), should as far as practical be protected on assembly.

(i) The fluids (i.e. liquids and vapours) to be taken into account should include:—

(A) water, cleaning fluids, ground and airborne de-icing fluids, fuel, oil, hydraulic fluid, fluids associated with galleys and toilets;

(B) slush (including grit, salt and other ground surface de-icing chemicals) which will impinge on, and possibly get inside parts of, the rotorcraft during taxying, take-off or landing on precipitation-covered ground surfaces.

(ii) Adequate protection should also be given against microbiological attack resulting from use of such liquids as kerosene and water.

ACB 29.610(a) Protection against lightning discharges

(1) *ELECTRICAL CHARACTERISTICS OF LIGHTNING DISCHARGES.* In the absence of better information the data contained in this paragraph should be used for the purpose of assessing the adequacy of lightning discharge protection of rotorcraft.

TABLE 1 (ACB 29.610(a))

Charger transfer	Maximum Normal	600 coulombs 50 to 200 coulombs
Peak current	Maximum Normal	500 kA Approx. 50 kA
Duration of flash	Maximum	2 seconds
Duration of peak current	about 25 microseconds to half peak value, critically damped	

NOTES: (1) The duration of flash may be made up of a number of discharges.

(2) For the purposes of test or assessment, a discharge current having two components (as in Table 2) may be taken as being equivalent to a lightning strike from the aspects of heating and disruptive forces.

TABLE 2 (ACB 29.610(a))

Component	Peak Current (kA)	Duration	Charge transfer (coulombs)
1	200	To peak value in 15 microseconds decaying to 50 kA in 30 microseconds from initiation	4
2	0·5	1 second rectangular wave	500

(2) *AREAS VULNERABLE TO LIGHTNING STRIKES*

(a) Based on aeroplane experience and limited rotorcraft experience, the following areas are considered most likely to need protection from direct strikes:—

(i) the main rotor blades,

(ii) auxiliary rotors or tail extremities extending outside the main rotor area,

(iii) within 0·5 m (18 in) of any sharp edge which is likely to form a point of attachment for lightning strikes,

(iv) unprotected projections (e.g. nose of rotorcraft, end of skid tubes), and

(v) any other projecting part which may constitute a point of attachment.

ACB 29.610(a) (continued)

(b) Additionally there is a possibility of strokes being swept rearward from such points of direct stroke attachment as are given in paragraph (a). Therefore, if a hazard, which could have a Catastrophic Effect could result from such swept strokes, the areas extending 0·5 m (18 in) laterally to each side of fore and aft lines passing through these points should also have adequate protection.

(c) Guidance on the most vulnerable areas for a particular rotorcraft configuration may be obtained by simulated lightning strike tests on a model rotorcraft.

ACB 29.610(b) Electrically conducting cage

(1) *ROTORCRAFT OF METALLIC CONSTRUCTION.* In general the skin of an all-metal rotorcraft will be accepted as adequate to meet the requirements of paragraph 29.610(b) provided that the method of construction is such that it produces satisfactory electrical contact at joints. An electrical contact with a resistance less than 0·05 ohm will be considered as satisfactory.

(2) *ROTORCRAFT OF NON-METALLIC CONSTRUCTION.* (See ACB 29.610(b)(4).)

(a) The cage should consist of metallic conductors, the surge-carrying capacity and mechanical robustness of which are at least equal to that required for Primary Conductors. The conductors should be as straight as practicable, and where changes of direction are unavoidable, sharp curves should be avoided.

(b) All metal parts should be bonded to the cage with Primary Conductors as appropriate.

NOTE: Guidance on the likelihood of a lightning strike at any particular location, and hence the need to bond, is given in ACB 29.610(a).

(3) *ROTORCRAFT OF COMPOSITE CONSTRUCTION.* (See ACB 29.610(b)(4).) Where component parts of a rotorcraft are of non-metallic construction, protection should be provided, as appropriate. If the protection is in the form of a cage, this should satisfy paragraph (2). When designing such protection the possible effects outlined in paragraph (5) should be taken into account.

(4) *MAIN EARTH SYSTEMS FOR ROTORCRAFT OF NON-METALLIC OR COMPOSITE CONSTRUCTION*

(a) *Fuselage*

(i) Four or more conductors, extending the whole length of the fuselage, should be provided. The number and disposition of these conductors should be such that they are not more than 1·83 m (6 ft) apart as measured round the periphery of the fuselage at the position of greatest cross-sectional area. The conductors should be placed on or near the outer skin at approximately equal intervals and joined together at their ends in the manner described in ACB 29.899(a)(1)(e).

(ii) The conductors described in paragraph (i) above should be interconnected by similar conductors at positions corresponding to the terminals provided for interconnecting the Rotor and fuselage main earth systems and intermediately at intervals not exceeding 6 m (20 ft).

(b) *Rotors and aerodynamic surfaces.* Conductors, extending from root to tip, should be provided in accordance with Table 3. The blade or surface root end of each conductor should be connected to the fuselage main earth system, and the outboard ends should be connected in the manner described in paragraph (d). The strips should be transversely interconnected by similar strips at intervals not exceeding 6 m (20 ft).

ACB 29.610(b) (continued)

TABLE 3 (ACB 29.610(b))

Rotor Blade or Aerodynamic Surface Root Chord (metres)	Minimum Number of Conductors	Approximate position
Less than 0·5	1	Located so as to provide adequate protection.
0·5 to 2·5	2	At leading edge and trailing edge.
2·5 to 4·5	3	At leading edge, trailing edge and mid chord.

(c) *Vertical tail surfaces.* A conductor should be provided at the leading edge and at the trailing edge of the vertical tail surface.

(d) *Lightning strike plates.* Lightning strike plates, extending round the edge of each extremity of each rotor blade and aerodynamic surface, and round the nose and tail of the fuselage, should be provided on the exterior of the rotorcraft structure except where existing metallic structure can serve the same purpose. The strike plates may be covered with dope, fabric, paint, etc., if desired. Each strike plate should consist of a strip of copper of not less than 25 mm width x 0·45 mm thickness (1 inch width 26 swg) or other material of equivalent surge current capacity and mechanical robustness, the plate should be of sufficient length to extend on both sides to a distance of 610 mm (24 in) as measured from the outer extremity, and should form the means of joining together the ends of the main earth conductors at these extremities.

ACB 29.610(c) External metal parts

(1) In addition to the requirements of paragraph 29.610(c), where internal linkages are connected to external parts (e.g. rotor blades), the linkages should be bonded by Primary Conductors, as close as is practical to the external part.

(2) Where a Primary Conductor is fitted across an operating jack (e.g. in control systems) it should be of such an impedance and so designed as to limit to a safe value the passage of current through the jack.

(3) In considering external metal parts, consideration should be given to all flight configurations (e.g. lowering of landing gear) and also the possibility of damage to the rotorcraft electrical system due to surges caused by strikes to protuberances (such as pitot heads) which have connections into the electrical system.

ACB 29.610(d) External non-metallic parts

(1) Where lightning diverters are used the surge carrying capacity and mechanical robustness of associated conductors should be at least equal to that required for Primary Conductors.

ACB 29.610(d) (continued)

(2) Where non-metallic parts are fitted externally to the rotorcraft in situations where they may be exposed to lightning discharges (e.g. radomes or rotors) the risks include:—

(a) the disruption of the materials because of rapid expansion of gases within them (e.g. water vapour),

(b) the rapid build up of pressure in the enclosures provided by the parts resulting in mechanical disruption of the parts themselves or of the structure enclosed by them, and

(c) fire caused by the ignition of the materials themselves or of the materials contained within the enclosures.

(3) The materials used should have low water absorption characteristics, should not occlude gases, and should be of high dielectric strength in order to encourage surface flash-over rather than puncture. Laminates made entirely from solid material are preferable to those incorporating laminations of cellular material.

(4) Those external non-metallic parts which are classified as Primary Structure should be protected by Primary Conductors.

(5) Where damage to an external non-metallic part which is not classified as Primary Structure may endanger the rotorcraft, the part should be protected by adequate lightning diverters.

(6) In some cases (e.g. radomes or rotors) confirmatory tests may be required to check the adequacy of the lightning protection provided.

ACB 29.610(e) Rotor blade and control surface hinges and bearings

Where bonding conductors are provided in accordance with the requirements of paragraph 29.610(e)(2) they should be as flexible and as short and of as low an impedance as possible and should not be tinned. Precautions should be taken to prevent the possibility of their jamming the hinge or bearing.

ACB 29.611 Inspection and maintenance provisions

(1) This information should include any provisions made to enable inspections such as radiographic and ultrasonic examination to be undertaken.

(2) See also ACB 29.609(7).

ACB 29.612 Identification of pipe lines

(1) Where pipe lines are marked for the purpose of distinguishing their functions it is recommended that a system of identification conforming to that contained in British Standards Specification M23* should be used. Markings incorporating names or descriptions should be in the language most suitable for ensuring compliance with section 29.612.

(2) Distinction by means of colour markings alone is not acceptable. The use of alphabetical or numerical symbols may be acceptable if recognition depends upon reference to a master key and any relation between symbol and function is carefully avoided.

*Obtainable from the British Standards Institution.

ACB 29.629 Flutter prevention and stiffness

(1) *GENERAL*

(a) At this juncture it is not possible to specify stiffness criteria for rotor blades and it is left to the designer with his experience to ensure as far as is possible in the design stage, that the blades possess such stiffness qualities as will prevent the onset of flutter up to the maximum permissible speed and rotor rotational speed.

(b) The tests carried out on the prototype rotorcraft will provide the positive proof of freedom from flutter characteristics within the permissible range of speeds and rotor rotational speed.

(2) *DESIGN ASSUMPTIONS*

(a) It is recommended that in the design of the blades, sufficient mass balance shall be provided uniformly along the blade to bring the aerodynamic and inertia axes as nearly coincident as possible. The flexural axis should be as nearly coincident as other considerations will permit.

(b) The displacement of the inertia axis due to the effect of humidity on the blade should be considered.

(3) *CONTROL SYSTEM STIFFNESS.* The percentage stretch of the control systems should be as low as possible having regard to —

(a) allowance for full control movement,

(b) avoidance of resonance with the rotor.

ACB 29.631 Bird strikes

In the absence of better information the maximum weight of the bird assumed to be struck by a rotorcraft the Maximum Weight of which is greater than 5700 kg (12,500 lb) should be 1·81 kg (4 lb) and for rotorcraft the Maximum Weight of which is greater than 2730 kg (6,000 lb) and less than 5700 kg (12,500 lb) the weight should be 0·91 kg (2 lb). The associated rotorcraft speeds should be all speeds up to the maximum true air speed which is likely to be achieved in operational service at altitudes up to 2440 m (8,000 ft).

ACB 29.661 Rotor blade clearance

In complying with the requirements of section 29.661 the combined effect of the manoeuvring loads and gust loads of the magnitudes prescribed in section 29.341 should be considered.

ACB 29.671(b) Incorrect assembly

(1) In meeting the requirement of paragraph 29.671(b), the recommendations of paragraph (2) should be applied to all control systems, irrespective of the type of system (mechanical, electrical, hydraulic, etc.) except those which,

(a) if assembled incorrectly are unlikely to prejudice the safe operation of the rotorcraft,

(b) are operated before take-off can be commenced, in such a way that incorrect assembly would be obvious.

NOTE: Such operation before take-off does not include special 'drills' but only those operations which must, of necessity, be made before a take-off.

ACB 29.671(b) (continued)

(2) Each such control should be so designed and constructed that, at all reasonably possible break-down points in the system, it is mechanically impossible to:—

(a) assemble the system to be disastrously out of phase or to assemble the system so that it operates in the reverse sense, or

(b) interconnect two systems where this is not intended.

(3) All other controls, the faulty operation of which might affect the continued safe operation of the rotorcraft, should be so designed and constructed as to be mechanically difficult to misconnect or so that misconnection is obvious from the appearance of the system.

ACB 29.671(d) Failure or disconnection of any element

(1) For the assumption that a part will not fail or become disconnected to be acceptable, the design should be such that no failure or disconnection of the part could be foreseen under any practical circumstances including errors in operation, assembly or maintenance. Some of the considerations which should be taken into account in designing these parts are:—

(a) Choice of materials to avoid undue notch sensitivity, undue tendency to stress corrosion cracking and corrosion and its effects.

(b) Provision of sufficient robustness for all 'handling' loads likely to occur, including those resulting from errors in operation, assembly or maintenance.

(c) Avoidance of design features tending to produce fatigue effects, such as, abrupt changes of section, natural periods of vibration of parts coincident with those induced by engines, transmissions, rotors or aerodynamic effects.

(2) Where any part which it is assumed will not fail or become disconnected is a bolt, pivot or other connecting device it should either:—

(a) be an acceptable permanently locked (e.g. bench riveted with adequate dimensional control) connection, never broken down when assembled in the rotorcraft, or

(b) be provided with secondary means of retention such that once the item is placed in position, the secondary retaining device becomes automatically effective in preventing it from dropping out of position even though the usual retaining device may have been omitted. This secondary device should be automatic in operation and should not depend upon personnel remembering to carry out a separate action such as the bending of locking tabs or the fitting of locking wire.

NOTES: (1) It is recommended that the design of the system should avoid the use of such connecting devices.

(2) Secondary means of retention which depend upon friction or springs can usually be accepted.

ACB 29.672(a) Stability augmention systems and
ACB 29.1329(e) Automatic pilot systems

(1) *INTRODUCTION.* This ACB gives guidance on acceptable methods of making a safety assessment for Stability augmentation systems and automatic pilot systems.

ACB 29.672(a) and ACB 29.1329(e) (continued)

(2) *EVENTS*

(a) Occurrences may consist of Events, Failures, Errors or combinations of any or all of them. Events, in the form of atmospheric disturbances, should be considered, and it should be shown that the response of the system will not be such as to hazard the rotorcraft. It should be shown that the rotorcraft is safely controllable if the system is disengaged or saturated in the presence of turbulence or gusts.

(b) It will not normally be necessary to consider the combined effects of atmospheric disturbances and Failures, unless such Failures might be caused by the disturbance, (e.g. automatic disengagement of the system). It will be necessary to consider crew errors to show that foreseeable errors will not have hazardous consequences.

(3) *FAILURES.* The types of Failure to be considered should include those given in subparagraphs (a) to (f).

(a) *Passive Failures.* These are defined as Failures which do not, of themselves, cause a flight path disturbance but permit the rotorcraft to be disturbed by other influences without correction, e.g. turbulence. The effect of such failures occurring anywhere in the system should be examined. It will generally be sufficient to show that the pilot is given a clear indication of the failure before the rotorcraft can diverge dangerously from the intended flight path (see paragraph 29.672(c)).

(b) *Runaways.* These are defined as Failures which force the rotorcraft to diverge from its intended flight path either slowly or rapidly. Such Failures in the system should be examined and the most critical cases shown to be safe by inflight demonstrations. It should be noted that the fastest runaway is not necessarily the most critical case. Slower runaways can continue undetected for longer periods and result in larger disturbances unless adequate provision is made for their detection.

(c) *Oscillatory Failures.* In considering oscillatory failures it is preferable that, rather than an attempt to discover what amplitudes and frequencies of oscillation would be caused by failures, an analysis is made of the protection against such failure to show that no possible oscillation is hazardous.

(d) *Non-disengagement.* It is anticipated that in the majority of cases the ability to fly and to land the rotorcraft with the system engaged will be demonstrated, to show compliance with section 29.672. However, as an alternative, it may be shown that non-disengagement of the system when required is Extremely Improbable.

(e) *Multiple axis features.* Where a single Failure can affect more than one axis, or more than one system, the total Effects should be considered.

(f) *Failures external to the system.* Consideration should be given to the effect on the system of Failures in other parts of the rotorcraft (e.g. of the engine, or of power-operated or power-assisted primary flight controls, or of trimming control systems) to ensure that these Failures do not induce dangerous characteristics in the system.

(4) *ASSUMPTIONS AND PROCEDURES FOR FAILURE DEMONSTRATIONS*

(a) Failure recognition. Where the response of the rotorcraft to the Failure is immediate and rapidly detectable it may be assumed that the pilot recognises the need to take action one second after the occurrence of the Failure. If the response of the rotorcraft to the Failure is not immediate and rapidly detectable the Failure recognition time should be that at which a pilot may reasonably be expected to recognise the need to take action.

NOTES: (1) Where the pilot is assumed to have his hands on the controls, a shorter time than 1 second may be accepted.

(2) In this context 'reasonably' means what can be expected of virtually all pilots on all occasions.

ACB 29.672(4)(a) (continued)

(b) (i) *Recovery.* At all speeds up to V_{NO}, the pilot should be assumed to take corrective action not less than 2·5 seconds after he has recognised the need to do so, except that during hover, take-off, initial climb, final approach, and at speeds between V_{NO} and V_{NE}, this delay may be reduced to not less than 1·5 seconds. For cases where the pilot is considered to have released the controls a delay time of 5 seconds should be assumed.

NOTE: Consideration of the case where the pilot has released the controls will be essential when certification is sought for single-pilot operation of rotorcraft having a Maximum Weight up to 5700 kg (12,500 lb).

(ii) Account should be taken of any changes in the sequence of operation and use of controls which, although not part of the recommended recovery technique, might be instinctively used (e.g. collective pitch). Such changes should not decrease significantly the manoeuvrability and ability to recover a level flight attitude.

(iii) While no specific values are given for changes in normal acceleration which may be considered excessive, changes greater than ±0·5g would be so considered.

(c) *Out of trim.* Failures should be assumed to occur with the system as far off centre, and/or the rotorcraft as far out of trim, as is likely in normal operation.

(5) *FAILURE EFFECTS*

(a) The control and manoeuvrability requirements of section 29.143 should be met after a Failure of a stability augmentation device within a practical flight envelope, which must be specified, but may be reduced from the original declared flight envelope. The trim and stability characteristics should not be reduced below a level which would permit either:—

(i) for Group A continued safe flight and landing, or

(ii) for Group B an Emergency Alighting to be safely accomplished without demanding more than normal skill on the part of the flight crew.

(b) No Failure or Event or combination thereof which is not Extremely Remote should have any of the following consequences:—

(i) a load on any part of the rotorcraft greater than its proof strength;

(ii) an exceedance of V_{DF};

(iii) a negative normal acceleration;

(iv) an exceedance of bank angle limitations or a bank angle of more than 60° en route; or more than 30° when in the configuration for the final approach;

(v) a hazardous deviation in flight path;

(vi) a hazardous degradation of the handling qualities of the rotorcraft;

(vii) a situation more severe than a Major Effect.

(6) *MAINTENANCE ERRORS.* The design of the installation should be such that, so far as is practicable, errors in maintenance cannot create a danger (e.g. limit switches etc., should not be provided with so great a range of adjustment that maladjustment could be catastrophic in either normal or failure conditions).

(7) *LIMITATIONS.* Limitations may be applied to the use of the system in order to enable compliance with these requirements provided that they are of a type which a pilot can be expected to observe (e.g. minimum height) (see also section 29.1518).

(8) *FLIGHT TESTS.* Flight tests to establish the consequences of the most critical Failures which are not Extremely Remote should be made to substantiate the safety assessment. The flight test programme to be completed should be agreed with the Authority beforehand.

ACB 29.683 Operation tests

Particular attention should be given during the tests required by section 29.683 to any swash plate or control spider assembly.

ACB 29.685(a) Freedom from jamming

The requirements of paragraph 29.685(a) should be met with controls normally adjusted and with such slackening of cables as may occur and, where tensioning devices are incorporated, in the event of such malfunctioning or failure of the tensioning device as may occur.

The design should take account of the following:—

(1) The design of the system should be such that jamming is unlikely to result from the incorrect fitting of connecting bolts or pins, e.g. in the opposite direction from that shown on the drawings. If jamming could occur with incorrect fitting of a bolt or pin, the design should be such that it is mechanically impossible to fit the bolt or pin other than as shown on the drawings.

(2) Any connecting bolt or pin, the loss of which would not result in a Catastrophic Effect, by reason of leaving a control disconnected, should not cause jamming of the control whilst it is in the process of working out of position.

(3) A control run to which paragraph (2) can be applied, should not become jammed as a result of the disconnected portions of the control circuit becoming caught on adjacent structure, etc., after they have become disconnected.

(4) A survey should be made of the control circuits to ensure that so far as can be foreseen, loose tools, nuts and rivets, etc., are unlikely to cause jamming of the controls. Common examples of design predisposing towards trouble in this respect are:—

(a) Control mechanism running too close to flooring or other horizontal surfaces liable to act as a catchment area for loose items. Ends of levers working in either sump-like depressions or fairings also come within this category.

(b) Holes and slots in flooring, control consoles, etc., and structure and brackets being in such a location that items falling through or from them would be directed into parts of the control system.

(c) Multiple levers mounted on a common spindle; levers with lightening holes.

(d) Chains working over sprockets with horizontal pivots. (Experience indicates that such chains act as catchments for rivets, small screws, etc, which jam in the sprocket teeth.)

(e) Insufficient clearance between gears and casings or between gears running at different speeds.

(f) Pulleys and cable drums such that small screws, etc., can fall in and jam against guards.

(5) The design of control circuits should be assessed from the point of view of whether or not accumulations of water in or on any part are likely to freeze and cause jamming. Particular attention should be paid to components in parts of the rotorcraft which could be contaminated by the water systems of the rotorcraft in normal or fault conditions; if necessary such components should be shielded.

ACB 29.685(d) Control system design

(1) *FLEXIBLE WIRE ROPES.* The design of installations incorporating flexible wire ropes should be such that the following main causes of failure and premature fraying of the ropes are avoided:—

(a) Fatigue arising from bending the rope over pulleys which are too small in diameter.

(b) Fatigue arising from increased stress concentrations caused by local reductions of wire area as a result of wires rubbing against wires within the rope and thus wearing local gooves in one another.

NOTE: This usually occurs where a rope passes over a pulley and it is a function of pulley diameter and intensity of steady load.

(c) Pulleys situated so as to necessitate reverse bends in ropes such that during control surface movements the same part of the rope traverses more than one pulley.

(d) A layout resulting in too small an angle of wrap.

NOTE: Experience shows that early failure occurs if the rope is not kept firmly in contact with the pulley.

(e) Wear resulting from poor cable and pulley alignment, from an incorrectly proportioned pulley groove, and from vibration of ropes.

(2) *PULLEYS.* For pre-formed carbon steel wire rope to BS 2W9*, the pulley diameter† measured at the bottom of the groove, should be at least as large as indicated by Figure 1.

(a) For conventional control systems the average value of W (see Figure 1) has been found to be of the order of 2% to 6% and although Figure 1 is valid for values of W between 3·7% and 15%, it is nevertheless recommended that, in the absence of more reliable data, a value of at least 6% should be assumed for design purposes.

(b) The section at the bottom of the rope groove should be a circular arc over an angle of not less than 120°. The radius of the groove should be 7·5% larger than the nominal radius of the rope.

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*Obtainable from the British Standards Institution.

†It is emphasised that these diameters are a recommended minimum; longer rope life is to be expected from larger pulleys.

ACB 29.685(d) (continued)

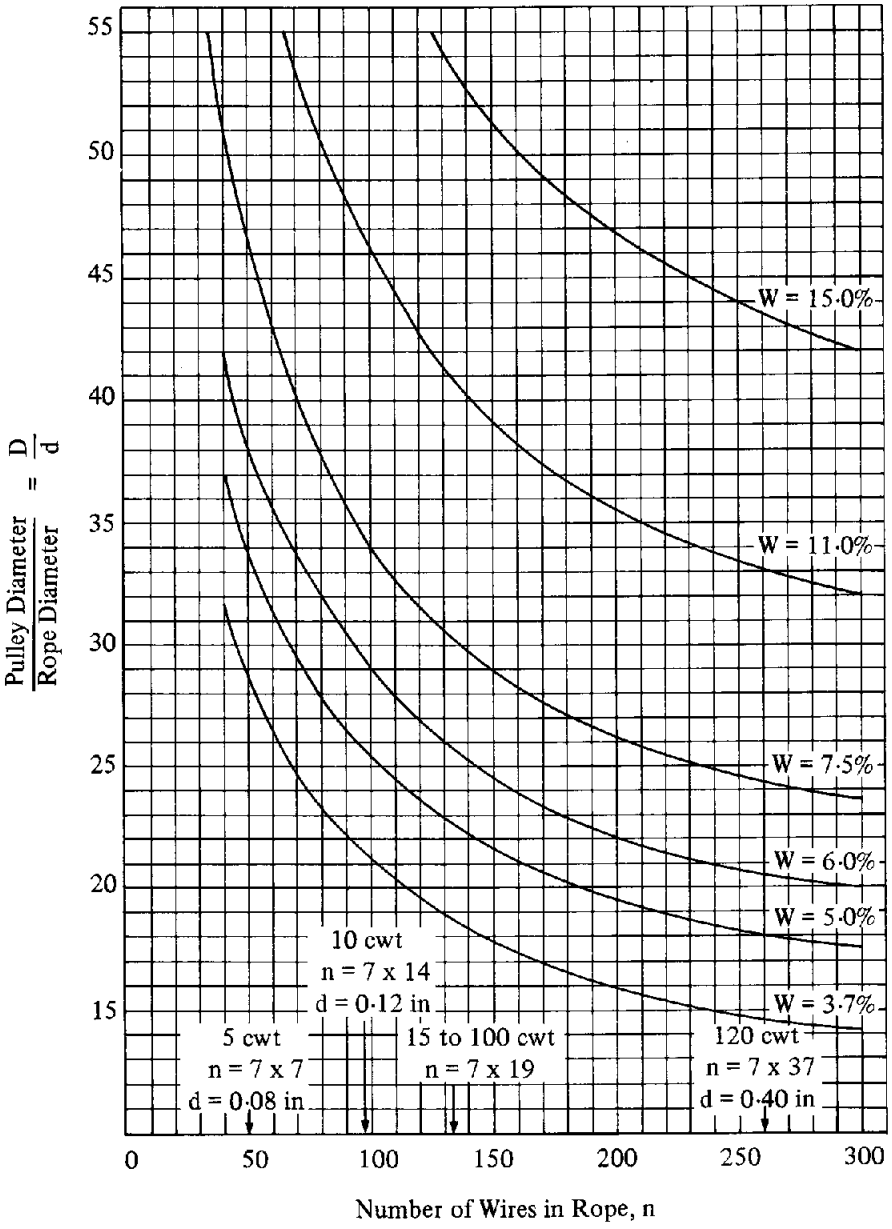


Figure 1 RECOMMENDED MINIMUM PULLEY SIZES

NOTE: W = rigging tension plus average hinge moment load expressed as a percentage of the nominal breaking strength of the rope.

ACB 29.685(g) Friction in control systems

It is recommended that the forces on the controls necessary to overcome static friction, with rotors turning at normal operating speeds, should not exceed the values given in Table 1. In the case of systems incorporating cables, this recommendation should be met with the cables rigged at the maximum and minimum limits of the declared tensions.

ACB 29.685(g) (continued)

TABLE 1 (ACB 29.685(g))

Maximum Weight of Rotorcraft	Maximum Static Friction Force on Control			
	Longitudinal Cyclic Pitch	Lateral Cyclic Pitch	Collective Pitch	Rudder Pedal
5700 kg or less	15 N (3·3 lbf)	10 N (2·2 lbf)	20 N (4·4 lbf)	20 N (4·4 lbf)
Above 5700 kg	20 N (4·4 lbf)	15 N (3·3 lbf)	30 N (6·6 lbf)	30 N (6·6 lbf)

NOTE: For rotorcraft with powered controls, irrespective of weight, the above figures applicable to a weight above 5700 kg may be doubled when the source of power has failed.

ACB 29.695 Power operation

Proposals for power-operated primary flight controls for rotors or other control surfaces should be submitted to the Authority at an early stage in design. The system should be such that the probability of a Catastrophic Effect due to a Failure in the system or total loss of engine power is predicted to be:—

(a) Extremely Improbable for Group A Rotorcraft.

(b) Extremely Remote for Group B Rotorcraft.

ACB 29.729(a) Operation of landing gear

Where other than manual operation of the landing gear is employed the mechanism should be such that if the movement of the landing gear is arrested, during retraction or extension, by transient acceleration outside the limits of paragraph 29.729(a)(5) it should recommence automatically and move to completion as soon as the acceleration conditions are again within the limits.

ACB 29.729(e) Position indicators

This ACB provides an acceptable means of complying with the requirement of paragraph 29.729(e).

Indicators easily visible to the pilot or appropriate members of the flight crew should be provided for each retractable unit of the landing gear, and be arranged so that:—

(1) A green lamp is alight only when:—

  (a) the unit is secured in the correct landing position, and

  (b) where it can be easily overlooked, the landing gear selector is in the landing position.

(2) A red lamp is alight at all times other than:—

  (a) when the conditions of (1) are fulfilled, and

  (b) when the unit, its doors and its selector are in the correct retracted position.

ACB 29.771(e) Environmental temperature

(1) This ACB contains information on the temperatures considered acceptable in flight-crew compartments.

(2) Where necessary, temperatures are given as globe temperature. Globe temperature depends on the effective mean radiation temperature of the environment, the air temperature, solar radiation, and on convective heat transfer. Globe temperatures should be measured at the position of each seated flight-crew member.

(3) It is recommended that in normal flight it should be possible for the flight crew to maintain globe recorded temperatures at their seat positions within the range +15°C to +30°C.

NOTES: (1) Where flight-crew compartment ambient temperatures are likely to stabilise at more than +30°C, consideration should be given to the provision of air-conditioning equipment.

(2) It is recommended that the temperature of those areas of floor where flight-crew members are likely to place their feet should not be less than +5°C.

(4) No surface which can be touched by the flight crew should exceed a surface temperature of +60°C or fall below −15°C in normal cruise conditions.

ACB 29.771(g) Signal pistol and discharger

Paragraph 29.771(g) does not prohibit the use of the mounting as a stowage for the pistol nor does it prohibit the firing of the pistol by hand.

ACB 29.773(d) Failure considerations

Paragraph 29.773(d) can be met by arranging that such failures affect only one pilot's windscreen or windows; it is not intended that duplication of systems on both pilots' windscreens or windows should be provided.

ACB 29.777(a) Cockpit controls

(1) In showing compliance with the requirements of paragraph 29.777(a) when a seat at a station from which the rotorcraft may be piloted has been adjusted so as to suit the occupant, subsequent change of seat position to operate any controls needed for piloting is not acceptable.

(2) It should be possible for the flight crew, with their safety harness correctly worn, to comply with the requirements of paragraph 29.777(a), except in respect of controls which it can be shown will only be required on very rare occasions dissociated from the need for safety restraint.

ACB 29.777(b) Friction device

The fitting of a suitable adjustable friction device is an acceptable method of satisfying the requirements of paragraph 29.777(b).

ACB 29.779 Sense of movement

(1) *ENGINE POWER CONTROLS.* Paragraph 29.779(b) relates to collective pitch levers which are pivoted at their rearward end.

(2) *LANDING GEAR CONTROLS.* For paragraph 29.779(c) the tripping of a simple safety catch on the control itself would not be regarded as a 'movement of control'.

ACB 29.785(a) Seats, safety belts and harnesses

(1) It is recommended that seats should be designed with a view to absorbing as much energy as possible before total failure in a Crash Landing.

(2) Attention is drawn to the fact that the strength prescribed in section 29.785 only caters for airworthiness and thus caters for flight and ground cases, and Crash Landing cases up to the accelerations prescribed in section 29.561. In meeting such cases sufficient robustness for general handling and usage in service will not necessarily be provided. It is recommended that such extra robustness should be provided. In particular, consideration should be given to the case of a heavy occupant pulling himself up by applying a sudden heavy load to the top of the back of the seat in front.

(3) It is recommended that pilots' seats should be designed so that possible long term injurious effects to health, as a result of incorrect posture and vibration, are reduced to a minimum.

(4) The design of seats shall be such that in emergency conditions they are unlikely to trap or injure the legs of the occupants or other persons (e.g. a seat of unsuitable design must cause unnecessary risk of injury to the legs of a person seated behind).

(5) Adjustable, folding or rotatable seats should be designed so that when locked they will not move under loads occurring in the stipulated loading conditions. The locking mechanisms of adjustable and folding seats should be such as to lock automatically when released.

(6) Any cushions, etc., designed for use with seats occupied by members of the flight crew on duty, should be suitably secured in position so that it is impossible for them to move and in any way interfere with the use of the controls or with the normal free movement of the flight crew. The pilot's seat together with its upholstery should be such as to react the loads applied to it by the pilot without deflecting to an extent that would prejudice his use of the controls. The pilot effort loads of paragraph 29.397(a) apply in this case.

(7) Seats not approved for occupation during take-off and landing need not be fitted with safety belts or harnesses to meet the Crash Landing conditions of paragraph 29.561(b) but they should be so designed and located as not to provide a source of danger in these circumstances.

(8) *AUTHORITY'S PILOTS.* The Authority may require its test pilots to wear parachutes when piloting rotorcraft undergoing airworthiness flight tests. In such cases the pilot's seat(s) and the safety belt or harness of the pilot's seat(s) of a rotorcraft submitted for flight tests should be suitable for use when a parachute is worn.

ACB 29.785(a) (continued)

(9) *FORWARD-FACING SEATS*

(a) In emergency conditions sharp edges or excrescences on the seats or parts of the passenger accommodation might prove a source of danger not only to the occupants of the seats but particularly to the occupants seated to the rear. Attention should be paid, therefore, to the passenger accommodation and to those areas of a seat back lying within the arc of travel of the head of an occupant seated to the rear and restrained by a safety belt.

(b) The radius of the arc of travel, representing the extremity of the occupant's head should be taken as 710 mm (28 in). This allows for tall occupants and stretch in the safety belt. The centre of the radius of the arc of travel should be taken as 460 mm (18 in) forward and upward of the junction of the seat back and bottom at 35° to the latter (see Figure 1).

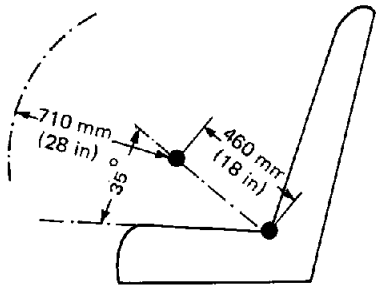


Figure 1

(c) Within these areas, all surfaces should be smooth and either flat or of large radius.

(d) If the top of the seat back occurs within the arc of travel of the head, it should be padded to at least 25 mm (1 in) radius, with at least 12·5 mm (0·5 in) of firm felt or balsa (or their equivalent) as well as any normal soft upholstery padding.

(e) Any substantially horizontal members other than seat backs occurring within the areas defined by (b) should either be padded as recommended in (d) or should be so arranged that the head will be deflected past them rather than strike them a direct blow. (The arrangement suggested in the latter alternative may be provided by a smooth covering of the seat back using plywood, metal or fibre sheet underneath the finishing material). The tops of vertical members occurring within these areas should be so protected as to be at least as safe as horizontal members. No member should occur where it might be struck by the throat.

(f) It is recommended that seat backs should be pivoted so as to move forward under Crash Landing conditions so that the occupant of the seat behind only strikes a glancing blow on the seat back.

(10) *SIDE-FACING SEATS*

(a) Side-facing seats should be arranged so that not more than two occupants can lean against any third in Crash Landing conditions up to the accelerations prescribed in paragraph 29.561(b). This assumes that the only means of restraint is a seat belt.

(b) Considering the case of paragraph (a) the safety belt attachment points should be suitably spaced or a bulkhead should be provided between each three occupants.

ACB 29.785(a) (continued)

(11) *APPROVAL*

(a) An Approved seat is one of a type individually approved by the Authority or is one certified as suitable for a particular rotorcraft type by an Approved Design Organisation (Aircraft). In the former case an Approved Organisation supervising the installation is responsible for selecting seats the forms and certified strengths of which are appropriate to the particular installation.

(b) An Approved type of safety belt or harness is one complying with a Specification approved by the Authority. Acceptable Specifications (e.g. Airworthiness Division Specification No. 1 'Safety Belts' and Airworthiness Division Specification No. 4 'Safety Harnesses') can be obtained on request from the CAA, Printing and Publication Services, PO Box 41, Cheltenham, Glos. GL50 2BN.

ACB 29.785(c) Safety belts and harnesses

On rotorcraft where two pilots' stations are provided, and where inertia-reel harnesses with locking mechanisms are installed, it is recommended that the means of operating both harness locking and seat adjusting mechanisms are fitted on the inboard side of each pilot seat.

ACB 29.785(f)(2) Seat strength

(1) All seats, other than seats not approved for occupation during take-off and landing, should both whilst occupied and unoccupied, comply with the strength requirements for the rotorcraft as a whole as prescribed in Subpart C.

(2) Seats not approved for occupation during take-off and landing should comply with the above requirements when unoccupied and should be strong enough to withstand such loads as their form permits them to receive when occupied in the conditions specified in paragraph 29.337(a).

(3) Suitable methods of testing seats to establish compliance with the strength requirements of section 29.785 are contained in CAA Airworthiness Division Specification No. 3, 'Tests for Seats with Safety Belts Attached', which is obtainable on request from the CAA, Printing and Publication Services, PO Box 41, Cheltenham, Glos. GL50 2BN.

ACB 29.785(f)(3) Safety belt and harness strength

(1) Assumptions regarding the load distribution on, and the geometry of, the safety belt or harness should be reasonably conservative. No relief should be assumed from muscular forces.

(2) The minimum strength acceptable for safety belts and harnesses is prescribed in paragraph 29.785(f)(3). In well designed accommodation, however, considerably greater crash protection is given by stronger restraints. The strength of stronger installations may be certified in terms of the *g* against which they provide restraint.

(3) The certified strength which is required for each member of a safety belt or harness should be stated on the drawings relating to its installation.

NOTE: A safety belt or harness is regarded as being divisible into various members (e.g. left thigh strap, right thigh strap, release mechanism, etc.) which are liable to be detached from one another for purposes of storage or replacement.

ACB 29.785(g) Aft-facing seats

(1) For general use the highest point of the seat back or head-rest should be not less than 915 mm (36 in) above the deflected seating surface when occupied by a 77 kg (170 lb) person.

(2) The head-rest of an aft-facing seat should be designed to support adequately the occupant's head against the maximum sideways acceleration of paragraph 29.561(b) which can be associated with the forward acceleration.

ACB 29.785(i) Seat belt and harness installation

(1) *GENERAL*

(a) It is acceptable, in certain cases, to make provision for relaxing the upper restraints of a safety harness to enable the wearer to increase his reach or field of view, but if this is done, it should be possible for the wearer to re-secure them without difficulty.

(b) Where there is a risk that a safety belt or harness might, when not in use, foul the controls or impede the crew, suitable stowage should be provided.

(2) *SAFETY BELTS*

(a) The belt should be installed in accordance with the Approved Specification; in the case of belts conforming to the Specification obtained from the Authority, the belt, when worn, should lie across the groins of the wearer.

NOTE: When designing accommodation incorporating a safety belt it is important to ensure that the occupant, if pivoting forward about the belt under the conditions of paragraph 29.785(f) will not be liable to come into contact with potentially dangerous objects.

(b) Safety belts should be so installed that they are released by operating the means of release from left to right.

(3) *SAFETY HARNESSES.* The harness should be installed in accordance with the approved Specification, and when correctly adjusted to the wearer —

(a) the straps or belts should remain in position irrespective of variation of load,

(b) the upper part of the torso should be restrained sufficiently to ensure that the wearer's head and trunk are safeguarded, under the conditions of paragraph 29.785(f) from contact with potentially dangerous objects.

ACB 29.787 Cargo and baggage compartments

(1) Attention is drawn to the fact that the strength prescribed in paragraph 29.787(a) only caters for airworthiness and thus caters for flight and ground and, in some instances, Crash Landing cases. In meeting such cases, sufficient robustness for general usage will not necessarily be provided. It is recommended that consideration should be given to providing sufficient robustness wherever possible.

(2) Account should be taken of any possible dynamic loading resulting from movement of the cargo or baggage; possible variations in the geometry of the means of restraint and wear and tear of the means of restraint and local attachments.

ACB 29.799 Water systems

(1) *CONTAMINATION*

(a) There should be no distinction between water supplies for drinking and ablutions.

(b) The tanks should be accessible for the purposes of inspection, cleansing and the introduction of additives in solid or liquid form.

(c) The tanks should have a removable plate so that the interior surfaces can be seen and cleansed.

(d) Each tank should have a service draining point through which it can be flushed and completely emptied.

(e) Filters should not be fitted in any interior water system.

(f) The filling point should be so situated and designed that foreign matter cannot enter during the process of refilling.

(g) Tanks should be lagged to prevent the water temperature rising to such an extent as to favour the growth of organisms.

(h) In meeting the requirements of paragraph 29.799(a) account should be taken of all foreseeable conditions of operation of the rotorcraft and all practicable conditions of operation of the water system.

(2) *DISCHARGE.* Where there is otherwise any possibility of the water freezing as lumps of ice on the outside of the rotorcraft, water should be discharged clear of the rotorcraft.

ACB 29.801(a) Ditching

The UK Air Navigation Order prescribes the operating conditions that constitute 'flight over water' for rotorcraft, as referred to in paragraph 29.801(a).

ACB 29.801(c) Flotation and trim

The flotation and trim characteristics should be investigated under the following conditions:—

(a) in sea states in the range 0 to 6 of Table 1 (but with a maximum wave height of 9·15 m (30 ft)),

(b) in individual waves with height/length ratios in accordance with (i) to (ii) in all sea states of (a):—

(i) 1 : 8 for Rotorcraft in Group B.

(ii) 1 : 10 for Rotorcraft in Group A.

NOTE: The wave height/length ratio may be changed with the increase in the declared time interval up to a maximum of 1 : 12·5 when there is no limit on the declared time interval.

ACB 29.801(c) (continued)

TABLE 1 (ACB 29.801(c))
SEA STATE CODE (WORLD METEOROLOGICAL ORGANISATION)

Sea State Code	Description of Sea	Significant Wave Height	
		Metres	Feet
0	Calm (Glassy)	0	0
1	Calm (Rippled)	0 to 0·1	0 to ⅓
2	Smooth (Wavelets)	0·1 to 0·5	⅓ to 1⅔
3	Slight	0·5 to 1·25	1⅔ to 4
4	Moderate	1·25 to 2·5	4 to 8
5	Rough	2·5 to 4	8 to 13
6	Very Rough	4 to 6	13 to 20
7	High	6 to 9	20 to 30
8	Very High	9 to 14	30 to 45
9	Phenomenal	Over 14	Over 45

NOTES: (1) The Significant Wave Height is defined as the average value of the height (vertical distance between trough and crest) of the largest one third of the waves present.

(2) Maximum Wave Height is usually taken to be 1·6 x Significant, e.g. Significant Wave Height of 6 m gives Maximum Wave Height of 9·6 m.

ACB 29.801(d) Flotation time

The rotorcraft should float in a stable position for not less than five minutes. This allows time for the deployment of the liferafts and for passengers to transfer from the rotorcraft to the liferafts in severe seas.

ACB 29.801(h) Declared conditions

ACB 29.801(c) defines generally applicable criteria for declared conditions. In particular geographical areas more severe criteria will be applicable.

ACB 29.807(b) Passenger emergency exits

(1) It is not the intention to require that exits necessarily be at locations diametrically opposed to each other.

(2) Where compensating factors exist which justify an increase in seating capacity beyond those specified in paragraph 29.807(b), such an increase up to a maximum of ten extra passengers is permissible with the agreement of the Authority.

ACB 29.807(d) Ditching emergency exits for passengers

Type IV exits are not to be considered for leferaft deployment and boarding purposes but are required to facilitate egress in the event of a capsize.

ACB 29.809 Location of passenger emergency exits

The optimum fore and aft location of emergency exits should be decided on each rotorcraft bearing in mind the relevant considerations which will include but not necessarily be confined to:—

(1) the disposition of passengers in the fuselage and the ease with which they can reach the exits;

(2) the probability of occurrence of damage to different parts of the fuselage in Emergency Landing conditions;

(3) the need to avoid passengers leaving the rotorcraft in areas where dangerous conditions (e.g. spilt liquids, hot engine parts, rotors, propellers) can be encountered;

(4) the need to avoid areas that might become potential fire hazards in an Emergency Landing or Crash Landing.

ACB 29.813 Access to exits

(1) Where footholds, ladders, etc., are provided giving access to exits they should be of rigid construction and should be permanently fixed in position except that they may fold if they can be brought into use immediately and are unlikely to jam as a result of structural distortions during a Crash Landing.

(2) Means should be provided to assist occupants to reach usable emergency exits should the rotorcraft come to rest on its side. Emergency Landings on both land and water need to be considered.

(3) During the carriage of any external load, the emergency exits should not be obstructed during the particular operation.

ACB 29.831 Ventilation

(1) To show compliance with the requirements of paragraph 29.831(b):—

(a) Fuel vapour may not be present in dangerous concentrations.

(b) Harmful concentrations of fire extinguishing agent may not be liable to occur either as a result of intentional use of any fire extinguishing systems, or extinguishers provided, or due to any failure which might lead to unintentional discharge of the extinguishing fluid.

(c) Systems employing fluids liable to give off noxious vapour (e.g. some hydraulic fluids) may not be installed in such a manner as to risk harmful contamination of the cabin air either by leakage or by use.

(2) Where internal doors or partitions between compartments are equipped with louvres or other ventilating means, provision convenient to the crew should be made for the prevention of flow of air through these means.

ACB 29.853(a) Compartment interiors

(1) As far as practicable, materials should be chosen to minimise the production of smoke or noxious fumes when overheated or burned.

(2) *TESTING FOR CORROSIVE IMPURITIES IN TEXTILES*

(a) *General.* It is recommended that all textile materials should be tested to ensure they are not liable to seep corrosive elements which might affect the rotorcraft structure.

(i) There are several processes by which non-flame-resistant materials can be made flame-resistant. Care should be taken, when choosing a process, to ensure that it will not cause corrosion by seepage when used in the vicinity of metal structure.

(ii) Compounds used for flame resistance, whether added during the manufacture of the material, or by application to the surface, should not accelerate corrosion of the metal against which the material is placed.

(b) *Chemical seepage tests.* One such test which is acceptable for this purpose is that described in British Standard Specification F100* Inspection and Testing Procedures and Certain Basic Requirements for Textiles for Aeronautical Purposes, and the test should also comply with the following paragraphs (i), (ii) and (iii).

(i) The pH value of the aqueous extract should be not less than 5 and not greater than 8.

(ii) There should be not more than 0·1% of water soluble chlorides expressed as sodium chloride, NaCl.

(iii) There should be not more than 0·25% of water soluble sulphates expressed as sodium sulphate, Na_2SO_4.

ACB 29.853(d) Waste receptacle fire precautions

(1) *MATERIALS.* Receptacles should be constructed of materials, which are flame-resistant, and which in addition, retain sufficient mechanical properties to contain a fire as may develop by burning of such material as paper towels within the receptacle. (It should be noted that a thermoplastic material may be flame-resistant but will not necessarily retain adequate mechanical properties in case of a fire.)

(2) *CONSTRUCTION*

(a) The receptacle should be completely enclosed with the exception of a self-closing entry flap or door, which itself should be rigid and when closed form as airtight a seal as is practicable. Entry flaps or doors should be designed so that they remain self-closing even after exposure to fire within the receptacle.

(b) The receptacle may be open-topped provided that it is mounted in a cabinet which itself complies with paragraphs (1) and (2)(a). In this case, the door of the cabinet should be of robust construction, ensure an adequate seal, and withstand misuse in service. Such cabinets should not contain other Flammable materials, potential fire sources (e.g. electrical apparatus) or apertures which would either allow air to feed a fire or permit a fire to spread beyond the cabinet (e.g. through aperture provided for services).

(c) It is recognised that some receptacles, e.g. paper towel dispensers, cannot readily be designed in accordance with paragraphs (2)(a) and (b). In such cases, they should be designed and positioned within the compartment to ensure that:—

*Obtainable from the British Standards Institution.

ACB 29.853(d) (continued)

(i) cigarette ends, etc., are not likely to be deposited into the receptacle, and

(ii) a fire, which could be expected to start in another container, cannot readily spread to them; for example, a paper towel dispenser should not be positioned adjacent to, or immediately above, either the entry flap or door of a waste container or an ash tray provided in the compartment.

ACB 29.865(a) External load attaching means

If it can be shown that a lesser angle than that specified in paragraph 29.865(a) cannot be exceeded, such a lesser angle may be used with the agreement of the Authority.

ACB 29.865(b)(5) Automatic release means

The minimum safe weight of external load when such a means is in use should be established, relative to still air. The incorporation of such an automatic release means should not prejudice the ability to release the load by means of the release devices required by section 29.865.

ACB 29.899(a) Electrical bonding and lightning discharge protection

(1) *PRIMARY AND SECONDARY CONDUCTORS.* For the purposes of this section, Primary Conductors should be those conductors which are required to carry lightning discharge currents, and Secondary Conductors be those conductors provided for other forms of bonding.

(a) The cross-sectional area of Primary Conductors made from copper should be not less than 3 mm^2 (0·0045 in^2) e.g. 0·25 in by 26 swg, except that where a single conductor is likely to carry the whole discharge from an isolated section, the cross-sectional area should be not less than 6 mm^2 (0·009 in^2) e.g. 0·5 in by 26 swg. Aluminium Primary Conductors should have a cross-sectional area giving an equivalent surge carrying capacity.

(b) Primary Conductors should be used for:—

(i) connecting together the main earths of separable major components, (including gear boxes and transmission systems) which may carry lightning discharges,

(ii) connecting engines to the main earth,

(iii) connecting to the main earth all metal parts presenting a surface on, or outside of, the external surface of the rotorcraft.

(c) The electrical impedance of Primary Conductors to a lightning discharge should be as low as is practicable.

(d) The cross-sectional area of Secondary Conductors made from copper should be not less than 1 mm^2 (0·0015 in^2). Where a single wire is used its diameter should be not less than 1·2 mm (18 swg).

(e) The joints detailed in this paragraph are acceptable as parts of the Primary Conductors.

(i) Provided that all insulating finishes are removed from the contact area before assembly, metal-to-metal joints held together by threaded devices, riveted joints, structural wires under appreciable tension, and bolted and clamped fittings.

NOTE: A surface anodised in accordance with Specification DEF 151 is an almost perfect insulator for a potential difference of less than 130 volts, but the surface is readily broken by the rotation of a bolt head or the forming of a rivet. In these latter cases it is unnecessary to remove the anodic finish. However, when two

ACB 29.899(a) (continued)

anodised parts are clamped together without any relative motion being involved, the anodised surface should be removed over an area strictly limited to that necessary to ensure efficient electrical contact, and the assembly coated with a suitable protective material such as a jointing compound containing barium chromate.

(ii) Most cowl fasteners, locking and latching mechanisms, metal-to-metal hinges for doors and panels and metal-to-metal bearings, provided that the current path is of sufficiently low impedance.

(2) *PROTECTION AGAINST THE ACCUMULATION OF STATIC CHARGES*

(a) *Bonding to main earth systems.* All items which by the accumulation and discharge of static charges may cause a danger of electric shock, ignition of Flammable vapours, or interference with Essential Equipment and Essential Systems (e.g. radio communications, navigational aids, control systems) should be adequately bonded to the main earth systems.

(b) *Intermittent contact.* The design of the rotorcraft should be such as to ensure that no fortuitous intermittent contact can occur between metallic and/or metallised parts.

(c) *Grounding of main earth system.* The main earth system should be connected to ground automatically when the rotorcraft is on the ground. The resistance between the main earth system and the ground, when the rotorcraft is at rest, should not exceed 10 megohms.

NOTE: The resistance should be measured between the main earth system and a metal plate on which the earthing means (e.g. tyre) is resting.

(d) *Filling points.* It should readily be possible to bond refuelling equipment, including the refuelling nozzle, to the rotorcraft and to make the bonding connection before the filler cap is removed. The effectiveness of the bonding connection should be independent of the particular type of refuelling equipment being used.

(e) *Pressure refuelling systems.* Where provision is made for pressure refuelling it should be established, by test, or by consultation with the appropriate fuel manufacturers that dangerously high voltages will not be induced within the fuel tank(s). If compliance with this requirement involves any restriction on the types of fuel to be used, the rate of refuelling or the use of additives, this should be stated in the Flight Manual and placarded at the refuelling point.

(f) With standard refuelling equipment and standard aircraft turbine fuels, voltages high enough to cause sparking may be induced between the surface of the fuel and the metal parts of the tank at refuelling rates above approximately 1136 litres/min (250 gals/min). These induced voltages may be increased by the presence of additives and contaminations (e.g. anti-corrosion inhibitors, lubricating oil, free water), and by splashing or spraying of the fuel in the tank.

(g) The static charge can be reduced in the following ways:—

(i) by measures taken in the refuelling equipment such as increasing the diameter of refuelling lines and designing filters to give the minimum of electrostatic charging,

(ii) by changing the electrical properties of the fuel by the use of anti-static additives and thus reducing the accumulation of static charge in the tank to a negligible amount, and

(iii) by filling each tank from the bottom.

(h) The critical refuelling rates are related to the rotorcraft refuelling installations, and the designer should seek the advice of fuel suppliers on this problem.

(3) *THE USE OF NON-METALLIC MATERIALS RELATIVE TO ATMOSPHERIC ELECTRICAL HAZARDS*

(a) Some of the materials used and possible effects on the rotorcraft and its systems are considered in this paragraph (a).

ACB 29.899(a) (continued)

(i) *Non-conducting materials such as fibre glass or all-plastic honeycomb.* Mechanical damage may be caused to such materials by the passage through them of a lightning strike, with possible resultant effects upon the airframe and on other systems. Loss of the intrinsic screening otherwise provided by a metal airframe should also be considered and the possible interference, by lightning strikes or static discharges with, for example, critical control systems taken into account.

(ii) *Composite materials such as metal-skinned plastic honeycomb or plastic-skinned metal honeycomb.* Effects similar to those in paragraph (i), depending upon the materials used and their location.

(iii) *Carbon (or boron) fibre-reinforced plastics.* Effects similar to those described in paragraph (i) with, in addition, possible severe degradation of the mechanical strength of the material if it is used in such a way as to make it possible for the conducting fibres to carry lightning currents. Present evidence indicates that, in such cases, the material must be protected by a suitable conducting cage.

(iv) *Paint finishes.* Certain paints are particularly good electrical insulators and experience has shown that an appreciable static build up can occur with resultant interference with rotorcraft systems. There are also indications that such paint finishes can affect the path and restrike locations of swept lightning strokes.

(b) *Tests.* Where non-metallic materials are used in such a manner that damage to them from lightning strikes may hazard the rotorcraft, it may be necessary to make high voltage/current tests to give confidence that no hazard will arise. Close attention will be needed both in the design of the airframe and of the system to ensure that electrical interference effects are minimised. Where appropriate, tests may be necessary to ensure that these design aims have been satisfied.

(4) *ESSENTIAL RADIO/NAVIGATION EQUIPMENT.* The following is applicable to the installation of essential radio/navigation equipment in rotorcraft.

NOTE: In the case of rotorcraft fitted with essential radio/navigation receiving or transmitting apparatus an additional reason for bonding is to provide an earth system of low resistance and maximum self-capacity for the efficient operation of the radio/navigation equipment.

(a) The metal frame and mounting structure carrying each radio/navigation unit should be bonded to the main earth by at least one Primary Conductor or its equivalent.

(b) Within a radius of 2·5 m (8 ft) of any unscreened radio/navigation transmitting equipment or its aerial lead, any long electrically conducting parts (including metallic pipe lines, metal braiding and conduit) which are not insulated from earth, should be electrically bonded to the main earth system.

(c) Provision should be made for the bonding of all radio/navigation transmitting and receiving apparatus to the main earth by means of one or more Primary Conductors, or their equivalent. In the case of rotorcraft of non-metallic or composite construction, the main bonding strips should be connected together near these points with Primary Conductors.

ACB 29.899(b) Resistance and continuity measurement

The schedule prepared in accordance with paragraph 29.899(b) should contain the data prescribed in paragraphs (1)(2) and (3).

(1) A description of the measuring apparatus to be used with a statement of the accuracy which is claimed for the equipment.

(2) A description of the method, or methods, to be employed for attachment of the test apparatus to the rotorcraft and its equipment.

NOTE: Where the type of apparatus employed and/or its method of attachment produces test values in excess of those given in Table 1 (ACB 29.899(b)) and Table 2 (ACB 29.899(b)) the background evidence to show the acceptability of such methods should be given.

(3) A detailed list of all points on the rotorcraft, including its equipment, for which measurements are required and for each set of measurements the maximum acceptable resistance. Measurements are required to determine the efficacy of bonding and connection between at least (i) to (vii) of paragraphs (a) and (b).

(a) *Primary bonding.* Typical resistance values for primary bonding are given in Table 1 (ACB 29.899(b));

(i) The extremities of the fixed portions of the rotorcraft,

(ii) the fixed structure and removable external panels,

(iii) The fixed structure and fixed external panels where the method of construction and/or assembly leads to doubt as to the repeatability of the bond,

(iv) The engines and the main rotorcraft earth,

(v) The extremities of fmetal rotor blades or other moveable external surfaces and the main rotorcraft earth,

(vi) The bonding conductors of non-metallic rotor blades or other moveable external surfaces and the main rotorcraft earth, and

(vii) Internal components for which a Primary Bond is specified and the main rotorcraft earth.

(b) *Secondary bonding.* Typical resistance values for secondary bonding are given in Table 2 (ACB 29.899(b));

(i) Metallic parts, normally in contact with Flammable fluids, and the main rotorcraft earth,

(ii) Isolated conducting parts subject to appreciable electrostatic charging and the main rotorcraft earth,

(iii) Electrical panels and other equipment, accessible to the occupants of the rotorcraft, and the main rotorcraft earth, to avoid the danger of electrical shock from circuits of 50 volts (RMS or dc) or more,

(iv) Earth connections, which normally carry the main electrical supply, and the main rotorcraft earth,

(v) Electrical and electronic equipment and the rotorcraft main earth, where applicable, and as specified by the rotorcraft constructor,

(vi) Static discharger wicks and the main rotorcraft structure,

(vii) The main rotorcraft earth system and ground, measured when the rotorcraft is at rest.

ACB 29.899(b) (continued)

(4) *MEASUREMENT OF ELECTRICAL RESISTANCE AND CONTINUITY*

(a) Several methods of measuring low values of resistance are available, but the following three methods are commonly used:—

(i) A bonding tester with integral battery and indicator with voltage and current coils.

NOTE: This instrument is normally supplied with connection leads and prods.

(ii) A double bridge milliohmmeter method using a current of not less than 10 amperes in the bond.

NOTE: Joints should be made using bolted connections.

(iii) Ammeter-voltmeter method using calibrated ammeter and voltmeter and bolted connections or a combination of bolted connections and prods.

(b) Large variations, up to approximately an order of difference, in measured results can be obtained, when measuring the same resistance, depending on the test equipment and connections used. Table 1 (ACB 29.899(b)) and Table 2 (ACB 29.899(b)) which are based on the use of bolted connections, give guidance on the values of resistance which experience has shown to give satisfactory results. Where other methods of attachment are used, which produce higher resistance values, these may be acceptable subject to evidence of their satisfactory use.

TABLE 1 (ACB 29.899(b))
PRIMARY BONDING

Paragraph No.	Condition	Maximum Resistance using Bolted Connections (milliohms)
(3)(a)(i) (ii) and (iii)	Between extremities of the fixed portions of the rotorcraft and between fixed panels and components as specified	1 for light alloy 10 for stainless steel
(3)(a)(iv)	Between engines and rotorcraft earth	1 for light alloy 10 for stainless steel
(3)(a)(v)	Between external components and rotorcraft earth	5 for light alloy 10 for stainless steel
(3)(a)(vi)	Between conductors on external non-metallic parts and rotorcraft earth	5
(3)(a)(vii)	Between internally mounted primary bonded components and rotorcraft earth	2

ACB 29.899(b) (continued)

TABLE 2 (ACB 29.899(b))
SECONDARY BONDING

Paragraph No.	Condition	Maximum Resistance using Suitable Test Equipment (milli-ohms unless otherwise stated)
(3)(b)(i)	Between metallic parts normally in contact with Flammable fluids and rotorcraft earth	10 for light alloy 100 for stainless steel
(3)(b)(ii)	Between isolated conducting parts subject to appreciable electrostatic charging and rotorcraft earth	0·5 megohm or not exceeding 10^5ohm/square surface resistivity for non-conducting surfaces in contact with the metal airframe
(3)(b)(iii)	For the avoidance of electrical shock from equipment which carries 50 volt (RMS or dc) or more	500
(3)(b)(iv)	Main electrical gear connections	50 mV drop for normal currents
(3)(b)(v)	Between electrical and electronic equipment and rotorcraft earth	Where applicable to be specified by the rotorcraft constructor
(3)(b)(vi)	Between static discharger wicks and structure	1000
(3)(b)(vii)	Between rotorcraft earth and ground	10 megohms

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ACB—SUBPART E

ACB 29.901(b)(4) Engine and engine mountings

Where the engine is not in direct electrical contact with its mounting the engine should be electrically connected to the main earth system by at least two removable Primary Conductors, one on each side of the engine. (See ACB 29.899(a).)

ACB 29.901(c) Power-plant systems safety assessment

Part of the safety assessment is a re-assessment of an analysis (which will have been made on the engine in accordance with JAR—E, Chapter C2—2 or C4—2, as appropriate) to take account of the characteristics of the engine as installed in the actual rotorcraft as compared with the typical installation assumed by the engine constructor.

ACB 29.901(e) Incorrect assembly

(1) All Power-plant systems, except those of paragraph (2) should be so designed and constructed that at all reasonably possible breakdown points, it is mechanically impossible to,

(a) assemble control systems to be disastrously out of phase,

(b) assemble control systems so that they operate in the reverse sense,

(c) interconnect the controls of two systems where this is not intended,

(d) interconnect the pipelines of one Powerplant system to those of another Powerplant system or some other system of the rotorcraft.

(2) The recommendations of paragraph (1) need not be applied to systems which,

(a) if assembled incorrectly are unlikely to prejudice the safe operation of the rotorcraft,

(b) are operated before take-off can be commenced, and are of a type where incorrect assembly would be obvious.

NOTE: Such operation before take-off does not include special drills but only those operations which will of necessity be made before a take-off.

(3) All Power-plant systems, the faulty operation of which might affect the continued safe operation of the rotorcraft, should be so designed and constructed as to be mechanically difficult to misconnect or so that misconnection is obvious from the appearance of the system.

ACB 29.901(f) Crash fire hazard

Operation of controls to reduce fire risk in Crash Landing conditions

(1) So far as is practicable means should be provided to enable precautions to be taken against the fire hazard in Crash Landing. The means should normally be brought into action by controls arranged such as to enable the flight crew to operate them:—

(a) with the minimum effort,

(b) with the minimum number of actions, and

(c) with the minimum risk of confusion.

ACB 29.901(f) (continued)

(2) Parts of the installation intended to be brought into use in a Crash Landing should so far as is practicable, be designed, mounted and connected so that the parts will operate satisfactorily in the conditions prescribed in section 29.561.

ACB 29.901(g) Ground and flight testing

The tests required by paragraph 29.901(g) should establish that:—

(1) The engines are free from any operating characteristics which might seriously affect their safe functioning, such as stall, surge, instability, flame-out or excessive turbine entry temperature. If an alternative intake is provided, additional tests should be made to demonstrate compliance with the requirements of this paragraph (1) with that intake in use.

(2) The temperatures of the Power-plant, including engines, components, equipment, liquids, together with nearby structural components are maintained within values established as safe for operation. (See also section 29.1041 for cooling requirements.)

(3) The engine/rotor speed control systems function satisfactorily.

(4) The propellers and their associated control systems function satisfactorily. (See also section 29.1149.)

(5) For system testing on Series rotorcraft the tests on fluid systems should consist of tests at the maximum working pressure on each complete system from which leakage of fluid or vapour could occur.

ACB 29.903(b) Power-unit independence

(1) The requirements of paragraph 29.903(b) are not applicable to a multiple engine failure resulting from non-containment of debris from the failure of any one engine.

(2) With regard to paragraph 29.903(b)(2), throttle movements of other engines, after an engine failure, to make use of contingency ratings, or any other Approved ratings, are acceptable.

ACB 29.903(e)(3) Starting tests

(1) *GENERAL.* Safe starting techniques both on the ground and in flight and appropriate to the range of climatic conditions for which certification is desired should be established and, where necessary, demonstrated by tests.

(2) *LOW TEMPERATURE STARTING.* The minimum oil temperature for safe starting for all grades of oil for which certification is sought should be declared and should be not lower than the minimum oil temperature declared for starting in accordance with JAR—E. Where necessary, the minimum safe starting temperature should be determined by low temperature starting tests which, in the case of piston engines, may involve the determination of oil dilution and "boiling off" techniques.

NOTE: In making tests to determine the minimum oil temperature for starting, the temperature of the engine should normally be equal to that of the ambient air; thus the engine oil temperature quoted as a minimum for starting can be regarded also as the minimum ambient air temperature for starting. However, this will not prevent the starting of engines in lower ambient air temperatures where arrangements have been made for the engine temperature to be not less than the minimum oil temperature established as safe for starting.

ACB 29.903(e)(5) Restarting — Group A Rotorcraft

(1) The purpose of the requirement of paragraph 29.903(e)(5)(ii) is to ensure that the existing hazard is not further aggravated by undue delay in restarting, or inability to restart, the engines.

(2) *ENVELOPE OF ALTITUDE AND AIR SPEED.* For the envelope of altitude and air speed to be acceptable as adequate for the safe operation of the rotorcraft, sufficient flight tests should be made to demonstrate that restarting can be achieved consistently over the range of conditions from sea level to the maximum restarting altitude, in the normal configuration appropriate to the particular phase of flight.

NOTE: Allowance should be made for take-off from high altitude airfields.

(3) *DELAY TESTS.* The tests referred to in paragraph (2) should include the effect on engine restarting performance of delay periods between engine shut-down and restarting of:—

(a) up to 2 minutes, and

(b) at least 15 minutes.

ACB 29.903(e)(6) Restarting

It should be demonstrated in flight that compliance is shown with the recommendations of paragraphs (1) and (2) when restarting engines after a False Start.

(1) That fuel discharged either as liquid or vapour will not create a fire hazard.

(2) The possibility of fuel discharged from the jet pipe, or of exhaust efflux, entering the jet pipe shroud or any part of the airframe such as to cause a fire hazard is precluded.

ACB 29.903(f)(1) Torching flames

Where design precautions to minimise the hazard in the event of a combustion chamber burnthrough involve the use of torching flame-resistant components and/or materials, satisfaction of the standards prescribed in BS 3G100*: Part 2: Section 3: Sub-section 3.13, is acceptable.

ACB 29.907(a) Engine vibration

(1) It should be established that there is no dangerous vibration in the Power-units in the rotorcraft design conditions, including:—

(a) the complete range of rotorcraft speeds, attitudes, altitudes and Power-unit operating conditions, and

(b) all conditions of steady and transient operation on the ground and in flight (including autorotation).

NOTES: (1) Non-critical conditions of operation which need not be considered should be agreed with the Authority.

(2) The vibration survey is complementary to the tests carried out on the engine in accordance with JAR—E, Chapters C4—4 and C4—6.

(2) Compliance with the requirement of paragraph (1) and of paragraph 29.939(b) should be established by one or by a combination of the methods of this paragraph (2).

*Obtainable from the British Standards Institution.

ACB 29.907(a) (continued)

(a) A demonstration:—

(i) that the variation in the engine inlet airflow conditions that would occur in the conditions specified in paragraphs (1)(a) and (b) and in paragraph 29.939(b), and

(ii) the variations in turbine exit conditions that could normally occur in operation, are within the limits established on the particular engine type.

(b) An investigation of the vibration characteristics by the method and of the scope indicated in JAR—E, Chapters C4—4, 3 and C4—6, 3, carried out on a representative installation on the ground using test equipment where the actual conditions of operation in the rotorcraft are reproduced.

(c) An investigation of the vibration characteristics by the method and of the scope indicated in JAR—E, Chapters C4—4, 3 and C4—6, 3, carried out on a representative rotorcraft on the ground and in flight, as appropriate to the conditions being investigated.

(d) The completion of sufficient flying with representative installations, prior to certification, such as to demonstrate that the vibration levels are satisfactory.

(e) Any other method acceptable to the Authority.

ACB 29.907(b) Vibration survey

(1) The vibration survey should cover likely combinations of such conditions as:—

(a) starting and stopping the engine(s) and rotors, at any permissible control setting, on the ground or as applicable in flight,

(b) the most critical cases of clutch, free wheel and rotor brake operation,

(c) rotor out of balance to a value to be agreed with the Authority.

(2) It should be established that the resulting stresses are within satisfactory limits for the materials and particular designs involved.

ACB 29.907(e) Vibration tests

Tests required by paragraph 29.907(e) involving speeds exceeding the declared operating limitations may be conducted on the ground.

ACB 29.908 Cooling fans

(1) Compliance with the requirements of paragraph 29.908(a) may be established by a tri-hub burst containment test.

(2) Compliance with the requirements of paragraphs 29.908(a) and (b) may be established by:—

(a) demonstrating by test that no dangerous resonant conditions can occur in the hub or the complete fan, as appropriate, within the normal range of rpm of the fan, and

(b) demonstrating by test that the hub or the complete fan, as appropriate, can withstand rotation at 1·25 times the fan rpm corresponding, as applicable, to either:—

(i) the declared maximum overspeed for the fan power unit,

ACB 29.908 (continued)

(ii) the Rotor Never Exceed RPM, or

(iii) the operating speed of an overspeed limiting device, whichever is the greater, and

(c) establishing a Safe Fatigue Life of the hub or the complete fan, as appropriate, under suitably factored loads, and

(d) applying to the parts concerned a quality control system which is agreed by the Authority.

ACB 29.917(b) Design criteria

(1) For Group A Rotorcraft:—

(a) Where a time interval is declared, this should be promulgated in the Flight Manual. (See paragraph 29.1583(o).)

(b) The declared time interval commences when the failure symptoms are presented to the flight crew.

(c) After the declared interval the rotorcraft may have to land immediately.

(2) For Group B Rotorcraft, following failure, the rotorcraft may have to land immediately.

ACB 29.917(d) Failure Analysis

(1) The Failure Analysis should be presented in a way which demonstrates a logical appraisal of all conceivable failure modes, and takes account of past experience with similar equipment.

(2) Except as permitted by paragraphs 29.917(b) (4) and (5), the probability of failure should be estimated, having regard to the design features, materials and past experience, as well as experience provided by the development programme.

(3) The Analysis is required down to component level, to identify the following for use in the Safety Assessment:—

(a) All conceivable failure modes for each component.

(b) The expected failure effect for each mode.

(c) The combined effects of consequential failures.

(d) The combined effects of failures where the probability of occurrence of each failure is such that the possibility of a multiple failure has to be considered.

(e) Failures which could be dormant — e.g. involving a hidden malfunction. These will need to be combined with at least one other failure, chosen to represent the worst case, to assess the effect.

(f) The failure modes which could cause Hazardous Effects or Catastrophe.

(g) The predicted rate for each failure mode, or multiple failure which could cause Hazardous Effects or Catastrophe.

ACB 29.954 (continued)

(ii) it should be established that an explosion occurring within the tank would not cause a Catastrophic Effect, or

(iii) where exposed to lightning strikes, the tank wall thickness should be not less than 2 mm (0·08 in). Additionally, the exposed extremities of pod tanks should not contain fuel. The exposed external surfaces of the tanks should be smooth, or

(iv) the exposed ends of pod tanks should not contain fuel and the tanks should be fitted with adequate lightning diverters. In such cases the walls of the tank should be not less than 1 mm (0·04 in) thick.

(c) *External non-metallic tanks.* The exposed ends of pod tanks should not contain fuel and the external surfaces of the tank should be protected by lightning diverters at least to the standard required for non-metallic rotorcraft. (See ACB 29.610(b).) The inside of the tank should be kept as free as possible of metal work and such metal work should be bonded by primary conductors to the main earth system of the rotorcraft. The internal bonding system should be so designed and arranged in relation to the lightning diverters that it will not constitute a path for the discharge in the case of the tank being struck by lightning.

ACB 29.959 Unusable fuel quantity

(1) *ENGINE FEED TANKS.* In tanks which feed fuel directly to the engine, the unusable fuel quantity should be the amount of fuel remaining in each tank when, with all fuel pumps operating, the first evidence of malfunctioning occurs in the conditions of paragraph (3).

(2) *TRANSFER TANKS.* In tanks which transfer fuel to other tanks and do not feed engines directly, the unusuable fuel quantity should be that amount which is not transferable with all pumps operating in the flight conditions in which the fuel transfer is intended to take place.

(3) *CONDITIONS.* The unusable fuel quantity for each tank should be established under the most adverse fuel feed conditions occurring for each intended operational and flight condition involving that tank. The appropriate members of the flight crew should be informed, either by placard or by instructions in the Flight Manual, of the conditions under which the full amount of usable fuel is available.

NOTE: Consideration should be given to the possibility of fuel starvation in all Reasonably Probable attitudes (e.g. after engine failure, or stability augmentation system failure).

ACB 29.961 Fuel system hot weather operation

(1) Where auxiliary tanks are provided which can be used in the climb for direct feed to the engines or for fuel transfer to the main tanks, additional tests may be required to demonstrate compliance with the requirements of section 29.961.

(2) In the case of paragraph 29.961(c)(5), a lower minimum altitude than that required by the Authority to satisfy the requirements of paragraph 29.961(b) may be acceptable.

ACB 29.963(b) Fuel tank crash protection

Fuel tank installations should be such that the tanks will not be ruptured by the rotorcraft rolling over, nor by a collapsed landing gear, nor by a landing gear or engine mounting tearing away.

ACB 29.965(a) Fuel tank tests

The proof pressure tests prescribed in section 29.965 are to be conducted on Prototype tanks. For Series tanks, the drawings should specify that each series metal tank, and each series flexible tank when installed in its compartment on the rotorcraft, should be subjected to a static pressure test of not less than one third of the design proof pressure.

ACB 29.971 Fuel tank sump

The design of flexible tanks should be such as to prevent changes in the shape of the tank in service that would invalidate the provisions of section 29.971.

ACB 29.979 Pressure refuelling systems

(1) It is recommended that pressure refuelling systems, fuel tanks, and the means for preventing excessive fuel pressures, should be designed to withstand steady refuelling pressures of not less than 345 kN/m^2 (50 lbf/in^2) at the coupling on the rotorcraft so as to minimise the possibility of the systems being damaged by use, inadvertently, of ground refuelling equipment capable of higher delivery pressures than those for which the systems have been designed.

(2) Pressure refuelling systems should be arranged so that the fuel entry point is at or near the bottom of the tank so as to reduce the level of electro-static charge in the tank during refuelling.

(3) Discharge pipes should terminate outside the rotorcraft so that fuel cannot be deposited on or in the rotorcraft in such quantities as to constitute a fire hazard.

(4) It should be possible before each refuelling operation to check the functioning of any moving parts of the means provided in accordance with the requirements of paragraph 29.979(b). The design of such parts should be such as to preclude the risk of malfunctioning as a result of ice accretion.

ACB 29.993 Pipelines and fittings

(1) The use of flexible hose clip connections under the conditions of paragraph 29.993(c) is only acceptable when it can be shown that no hazard would result from disconnection.

(2) Inverted U bends should be avoided in pipelines where vapour or air locks may cause malfunctioning of the system.

ACB 29.1001 Fuel jettisoning system

(1) It is recommended that the average fuel jettisoning rate should be not less than 2·5% of the Maximum Weight per minute in the conditions of paragraph 29.1001(a).

(2) Unless otherwise agreed with the Authority the minimum rate of descent required by paragraph 29.1001(a)(2) should be approximately 500 ft/min.

ACB 29.1013(b) Oil tanks — expansion space

(1) When determining the expansion space account should be taken of any provision for oil dilution.

(2) The scavenge oil return to the tank should be arranged to minimise the risk of excessive foaming.

ACB 29.1013(d) Tank vents

(1) Each oil system venting system should be designed and arranged so that in the rotorcraft design conditions there will be:—

(a) no syphoning of oil,

(b) no prevention or restriction of oil flow as a result of aerodynamic suction,

(c) no obstruction of the vents by fluid (including condensed water vapour) or foreign matter when the rotorcraft is in the normal ground attitude or any steady flight attitude.

(2) Tanks, the outlets of which are interconnected, shall have their air spaces interconnected (but see paragraphs 29.1011(a) and (b)).

ACB 29.1015(b) Oil tank tests

The tests prescribed in 29.1015(b) are Prototype tank pressure tests. For Series tank pressure tests, the test pressure and the procedure to be followed should be specified on the appropriate drawings.

ACB 29.1043 Cooling tests

(1) *GENERAL.* Tests should be conducted in accordance with the general provisions of paragraphs (2) and (3) and the test schedules should include the items detailed in paragraphs (4) to (6).

(2) *TEST CONDITIONS*

(a) Tests should not be made in conditions of rain or cloud unless it can be shown that the effect on the test results is insignificant or, alternatively, appropriate corrections to the satisfaction of the Authority can be made.

(b) The initial weight of the rotorcraft during the flight tests should be as near as practical to the maximum permitted and where appropriate by the WAT curve limitations. Weight differences during the tests should be corrected using methods acceptable to the Authority.

(c) The atmosphere temperature conditions in which the tests are made should be as near as practical to the limits of the temperature(s) for which compliance with the cooling requirements is to be shown.

(d) For the purpose of these tests, automatically operated air flow control devices (e.g. oil cooler shutter control) which can affect the cooling should not operate automatically but, where practicable, should be fully open. Such controls should be checked after the test to ensure that the range of automatic operation is adequate.

(e) If adjustments which could affect fuel consumption or cooling are made during the tests, such tests as may be affected by the adjustments should be repeated.

(f) The speed of the rotorcraft may be as high as, but not higher than, the speeds used in determining the corresponding performance in accordance with Subpart B.

(g) *Ground.* Prior to take-off the engines should be run at the lowest speed recommended for running on the ground for 15 minutes or until the temperatures of the engines and equipment are stabilised, whichever is the sooner.

ACB 29.1043 (continued)

(h) *Hover*

(i) Hovering tests should be made in calm air conditions.

(ii) Hovering tests should be commenced with Power-plant temperatures as near as practical to the highest temperatures at which hovering is likely to be commenced in operation.

(j) *Climb*

(i) Wherever possible, climb tests should not be made through inversions of temperature. Where this is not possible, supporting evidence for the correction factors used, should be provided.

(ii) En-route climb should be commenced with Power-plant temperatures as near as practical to the highest temperatures at which en-route climb is likely to be commenced in operation.

(k) *Power offtakes.* Power offtakes such as engine air bleeds, accessory drives, should be at the appropriate maximum for which cooling conditions are critical.

(l) *Propeller conditions.* The propeller conditions for the Critical Power-unit should be agreed with the Authority.

(3) *DATA.* The data of this paragraph (3) appropriate to the type of Power-plant and the type of test should be recorded. Observations should be made and the results recorded at frequent intervals during the climb, and until consecutive readings during level flight indicate that conditions have stabilised.

(a) Weight of the rotorcraft at the commencement of the test.

(b) Outside air and intake air temperature.

(c) Engine and rotor rotational speeds.

(d) Engine induction system manifold pressure.

(e) Engine induction system charge temperature.

(f) Torquemeter reading or parameters from which power/thrust can readily be determined.

(g) Turbine gas temperature or jet pipe gas temperature.

(h) Engine oil pressures — engine and cooler inlet and outlet.

(j) Engine oil temperature — engine inlet and outlet and cooler outlet.

(k) Transmission assembly oil pressures including gearbox and cooler inlet and outlet.

(l) Transmission assembly oil temperatures including gearbox inlet and outlet and cooler outlet.

(m) Cylinder head, and where appropriate barrel temperature, of each cylinder.

(n) Fuel consumption per engine.

(o) Engine fuel pressure — pump inlet, pump delivery and injector inlet.

(p) Fuel temperature at engine-driven pump inlet.

(q) ASIR.

(r) Time of day.

(s) Rotorcraft altitude.

(t) Cooling gill position.

ACB 29.1043 (continued)

(u) Oil cooler flap position.

(v) Magneto temperatures.

(w) Temperatures of surfaces adjacent to the exhaust system and its efflux.

(x) Equipment temperatures.

(y) Engine bay and gearbox bay temperatures.

(z) Any other data which, on a particular rotorcraft, is relevant to cooling.

(4) *PRELIMINARY TESTS.* Prior to the tests, preliminary tests should be made on the ground and where necessary, in flight, in order to establish that the engine systems and all equipment involved in, or subject to, test is functioning correctly.

(5) *GROUND TESTS.* The schedule prepared in compliance with paragraph 29.1043(e) should cover:—

(a) The effect of heat soakage on the temperatures listed in paragraph (3) following engine shutdown, and

(b) sustained engine operation at maximum powers and duration likely to be experienced in service on the ground.

NOTE: The most critical case for engine cooling may not be the most critical for the Transmission System, therefore if the critical case for engine cooling is with the rotor stationary, consideration should also be given to the critical transmission case.

(6) *FLIGHT TESTS*

(a) *General*

(i) Compliance with paragraph 29.1043(e) should include the tests of this paragraph (6) in the appropriate rotorcraft configurations at which the performance of the rotorcraft is established. Observations should be made on the Power-unit(s) shown by preliminary flight tests to be the most critical.

NOTE: The tests of paragraph (6) are based on demonstrations with all Power-units operating and with the Critical Power-unit inoperative. For rotorcraft having three or more Power-units, the need for cooling tests with two Power-units inoperative should be decided in conjunction with the Authority.

(ii) The tests should include the effect of heat soakage on the temperatures listed in paragraph (3) (e.g. following the termination of the climb when engine power is reduced to cruising power).

(b) *Rotorcraft without contingency ratings – all Power-units operating*

(i) *Hover.* Hover for a continuous period of 10 minutes in ground effect or until the temperatures have been stabilised for a period of 5 minutes, whichever is the greater.

(ii) *Initial climb.* Climb for a continuous period of 5 minutes at the maximum rating Approved for take-off.

(iii) *En-route climb.* Climb from 305 m (1,000 ft) at the maximum rating Approved for the climb:—

(A) until the rate of climb has fallen to 30·5 m/min (100 ft/min), or

(B) for 5 minutes after the temperature has stabilised, or

(C) until the maximum certificated operational altitude is reached.

(iv) *En-route cruise.* Fly in straight, steady, level flight at Maximum Weak Mixture Power or maximum rating Approved for continuous use or the power required to reach V_{NO}, as appropriate, until the temperatures stabilise.

ACB 29.1043 (continued)

(A) *Piston-engined rotorcraft.* The altitude should be at or near full throttle altitude for this power. If the full throttle altitude is at or near sea-level, the test should be made at a height as near sea-level as is reasonably possible.

(B) *Turbine-engined rotorcraft.* The altitude should be representative of the normal operating range and should include tests at the upper and lower altitude limits.

(c) *Rotorcraft without contingency ratings – Critical Power-unit inoperative*

(i) *Hover.* Repeat the test of paragraph (6)(b)(i) with the Critical Power-unit inoperative for the maximum duration for this condition.

(ii) *Initial climb.* Climb initially with all Power-units operating at the maximum rating Approved for take-off and simulate failure of the Critical Power-unit immediately after the Decision Point. Continue the climb for a period of 5 minutes with the Critical Power-unit inoperative and the remaining Power-unit(s) at the maximum rating Approved for take-off.

(iii) *En-route climb.* Repeat the test of paragraph (6)(b)(iii) with the Critical Power-unit inoperative.

(iv) *En-route cruise.* Repeat the test of paragraph (6)(b)(iv) with the Critical Power-unit inoperative. The test altitude should be representative of the normal operating range with one Power-unit inoperative.

(d) *Rotorcraft with contingency ratings – Critical Power-unit inoperative*

(i) *Hover.* Repeat the test of paragraph (6)(c)(i) but the maximum duration should not exceed the limitation for use of contingency rating.

(ii) *Initial climb.* Climb initially with all Power-units operating at maximum rating Approved for take-off and then simulate failure of the Critical Power-unit after the Decision Point. Continue the climb with the Critical Power-unit inoperative and the remaining Power-unit(s) at Maximum Contingency Power for 2·5 minutes and then at Intermediate Contingency Power to an altitude 305 m (1,000 ft) above the take-off surface.

(iii) *En-route climb.* Climb from 305 m (1,000 ft) at Intermediate Contingency Power:—

(A) until the rate of climb has fallen to 30·5 m/min (100 ft/min), or

(B) for 5 minutes after the temperature has stablised, or

(C) until the maximum certificated operational altitude is reached.

(iv) *En-route cruise.* Fly in straight, steady, level flight at Intermediate Contingency Power until the temperatures stabilise. The test altitude should be representative of the normal operating range with one Power-unit inoperative.

ACB 29.1103 Induction system ducts

For compliance with paragraph 29.1103(b) where the ducts are subject to the full severity of backfire conditions the strength should be such as to withstand a test pressure of 100 kN/m² (15 lbf/in²). Account may be taken of devices which reduce the severity of backfire conditions.

ACB 29.1141(g) Power-plant controls

For Power-plant controls meeting the requirements of paragraph 29.1141(g) it should not be difficult to operate such controls during and after a fire. Any damage resulting from a fire should not cause any shut-off devices to re-open if this could cause a hazard.

ACB 29.1145 Ignition switches

(1) *FOR PISTON-ENGINED ROTORCRAFT*

(a) Ignition switches provided under paragraph 29.1145(a) for each ignition circuit on each engine should comply with either paragraphs (i) or (ii).

(i) *Toggle type switches.* Toggle type switches should be such that when mounted on a vertical surface, ignition is "off" when the switch is down and "on" when the switch is up.

(ii) *Rotary type switches.* Where a rotary type of combined ignition switch is used, the selection should be clearly marked and the switch should be installed such that it cannot rotate relative to these markings.

NOTE: It is recommended that the selection for both magnetos together should be on the right-hand side of the switch.

(b) Each ignition circuit should be independent of any other rotorcraft electrical system circuit, except for starting circuits and for circuits which may be used with equipment for analysing the operation of ignition circuits. The probability of a Failure in any circuit used for starting or for ignition analysis affecting the ignition circuit should be Remote for a Failure which could affect one Power-unit and Extremely Improbable for a Failure which could affect more than one Power-unit.

(2) *FOR TURBINE-ENGINED ROTORCRAFT*

(a) Where two igniters are provided under paragraph 29.1145(a) for each engine it is recommended that, except possibly for the selector switch, each ignition circuit should be independent.

(b) At least one ignition circuit for each engine should be independent of any other rotorcraft electrical system circuit.

(c) At least one ignition circuit for each engine should be capable of operation in flight independent of the functioning of the main electrical generating system.

ACB 29.1163 Power-plant accessories

(1) The weak link has to be designed to accommodate the highest peak torque; where the torque on the drive varies considerably with rpm, load, acceleration, etc, especially as in the case of electrical accessories, the weak link may not provide an effective safeguard at the normal torque. In such a case, other means of disconnect would have to be provided to permit disengagement of the equipment with the transmission running.

(2) *GROUP 2 EQUIPMENT.* Group 2 equipment should be approved for use on or with the type of engine concerned and should be correctly located and installed (see Section A, Chapter A3—1 Appendix).

ACB 29.1181(a) Piston engine accessory section diaphragm (shoulder cowl)

In order to achieve fire containment as required by paragraphs 29.1181(a), (b) and (c) a diaphragm should be provided in radial air-cooled engine installations to isolate the engine power section and all portions of the exhaust system from the engine accessories section, unless equivalent fire protection can be demonstrated by other means or experience with a similar type of engine has shown this to be unnecessary. This diaphragm should comply with the requirements for firewalls under section 29.1191.

ACB 29.1181(e) Crew drill to combat Power-plant fire

(1) The procedure to be followed by the flight crew in the event of a fire in a main Power-unit should be such that the actions described in paragraphs (a) to (d) are completed in the sequence given as quickly as possible.

(a) Where applicable the stopping of the rotation of the affected engine.

(b) The shutting off of Flammable fluids (including the closing of both the HP and LP fuel cocks on turbine engines) to the affected engine compartment.

(c) Where applicable, the reduction to the minimum of the air flow through the compartment.

(d) The operation of the appropriate extinguishing system.

(2) The number of separate operations which has to be made in accordance with paragraph (1) should be as few as practicable, and, if feasible, accomplished by the operation of a single Operating Control.

(3) It is recommended that placards should be provided giving fire drill instructions for the relevant crew members.

ACB 29.1183(a) Tanks in Designated Fire Zones

(1) Concerning engine fuel drain tanks that may be installed under paragraph 29.1183(a) in a Designated Fire Zone, they should not only be Fireproof, but they should also be explosion-proof.

(2) Small oil reservoirs need only be fire-resistant if the release of oil as a result of damage to the reservoir would not significantly increase the fire risk.

(3) Where necessary, tanks should be adequately vented to the exterior of the rotorcraft by Fireproof vents, and any shut-off devices required by section 29.1189 should be Fireproof and should be mounted on the tank or connected to the tank by a Fireproof line.

ACB 29.1183(c) Structural members inside Designated Fire Zones

Structural members inside Designated Fire Zones should be capable under the conditions of paragraph 29.1183(c) of carrying the loads appropriate to gentle manoeuvres and any superimposed loads resulting from vibration normally experienced in flight. In the absence of further information normal acceleration achieved during flight in which only gentle manoeuvres are made and on which gusty weather is not encountered will not exceed 1·5 g.

ACB 29.1185 Flammable fluids

For fuel and fuel vapour, where there is little or no ventilating air flow, the maximum temperature of an exposed surface for paragraph 29.1185(e) should not exceed 200°C. At higher ventilating air flow rates, a higher temperature limitation may be acceptable, depending upon the installation arrangement.

ACB 29.1187 Drainage and ventilation of fire zones

Where there is a risk of leaking Flammable fluids re-entering the rotorcraft through joints in the cowling or other rotorcraft surfaces, the ventilation of such compartments should, where practical, be arranged to provide an air pressure within the compartment higher than that of the pressure of the ambient air.

ACB 29.1189(b) Means of controlling fuel

(1) The need for shutting off the fuel supply from each tank or group of tanks should be considered, taking into account the general arrangement of the system and the fuel system management procedure.

(2) For Group A Rotorcraft where a minimum flight crew of two or more are required the operating controls for the shut-off means should be so positioned as to be operable by at least one pilot and another flight-crew member or, if no provision is made for the carriage of another flight-crew member, by two pilots, without leaving their seats.

ACB 29.1191 Firewall materials

In complying with the requirements of section 29.1191, the following materials are acceptable:—

(a) stainless steel 0·38 mm (0·015 in) thick,

(b) mild steel 0·46 mm (0·018 in) thick and suitably protected against corrosion.

Other materials may be used provided their suitability can be demonstrated.

ACB 29.1193 Cowlings and engine compartment covering and other surfaces

(1) *REGIONS IMMEDIATELY ADJACENT TO DESIGNATED FIRE ZONES AND ENGINE POD ATTACHMENT STRUCTURES.* In addition to complying with the requirements of paragraphs 29.1183(a) and 29.1181(c) and for Designated Fire Zones, components in regions immediately adjacent to firewalls and in engine pod attachment structures should be of such materials and at such a distance from the Designated Fire Zone that they will not suffer damage that could hazard the rotorcraft if the inner surface of the firewall is enveloped in flames at 1100°C for 15 minutes. In demonstrating compliance with section 29.1193, the area of the firewall adjacent to the critical component should be subjected to flames at a temperature of 1100°C for 15 minutes, using as many standard test torches as is necessary.

(2) Cowlings, and all rotorcraft surfaces near and to the rear of Designated Fire Zones, should be constructed of material at least equivalent in fire-resistance to aluminium alloy (see also paragraph 29.1121(c)).

ACB 29.1193 (continued)

(3) Cowlings, and all other rotorcraft surfaces should be designed and constructed so that fire originating in any Designated Fire Zone cannot re-enter through normal openings or burn through external surfaces of other regions where it could create an additional hazard. Such surfaces that are likely to be subjected to flame should be constructed of or be protected by a suitable heat-resistant material.

(4) Attention is drawn to the need to prevent flames from being sucked into the interior of the rotorcraft through holes.

(5) In deciding the surfaces over which flames might play, account should be taken of the possibility of portions of the cowling being melted.

(6) Account should be taken of the possibility of any discontinuity in the surface over which the flames may pass acting as a flameholder.

(7) Account should be taken for paragraph (3) of the damage that could result from non-containment of engine debris (e.g. punctured cowling or firewall, or local lifting of the cowling allowing fire to spread to other regions of the rotorcraft).

(8) It is recommended that access doors should be provided in engine cowlings to facilitate the use of ground fire-fighting facilities (e.g. fire extinguisher nozzles).

ACB 29.1195 Fire extinguishing systems

(1) *TURBINE ENGINE INSTALLATIONS.* The design, general lay-out and detailed installation of all parts of the fire extinguisher systems should be to the satisfaction of the Authority. The means by which the effectiveness of the systems can be demonstrated should be decided in consultation with the Authority but will normally be confined to the measurement of the rate of discharge of the extinguishant and the distribution of the discharged extinguishant, although in certain circumstances the Authority may require rig tests or a fire tunnel test so as to include the extinguishing of representative engine fires. Each installation should be designed or protected so as to operate satisfactorily under the Crash Landing conditions of paragraph 29.561(b).

(2) The need for a fire extinguishing system in areas immediately adjacent to a Designated Fire Zone should be decided in consultation with the Authority.

(3) The purpose of paragraph 29.1195(e) is to enable the relevant member of the flight crew to delay commencement of the fire drill (and hence stopping the engine) in circumstances when engine shutdown might momentarily be more hazardous than an engine fire.

(4) *ADEQUATE DISCHARGE OF EXTINGUISHANT*

(a) *General.* For the purpose of the requirements of section 29.1195, an adequate discharge of extinguishant is a discharge of extinguishant such as to achieve a concentration not less than the minimum concentration for a period not less than the minimum prescribed period.

(b) *Extinguishant quantity.* (See section 29.1197.) This paragraph (b) describes a method by which the amount of extinguishant necessary for compliance with paragraph (a) may be determined for systems in which the extinguishant is bromochlorodifluoromethane ($CBrClF_2$) where the minimum concentration, by volume, for a period of not less than 2 seconds is 10·5%.

ACB 29.1195 (continued)

(i) The amount of extinguishant needed and the appropriate discharge period should be determined for sea-level conditions from the following formulae:—

(A) *During the period of discharge*

$$C = \frac{B}{A+B}\left(1 - e^{-t(A+B)}\right)$$

where C = concentration of extinguishant by volume at time t,

B = rate of extinguishant vapour discharge in $m^3/s/m^3$ ($ft^3/s/ft^3$) of zone volume,

A = ventilating airflow through the zone in $m^3/s/m^3$ ($ft^3/s/ft^3$) of zone volume,

e = base of Napierian Logarithms (a value of 2·7 may be used),

t = time from start of discharge in seconds.

(B) *After the period of discharge*

$$C = C_{max}\, e^{-A(t - t_{max})}$$

where C_{max} = concentration at end of discharge,

t_{max} = value of t when $C = C_{max}$

NOTE: To obtain the weight of extinguishant required, it may be assumed that, at 0°C at a pressure of $1{\cdot}01325 \times 10^5$ N/m^2 (29·92 in Hg) (1013·2 mbar), the volume of 1 kg (2·205 lb) of bromochlorodifluoromethane is 0·137 m^3 (4·85 ft^3).

(ii) The specified concentration should be reached within 2 seconds.

(iii) *Type of system and distribution*

(A) The amount of extinguishant calculated in accordance with paragraph (b)(i) may have to be increased by a factor dependent upon the method of discharge. The factor will vary between a value of 1·4, if the method of discharge is a single nozzle in a narrow annular zone the length of which does not exceed approximately two diameters, and a value of 1·0 if the method is a suitably routed spray pipe system. The purpose of this factor is to increase the discharge rate; the discharge period should remain unchanged from the original design value.

(B) Discharge nozzles should be located near to ventilating air inlets and, in an annular zone, should be positioned to direct the spray spirally around the zone.

(iv) *Tests.* In assessing the effectiveness of an installed system, in accordance with section 29.1195, the period of specified concentration achieved should be determined.

ACB 29.1203 Fire detectors

(1) It is recommended that where a thermal detector system is used, a continuous type detector, rather than a number of single-point detectors, should be installed.

(2) The fire detection system should indicate a fire within 5 seconds of its ignition and should indicate extinction of a fire within 30 seconds of its extinction.

(3) The location of detector sensing elements should include the main ventilating air exits from each region provided with a detector system.

(4) For paragraph 29.1203(d), it is recommended that it be possible to check the complete system both on the ground and in flight.

ACB 29.1207 Compliance

(1) If in meeting the requirements of section 29.1207 the arrangement of the Power-unit installation is unconventional and there is no previous experience, or there are any unusual design features that might present an increased fire risk and severity, the Authority may require tests to be made on a representative Power-unit installation or, alternatively, on a suitably adapted mock-up version, using a test facility which is capable of simulating, as necessary, the appropriate engine and rotorcraft operating conditions that are likely to be met in service.

(2) *TEST CONDITIONS.* Where tests are prescribed to demonstrate that a component is Fireproof or Fire-resistant, the test conditions shall be those prescribed in BS 3G100*, Part 2, Section 3, Sub-section 3.13.

(3) The Authority may require that where vibratory conditions could be critical, components should be subjected to vibration during flame testing.

*Obtainable from the British Standards Institution.

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ACB — SUBPART F

ACB 29.1301 Equipment installations

(1) Mandatory equipment, systems and installations (i.e. those installed for compliance with the Requirements, or with operational regulations, or those on the proper functioning of which the airworthiness of the rotorcraft may depend) should be such as to ensure that the intended function will be performed safely and reliably even under the most adverse likely operating conditions. To this end, all such equipment, except that specifically exempted by operational regulations should comply with paragraphs (a), (b) or (c):—

(a) it should be Approved by the Authority generally for use on Rotorcraft, or

(b) it should be Approved by the Authority as part of the particular Rotorcraft type, or

(c) it should be Approved by the Authority in relation to the particular Rotorcraft as part of the acceptance by the Authority of the Rotorcraft including the equipment.

(2) In the case of approval in accordance with paragraph (1)(c), the Approved Design and Inspection Organisation (usually the Rotorcraft constructor) should establish that the equipment is suitable for the purpose for which it is installed. The suitability of such equipment (including commercial equipment) should be established by the employment of one or more of the following procedures:—

(a) a detailed examination of the equipment and its design,

(b) suitable testing,

(c) consideration of previous relevant experience.

(3) The Approved Organisation accepting responsibility for equipment Approved in accordance with paragraph (1)(c) should establish satisfactory quality control procedures for series items.

NOTE: See also BCAR Section A, Chapter A3—3 for Approval procedures.

ACB 29.1303(b) Clock

This item does not have to be Approved but is required by operational regulations to be suitable for its purpose and must be installed or carried in any manner which will ensure that it can be used effectively as and when required.

ACB 29.1305(a)(26) Disconnection of defective equipment

See JAR—E, Chapters C2—2, 2.3 and C4—2, 3.1.

ACB 29.1305(c) Audible warning of engine failure

(1) Where the audible warning installed for compliance with paragraph 29.33(e) is also actuated by engine failure, it will be acceptable for compliance with paragraph 29.1305(c)(3).

(2) *ENGINE FAILURE.* (See paragraph 29.1305(c)(2).)

(a) A flashing warning light mounted in such a position that its operation is immediately obvious to the pilot would meet this requirement.

(b) A master visual warning indicator, with individual engine indication on a central warning panel, is also acceptable.

ACB 29.1305(c) (continued)

(3) *VISUAL AND AURAL – INDEPENDENCE.* (See paragraphs 29.1305(c)(2) and (3) and 29.33(e).) If both visual and audible warnings are activated by the same sensor, this sensor should be completely independent of the normal engine power and rotor speed indicating systems. If either of the visual or audible warnings are actuated by the normal engine power and rotor speed indicating systems, the other warning sensor should be completely independent.

ACB 29.1321(a) Instrument indications

Indications given by instruments which provide information on similar subjects should be compatible with each other. This is intended, for example, to prevent duplicate or similar instruments working in opposite senses.

ACB 29.1321(e) Power-plant instruments

Power-plant instruments should be such as to permit, without difficulty, setting and maintenance of engine operating conditions to within acceptable tolerances agreed by the Authority. Due regard should be given to the degree of accuracy attainable in reading the instruments arising from location and size of instruments, fineness of scale of the operating range, parallax, etc.

ACB 29.1323 Pitot-static systems

(1) For Group B Rotorcraft, it is recommended that the pitot-static head should be heated so as to ensure its suitability during short periods of flight in ice-forming conditions.

(2) For paragraph 29.1323(h), tubing with an inside diameter of less than 6·35 mm (0·25 in) will not normally be acceptable.

ACB 29.1329 Automatic pilot system

See ACB 29.672.

ACB 29.1329(c) Attitude controls

The direction of motion, if not obvious, should be clearly indicated on or near the control.

ACB 29.1331(a) Independent source of power supply

It is recommended that, on single-engined Rotorcraft, where a turn and slip indicator is provided in addition to a gyroscopic direction indicator and a gyroscopic bank and pitch indicator, the supply to the turn and slip indicator be independent of the supply to the bank and pitch indicator.

ACB 29.1334 Attitude display systems

(1) This section 29.1334 does not cover head-up display systems. Where it is intended to use such a system, reference should be made to the Authority.

(2) The usable attitude information (see paragraph 29.1334(e)) should be displayed in a position such that it can also be used by the co-pilot. The provision of uninterrupted usable information implies that, when necessary, adequate illumination of the display is also maintained without interruption for the required period.

(3) Compliance with the requirements of this section 29.1334 does not imply that the system is acceptable in its effects on other systems.

(4) The Authority may limit the operation of the Rotorcraft if adequate time is not provided, under paragraph 29.1334(g).

(5) *GENERAL*

(a) For main attitude displays the width of the perceived moveable horizon display should not be less than 76 mm (3 in), except that smaller displays may be accepted subject to a satisfactory flight evaluation.

(b) Means may be provided to adjust the position of the Rotorcraft reference symbol, or the horizon line, but in pitch only, to allow for variations in the Rotorcraft attitude in flight, due to different centre of gravity positions, so that the symbol and line can be aligned during cruising flight. The range of adjustment should be such that hazardous misalignment is not possible.

(c) An acceptable means of compliance with the requirements of paragraphs 29.1334(c) to (f) inclusive, would be the provision of three displays, the reliability and independence of which was shown to be adequate by a suitable assessment, one for each of the two pilots' stations, and a third 'standby' display positioned so that both pilots can use it. Each display should have independent sensors and power supplies. The power supply to the standby display should be such that it will be maintained automatically, in the event of total failure of the main generated electrical power supply, for at least 90 minutes. However, a shorter period, but in no case less than 45 minutes, may be acceptable where it can be shown that the rotorcraft can be landed safely, in all circumstances, within this time. For the purposes of paragraph 29.1334(c), the lower part of the Extremely Remote range should be taken as not greater than 1×10^{-8}.

NOTE: The probability of total loss of attitude indication during flight to the flight crew is required to be in the lower part of the Extremely Remote range, i.e. not greater than 1×10^{-8}. It is considered that such a total loss of information would be potentially catastrophic only when an aircraft was operating in IMC. The probability of being in IMC during flights is considered to be a maximum of 1×10^{-1}. Hence the probability of the total loss of attitude indication to the flight crew whilst in IMC is 1×10^{-9}, i.e. Extremely Improbable.

(d) Where a third 'standby' display is fitted, the instrument should be provided with a failure warning device, e.g. a warning flag which should indicate loss of power supply or significant wheel speed deviation. For two-pilot operation the warning should be visible to both pilots.

(e) The standby display should be similar in presentation to the other displays except that it may be smaller, with a width of perceived moveable horizon display of not less than 50 mm (2 in).

(f) When making the assessment required by paragraph 29.1334(d) it should be established that the provision of Rotorcraft attitude retention by means of an automatic flight control system using the same attitude sensor information does not introduce any greater degree of hazard.

ACB 29.1334 (continued)

6 *DISPLAY CHARACTERISTICS*

(a) Each display should function correctly over a range of ±120° in roll and ±80° in pitch.

(b) The following graduation intervals are acceptable:—

Pitch: 20° nose up to 20° nose down: every 5°.

Beyond this range: at least one numbered graduation to be in view at any attitude but without unnecessary clutter.

Roll: 0° to 30°: every 10°
30° to 90°: every 30°.

Sufficient pitch graduation intervals should be numbered and in such a way as to ensure ready and correct identification.

(c) Where it is considered necessary to add wording to displays the wording should be agreed with the Authority.

ACB 29.1335 Flight director systems

(1) A satisfactory method of meeting the requirements of section 29.1335, is to ensure that no single fault will affect both the flight director system and that system (or instruments) to which the pilot would turn to avoid danger. Additionally, where a fault analysis shows that the inherent characteristics of the flight director system are such that a fault liable to mislead the pilot dangerously could occur, then fault indicating devices (e.g. warning flags) should be incorporated.

(2) The phrase "flight director systems" is used to distinguish those systems where:—

(a) the discerning devices are remote from the indicator, and/or

(b) the outputs of the discerning devices are modified by other signals, from those simple instruments where the discerning device and the indicator are intimately associated.

ACB 29.1351(b)(5) Generating system

The means of disconnection required by paragraph 29.1351(b)(5) should be accessible to the appropriate flight-crew members in their normal seated positions.

ACB 29.1353(a) Electrical equipment and installations

The possible sources of interference to be considered should include:—

(1) conducted and radiated interference caused by electrical noise generation from apparatus connected to the busbars,

(2) coupling between electrical cables or between cables and aerial feeders,

(3) malfunctioning of electrically-powered apparatus,

(4) parasitic currents and voltages in the electrical distribution and earth systems, including the effects of lightning currents or static discharge,

(5) difference frequencies between generating or other systems, and

(6) the requirements of section 29.1309 should also be satisfied.

ACB 29.1355(b) Distribution system

The arrangement, protection and control of the feeders from the busbars to the distribution points, and the divisions of loads among the feeders, should be such that no single fault occurring in any feeder or associated control circuit will hazard the Rotorcraft.

ACB 29.1357(a) Circuit protection devices

No hazard should result from the effects of variations in ambient temperatures on either the protective device or the equipment it protects.

ACB 29.1359 Electrical system fire and smoke protection

The requirements of section 29.1359 and those of section 29.863 applicable to electrical equipment, may be satisfied by the following:—

(1) Electrical components in regions immediately behind firewalls and in engine pod attachment structures should be of such materials and at such a distance from the firewall that they will not suffer damage that could hazard the rotorcraft if the surface of the firewall adjacent to the fire is heated to 1100°C for 15 minutes.

(2) Electrical equipment should be so constructed and/or installed that in the event of failure, no hazardous quantities of toxic or noxious (e.g. smoke) products will be distributed in the crew or passenger compartments.

(3) Electrical equipment, which may come into contact with Flammable vapours should be so designed and installed as to minimise the risk of the vapours exploding under both normal and fault conditions. This can be satisfied by meeting the Explosion Proofness Standards of draft ISO document TC20/SC5/N43, dated 1974.

ACB 29.1360(a) Precautions against injury (shock)

(1) Where there may be a hazard during maintenance or servicing, rotorcraft panels etc., carrying voltages of above 50 V RMS, should be marked with the voltage.

(2) Where socket outlets are provided, e.g. for electric razors, these should be labelled as to use and with the output voltage or voltages. Where the output voltage exceeds 100 volts dc and/or 50 volts ac RMS either the output should be electrically isolated from the rotorcraft structure, or means should be provided to prevent inadvertent contact with live parts.

ACB 29.1360(b) Precautions against injury (burns)

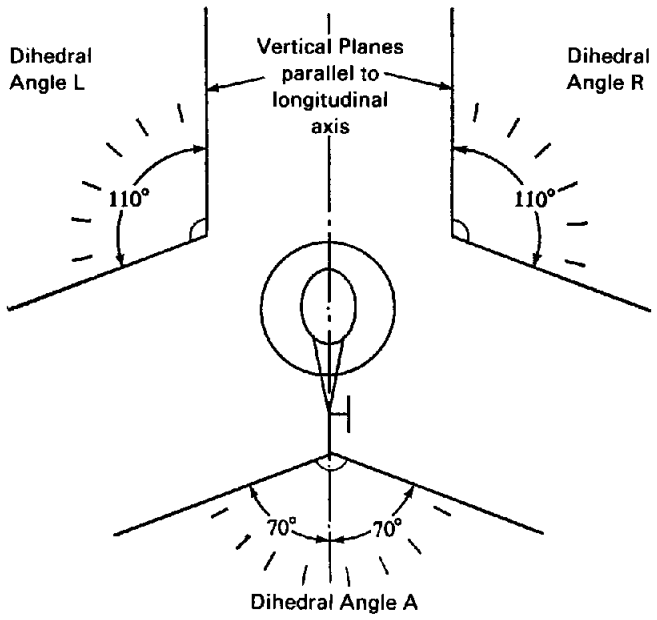
(1) For equipment which has to be handled during normal operation by the flight or cabin crew, a temperature of 20°C above the ambient temperature should not be exceeded. For other equipment, mounted in parts of the rotorcraft normally accessible to passengers or crew, or which may come into contact with objects such as clothing or paper, the surface temperature should not exceed 100°C, in an ambient temperature of 20°C.

(2) The heating surfaces of properly installed cooking apparatus are excluded from the requirements of paragraph 29.1360(b).

(3) The provision of guards around hot surfaces is an acceptable method of complying with the requirements of paragraph 29.1360(b).

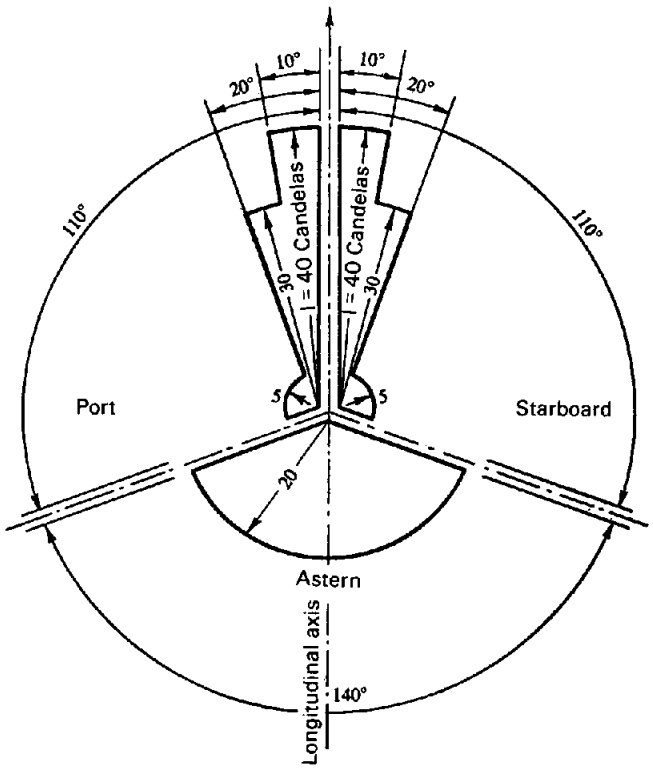
ACB 29.1387 Navigation lights — dihedral angles

The following diagram is presented for guidance.



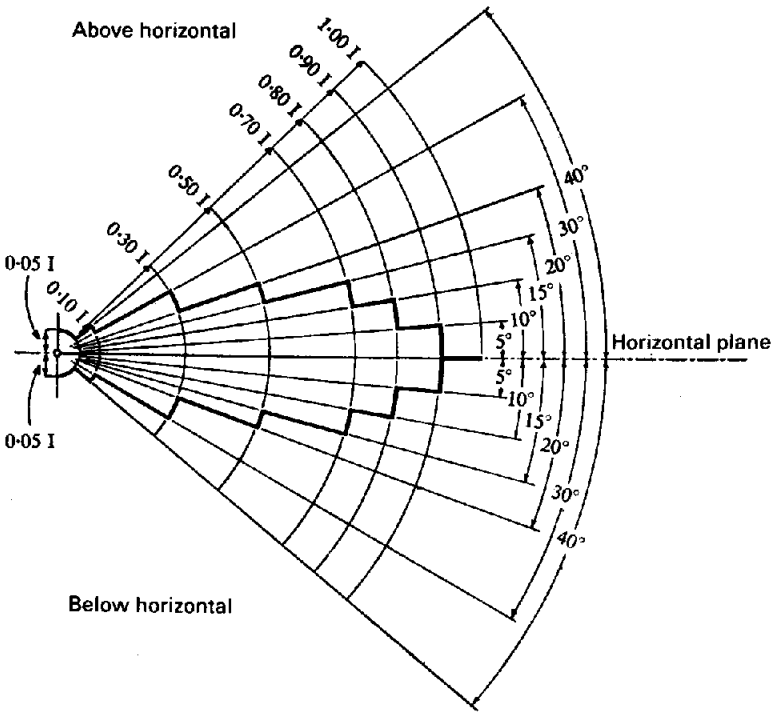
ACB 29.1391 Minimum intensities in horizontal plane

The following diagram is presented for guidance.



ACB 29.1393 Minimum intensities in vertical plane

The following diagram is presented for guidance.



ACB 29.1411(d) Liferaft

(1) *LOCATION.* For rotorcraft carrying more than 19 occupants, it is recommended that liferafts be mounted either externally, or on the ditching emergency exit doors, such as to minimise the physical effort required to release and launch them from either inside or outside the rotorcraft.

(2) For paragraph 29.1411(d)(3), sea state and wave steepness, as defined in ACB 29.801(c) are the most significant parameters for ditching considerations. The associated wind speeds also need to be taken into account in respect of launching and boarding liferafts.

(3) It is recommended for paragraph 29.1411(d)(5)(iv) that release means, on the outside of the Rotorcraft and likely to be accessible to survivors in the water, be provided.

(4) For paragraph 29.1411(d)(8)(i) a suitable line which can be attached to the Rotorcraft prior to launching is provided as part of the liferaft.

ACB 29.1415 Ditching equipment

(1) Detailed liferaft specifications are contained in CAA Airworthiness Division Specification No. 2, Inflatable Liferafts, obtainable from the Civil Aviation Authority, Printing and Publication Services, Greville House, 37 Gratton Road, Cheltenham, Glos GL50 2BN.

(2) Single-seat liferafts which might be provided for crew should not be taken into consideration for paragraph 29.1415(b)(1) when passengers are carried.

(3) The effects of wind on the liferaft with any inflatable canopies erected should be taken into account when deciding the breaking strength and length of the line required by paragraph 29.1415(b)(2).

ACB 29.1416(d) Stability

(1) Paragraph 29.1416(d)(i) may be demonstrated by means of model tests in representative sea conditions. Limitations on the range of sea states regarded as acceptable may need to be included in the Flight Manual.

(2) For paragraph 29.1416(d)(ii), for subsequent salvage purposes, consideration should be given to providing continued stability of the Rotorcraft with the weight and centre of gravity combination which would exist after evacuation of the occupants.

ACB 29.1416(g)(3) Inflation

(1) Paragraph 29.1416(g)(3)(i) will normally require two fully independent systems for initiating inflation and the interconnection of all inflation systems. For example, if initiation is by water contact, a pilot-operated back-up system will be requried.

(2) For automatically-inflating systems a disarming system, if used only above a certain air speed or height, could satisfy the requirement of paragraph 29.1416(g)(3).

(3) It is recommended that, for Group B Rotorcraft in complying with paragraph 29.1416(g)(3)(v), the time of inflation, from initiation to neutral buoyancy, should not be more than 2·5 seconds.

ACB 29.1435(a)(2) Strength

(1) *GENERAL*

(a) The strength requirements are based on the following limit pressures:—

Pw The maximum steady pressure permitted by the limiting means required by paragraph 29.1435(a)(4) within the design tolerances, or any higher pressure that the designer may declare.

Pr The maximum steady pressure permitted by any pressure-relief means provided in compliance with paragraph 29.1435(a)(4) within their design tolerances.

(b) Where any part of the system is subject to fluctuating or repeated external or internal loads, due allowance should be made for fatigue.

(2) Such deformation or leakage referred to in paragraph 29.1435(a)(2) as might directly prevent the operation of any part, or would in the course of one flight be likely to render the system inoperative will be regarded as ultimate failure.

ACB 29.1435(a)(8) Abnormally high temperatures

It is recommended that, in achieving compliance with paragraph 29.1435(a)(8), reliance should not be placed upon a simple pressure-relief device. Experience gained from hydraulic pumps which have failed to off-load and thereafter delivered maximum flow at maximum pressure, shows that the resultant temperature rise across the pressure-relief valve can produce fluid degradation and a potentially serious fire hazard, depending upon the type of fluid being used. This may also affect the integrity of items such as joints, seals and flexible hoses.

ACB 29.1435(a)(9) Filters

The capacity of filters should be such as to prevent the need for frequent filter inspections and cleaning.

ACB 29.1435(b) Tests

(1) The representation of external loads for fatigue testing and the extent of testing to the ultimate pressure should be to the satisfaction of the Authority.

(2) It is recommended that all prototype flexible pipes, couplings and components containing compressed gas should be tested under hydraulic pressure to at least 100% of the ultimate design pressure.

(3) The tests required for each system, which should give due regard to its characteristics and conditions of operation should be specified by the designer, and should include proof pressure tests of each system at a pressure equal to at least Pr.

(4) The designer should specify the tests necessary for series components, pipes and couplings and these tests should be to the satisfaction of the Authority.

(5) All pressure-regulating and relief devices will require testing at their functioning pressure. Also, unless shown to be unnecessary, all lengths of piping should be tested, in finally assembled condition, to their proof pressure.

(6) All complete series systems should be tested at the working pressure for leakage and correct functioning.

ACB 29.1435(d) Hydraulic fluids

(1) The fluid chosen for use in the system should:—

(a) be established as suitable for use under the ranges of conditions in which the Rotorcraft may be operated;

(b) be to an Approved specification; and

(c) be specified in the appropriate manual required by BCAR Section A, Chapter A6—1.

(2) If the fluid is noxious to human beings when liberated in any form, the installation should be so arranged that the fluid cannot enter personnel compartments in the event of leakage or spillage.

(3) If the fluid is not harmful to human beings when liberated in any form the installation should be such that in the event of leakage the fluid, especially in the form of a spray or mist, will not interfere unduly with the flight crew when carrying out their normal duties.

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ACB—SUBPART G

ACB 29.1518 Automatic flight control and stability augmentation system limitations

(1) Except for the case specified in paragraph (2) the minimum permissible height above terrain for use of the automatic system should be equal to twice the height lost as a result of the most critical malfunction of the automatic system.

(2) When approval is required for an automatic approach system or an automatic system coupled to ground radio installations, the minimum height for operation of the automatic system should be related to the approach aiming point elevation. This minimum height should be such that, following the most critical malfunction of the automatic system to be considered, the height above terrain remaining after recovery from the malfunction would not be less than half the minimum permitted height.

ACB 29.1533(c) Interrelated limitations

(1) Paragraph 29.1533(c) refers to paragraphs 29.1505(a), 29.1521(k), 29.1509, 29.1533(a) and (b).

(2) In deciding whether a proposed set of such limitations is acceptable, account should be taken of the presence of any characteristics or devices giving reliable, clear and sufficiently early warning that dangerous conditions are being approached. Account should also be taken of the safety margin allowed by the limitations and the nature of the hazard involved.

ACB 29.1533(d) Miscellaneous limitations

Flight trials covering reasonable ranges of conditions in respect of the items in paragraph 29.1533(d) will be required: provided, however, that reasonable ranges of conditions are covered the choice of the exact ranges will be left to the Applicant.

ACB 29.1541 General

(1) It is recommended that, wherever possible, markings and placards should be in the form of engraved metal or plastic labels.

(2) Markings and placards should be as close to the related feature as is practical.

(3) Information conveyed by markings and placards should be presented as briefly as possible and with maximum clarity. Terminology should as far as is possible, be standardised.

ACB 29.1543 Instrument markings — general

(1) No placard should be positioned such that it reduces the readability of the instrument.

(2) When the limitations to be presented are of such complexity that the significance of markings is unlikely to be quickly apparent to the flight crew, the limitations may, with the agreement of the Authority, be presented in the form of placards.

ACB 29.1545 Airspeed indicator

Other speed limitations established in accordance with this Subpart (e.g. V_{DF}, V_{LO}) should be placarded or provided in a suitable form.

ACB 29.1559 Limitations placard

The placard required by section 29.1559 should state:—

(1) the type of operation (e.g. day or night) for which the rotorcraft is approved to be used, drawing attention, where necessary, to the need for the required equipment to be installed for such operations, and

(2) the type of operation (e.g. flight in icing conditions) for which the rotorcraft should not be used.

ACB 29.1581(a) General — furnishing information

(1) BCAR Section A, Chapter A6—1 prescribes the division of responsibility between the Authority and the Applicant for the production of Flight Manuals and details appropriate administrative procedures.

(2) The Flight Manual may be included as part of the Crew Manual required by BCAR Section A, Chapter A6—7 (which contains material not prescribed by section 29.1581 and which is not Approved by the Authority).

(3) Normally no material need be included in the Flight Manual if, beyond reasonable doubt, it can be assumed to be knowledge common to the flight crew who will be entitled by their licences to operate the rotorcraft.

(4) The Flight Manual should be provided with a protective cover, except when it forms part of another manual. The binding should be such that pages are unlikely to be inadvertently detached, and such that amended pages can be inserted.

(5) The Flight Manual approved by the Authority should indicate this fact on each page together with the date of issue of the page. Also, the Flight Manual should be identified by a reference number which will be appropriate only to that particular Manual; this reference number should appear on every page.

(6) The method of reproduction adopted should be such as to provide good quality text and graphs, with minimum distortion of graphs and minimum variability in legibility and contrast between pages.

ACB 29.1581(b) Approved information

(1) *INCLUSION OF FLIGHT MANUALS IN ANOTHER MANUAL.* When this alternative is adopted and the Maximum Weight of the rotorcraft does not exceed 2730 kg (6000 lb) it is recommended that such a manual be called the "Owner's Manual". This title should appear on the front page followed by a note to the effect that it incorporates the approved Flight Manual and stating which parts comprise the Flight Manual. When the Maximum Weight exceeds 2730 kg (6000 lb) it is recommended that the title "Flight Manual" be retained and that a note be put on the front page that the Manual includes certain unapproved information and instructions.

(2) *SIZE.* For standardisation with other manuals, A4 size paper should be used (210 mm x 297 mm). For small rotorcraft in which stowage space for documents is limited, a size more convenient to the pocket may be selected.

ACB 29.1581(b) (continued)

(3) *REPRODUCTION.* Graphs should be printed on a right hand page; text associated with a graph should, where practical, appear on the left hand facing page. Where a number of graphs form a series and are likely to be used successively in a calculation, the same scales should be used.

NOTE: It is recommended that an offset-lithographic process or one of similar quality should be used.

(4) *CONTENTS*

(a) When the contents of the Manual consist of more than ten pages, each Section of the Manual should commence on a right hand page, and Sections should be separated from one another by divider cards. These cards should each be identified by a tab with the name of the Section printed on it. The card and tab for the Emergency Procedures should be coloured red.

(b) When the Manual forms part of another manual or when it includes unapproved portions not prescribed by this Section, other Sections may be included but the following order should be used:—

Section 1 — General

Section 2 — Design Features

Section 3 — Limitations

Section 4 — Emergency Procedures

Section 5 — Normal Procedures

Section 6 — Performance

Section 7 — Supplements

(5) *AMENDMENTS.* Provision should be made for the incorporation of amendments. Amendments should be effected by the provision of revised or additional approved pages. The amendment number should be shown on each page affected by the amendment. Where the Manual consists of less than ten pages amendment may be made by a complete re-issue of the Manual.

(a) When it is likely that the Manual will require frequent amendment, an explanation should be given of the system that will be used e.g. temporary revisions or advance amendment bulletins. Divider cards etc., should also be included.

ACB 29.1581(e)(1) Flight Manual — General Section

The General Section of the Flight Manual should contain the following items, except for any item that is incorporated in another manual of which the Flight Manual is part:—

(1) A front page which includes, or incorporates provision for, the following:—

(a) The official designation of the rotorcraft.
NOTE: A type name will only be acceptable if this has also been used consistently in other official documents such as the Certificate of Airworthiness and Certificate of Registration.

(b) Registration marks.

(c) The constructor's serial number.

(d) The name of the designing company, and (if different) the name of the constructor.

(e) The number and date of issue of the associated Certificate of Airworthiness.

(f) The date of the initial approval of the Flight Manual and the name of the Authority which approved it.

ACB 29.1581(e)(1) (continued)

(g) A statement as follows:—

"This rotorcraft shall be operated in accordance with the limitations in Section 2 and any additional limitations in the Supplements contained in Section 6."

NOTE: For Flight Manuals included as part of another document the references to the Sections will have to be altered accordingly.

(2) A Table of Contents.

(3) A description of the amendment system, together with amendment record sheets.

(4) A general arrangement drawing to a stated scale giving three views of the outline of the rotorcraft, together with the principal dimensions relevant to handling in flight and on the ground.

(5) A graph showing the relationship of air temperature to pressure altitude in the ICAO International Standard Atmosphere, if reference is made in the Flight Manual to this atmosphere.

(6) Conversion of graphs or tables where additional units are given in accordance with paragraph 29.1581(f).

(7) Definitions, as appropriate, of the following terms:—

(a) Air Temperature

(b) Altitude

(c) Gradient

(d) Gross Performance

(e) Height

(f) Decision Point (Group A)

(g) Net Performance

(h) Air speeds, EAS and IAS

(j) Take-off Safety Speed, V_2

(k) Any other term or abbreviation used in the Flight Manual which may not be generally understood.

NOTE: The definitions should, where possible, be based on those contained in BCAR 29-1.

ACB 29.1581(e)(6) Flight Manual — Supplements Section

(1) The Supplements Section of the Flight Manual should contain, in the form of Supplements, information applicable to any particular feature or use of the rotorcraft which is not covered by the information and data included in the Flight Manual, (e.g. carriage of external loads; flotation equipment).

NOTES: (1) It is the intention that the Flight Manual of each particular rotorcraft should include only those supplements which apply to it.

(2) When weight and balance data are required to be included in the Flight Manual (see BCAR Section A, Chapter A5—1) they should be included in Section 6 as a Supplement.

(2) Each Supplement should describe the specific feature or use of the rotorcraft to which it is related and should list any additions to, or revision of, the scheduled information and data which have to be observed in the particular circumstances.

(3) The material contained in a Supplement should comply with the relevant requirements of sections 29.1581 through 29.1589.

ACB 29.1581(e)(6) (continued)

(4) An illustration of an acceptable method of presenting a Supplement is shown below:—

NOTE: It is recommended that amendments to Supplements be usually effected by a re-issue of the complete Supplement.

SPECIMEN SUPPLEMENT

Flight Manual Ref. No. 1234 CAA approved 1.4.74

AERIAL CRANES LTD.

Supplement No. 3

EXTERNAL FREIGHT LIFTING EQUIPMENT

INTRODUCTION

When ACL Modification No XY99 is installed on Bordair Model 67 helicopters, this supplement must be included in the Flight Manual. The freight lifting equipment consists of a frame and hook assembly, eletrical and manual release systems, and attachments. An elastic shock cord is attached to the freight hook, which provides automatic stowing when the hook is not in use.

SECTION 2 LIMITATIONS

TYPES OF OPERATION

1 The helicopter shall be flown solely for aerial work when loads are carried on the freight hook, and no passengers shall be carried unless directly concerned with the freight-carrying operation.

2 The load carried on the hook shall not exceed 600 kg.

3 The load carried shall not touch any part of the helicopter structure.

4 For those types of load which may cause significant changes in the flight characteristics of the helicopter/load combination from those which have been demonstrated previously as being satisfactory, the operator must conduct flight checks in order to determine the conditions within which such loads may be carried safely.

Such flight checks, which should take place in an environment free from third party hazard, are required to ensure that the following manoeuvres can be performed safely.

(a) The picking up of an external load.

(b) Turns in the hover to ensure that adequate directional control is available.

(c) Transition from the hover.

(d) Level flight and turns at an airspeed not less than that required during the proposed operation.

(e) Return to the hover and release of the load.

PLACARDS

The following placard must be placed in a prominent position near to the freight hook—

"THE MAXIMUM LOAD APPROVED ON THIS HOOK IS 600 kg."

SECTION 3 EMERGENCIES

In the event of failure of the electrical release device, pull the mechanical release handle, marked "EMERGENCY CARGO RELEASE", fully backwards to release the load.

In the event of engine failure, the load must be jettisoned before an autorotative landing is made.

ACB 29.1581(e)(6) (continued)

SECTION 4 NORMAL PROCEDURES

BEFORE PICKING UP LOAD

1 Cargo Hook Release circuit breaker — IN

2 Cargo Release Switch — ON

RELEASING LOAD

Depress cargo release push button located on the pilot's cyclic control grip.

NOTE: The mechanical release will function regardless of the Cargo Release switch or circuit breaker position.

GROUND CREW INSTRUCTIONS

Instruct the ground crew member to discharge helicopter static electricity, before attaching a load in the hover, by touching the airframe with a ground wire, or the hook up ring if a metal sling is used.

SECTION 5 PERFORMANCE

See Section 5 of basic Flight Manual.

ACB 29.1581(f) Units

(1) *UNITS.* The following units should be used in the Flight Manual.

(a)	Horizontal distance — large	... nautical miles (n miles)
(b)	Horizontal distance — small	... metres (m)
(c)	Speed	... knots (knots)
(d)	Temperature	... degrees Celsius (°C)
(e)	Vertical distance	... feet (ft)
(f)	Weight	... kilograms (kg)

(2) CONVERSION GRAPHS AND TABLES

(a) In addition to the system of units prescribed in paragraph (1) it is recommended that unless dual scales are used throughout, the following conversions be supplied either in graphical or in tabular form:—

kilograms	to pounds
knots	to miles per hour, to kilometres per hour
degrees Celsius	to degrees Fahrenheit
feet	to metres
nautical miles	to kilometres

ACB 29.1581(f) (continued)

(b) The method in Figure 1 should be used for showing more than one scale on a graph.

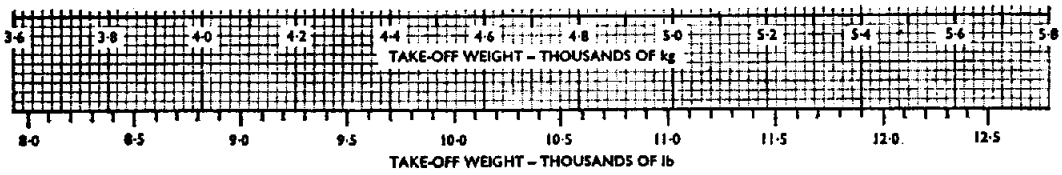


FIGURE 1 METHOD OF SHOWING MORE THAN ONE SCALE ON A GRAPH

ACB 29.1583(c)(2) Baggage and freight loading

(1) If necessary, the limitations required by paragraph 29.1583(c)(2) may be shown on a diagram or graph.

(2) For the limitations of paragraph 29.1583(c)(2) only structural considerations need be taken into account. Balance considerations will be the subject of loading instructions provided in accordance with BCAR Section A, Chapter A5—1.

ACB 29.1583(i) Ambient temperature

Where the fitting of any device (such as a radiator blanking piece) is necessary for operation below certain air temperatures, a statement to that effect should be furnished.

ACB 29.1583(j) Number of occupants

The maximum number of occupants limitation should be expressed as follows:—

"The total number of persons carried including crew shall not exceed X or the number of seats which are approved for use during take-off and landing. Children under the age of three years carried in the arms of passengers need not be included in the total".

ACB 29.1585(a) Flight Manual — procedures

(1) *GENERAL.* In order to assist the flight crew to follow the procedures contained in the Flight Manual, capital letters should be used to correspond with the marked position of the switch or control in question. The names by which switches or controls are identified should be the same as the marking in the rotorcraft. For example the procedure:—

"HP fuel valve: START" means that the control marked "HP" should be moved to the position marked "START".

(2) *NORMAL AND EMERGENCY PROCEDURES.* In addition to the procedures described in paragraph 29.1585(a) the Flight Manual should include any procedure which is recommended in the event of malfunctioning of any part of the rotorcraft which is not considered to be serious enough to be classified as an Emergency.

ACB 29.1585(a) (continued)

(3) *CARRIAGE OF EXTERNAL LOADS.* The following information applicable to the carriage of external loads should be incorporated into the Flight Manual:—

(a) The class of rotorcraft/load combination which has been Approved.

(b) All operating limitations applicable to the class, including:—

(i) the maximum weight of external load,

(ii) the maximum air speed established in accordance with section 29.252 and

(iii) the normal and emergency procedures.

(c) Any information on particular handling qualities or other techniques applicable to operating particular rotorcraft/load combinations.

(d) Advice regarding precautions against static electricity discharges when operating Class B combinations (in relation to ground personnel).

(e) A maximum windspeed for any particular type of rotorcraft/load combination may need to be determined.

(f) Any other information essential for safe operation.

ACB 29.1587 Performance information

This ACB provides guidance material for the Performance Section of the Flight Manual for Group A and B rotorcraft.

(1) *GENERAL.* This Section should contain the performance information derived in accordance with Subpart B of BCAR 29. The information should cover the ranges of weight, altitude, temperature and wind conditions selected in accordance with the Performance Sections of Subpart B.

(2) *PRESENTATION OF GRAPHS*

(a) Graphs should be drawn in a clear and unambiguous manner.

(b) The scales used in the graphs should be the largest permitted by the size of the paper remaining after suitable allowance has been made for margins, consistent with ease of interpolation.

(c) Except where the interpretation is obvious, the manner in which each graph is to be used should be illustrated by means of an example shown on the graph with broken lines. An explanation should also be given when two or more graphs are to be used in a calculation.

(d) The configurations and conditions which are associated with each graph should be stated either on the graph or on the left hand facing page.

(3) *GROUP A ROTORCRAFT.* The Performance Section of the Flight Manual for Group A rotorcraft should be presented in accordance with the general requirements of paragraphs (1) and (2) and the detailed requirements of this paragraph (3).

(a) *Method of scheduling data*

(i) The information should be presented in graphical form with supporting text which should include an explanation of the use of the graphs and examples of typical calculations.

(ii) Each Sub-section should contain information appropriate to all the alternative powers and configurations which are approved for the rotorcraft.

ACB 29.1587 (continued)

(b) *Sub-division of the Section.* The Section should be divided into Sub-sections as follows:—

Number	Title
5.1	General
5.2	Take-off Procedures and Speeds
5.3	Take-off and Landing WAT Curves
5.4	Take-off and Landing Climb Gradients
5.5	Take-off Spaces and Areas
5.6	Net Take-off Climbout Path
5.7	En route
5.8	Landing Procedures and Speeds
5.9	Landing Spaces
5.10	Gross Performance Data

(c) *Sub-section 5.1 – General.* This Sub-section should include the items prescribed in paragraphs (i) to (v).

(i) Representative cruising true air speeds (see paragraph 29.1587(a)(7).)

(ii) The type of engines and, if appropriate, the type of propellers for which the performance is valid.

(iii) A statement indicating whether the performance information in the Flight Manual may be extrapolated or not and the extent, if any, of the extrapolation permitted.

(iv) Graphs to enable speeds when expressed in IAS to be corrected to EAS. These should take into account the effects of rotorcraft attitude and flight conditions, if significant. An example of a graph for the correction of IAS to obtain EAS is shown in Figure 1. This Figure illustrates a case where the differing effects resulting from climb, level flight and autorotation have been taken into account.

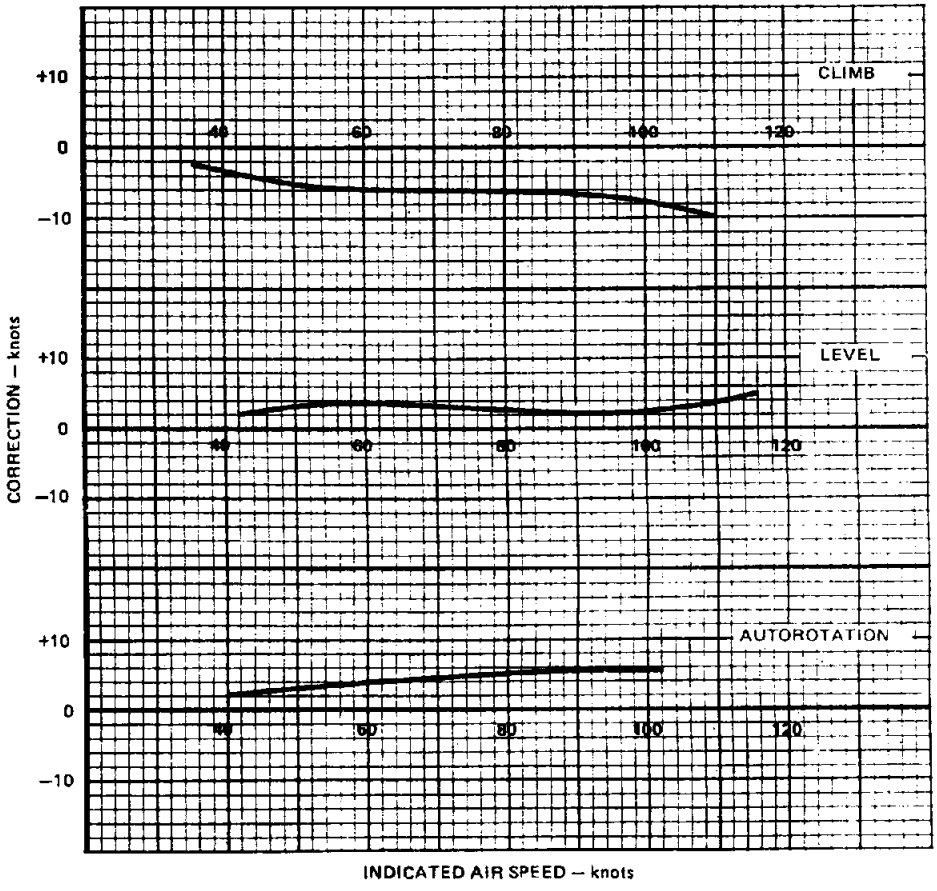


FIGURE 1 POSITION ERROR CORRECTION TO INDICATED AIR SPEED (IAS)

ACB 29.1587 (continued)

(v) A statement of the maximum value of the static error correction to be applied to the altimeter reading, or a graph showing variations.

(d) *Sub-section 5.2 – Take-off Procedures and Speeds.* This Sub-section should include the items prescribed in paragraphs (i) to (iii).

(i) The recommended procedures and speeds required to enable the take-off performance to be achieved.

(ii) A statement of the Critical Power-unit, if any.

(iii) A statement of the maximum cross-wind component for take-off. This component should be appropriate to a wind speed measured at a height of 10 m.

(e) *Sub-section 5.3 – Take-off and Landing WAT Curves.* This Sub-section should include the Take-off and Landing WAT Curve for each take-off configuration derived in accordance with section 29.67. An example of the graphical presentation of the Take-off and Landing WAT Curve is shown in Figure 2.

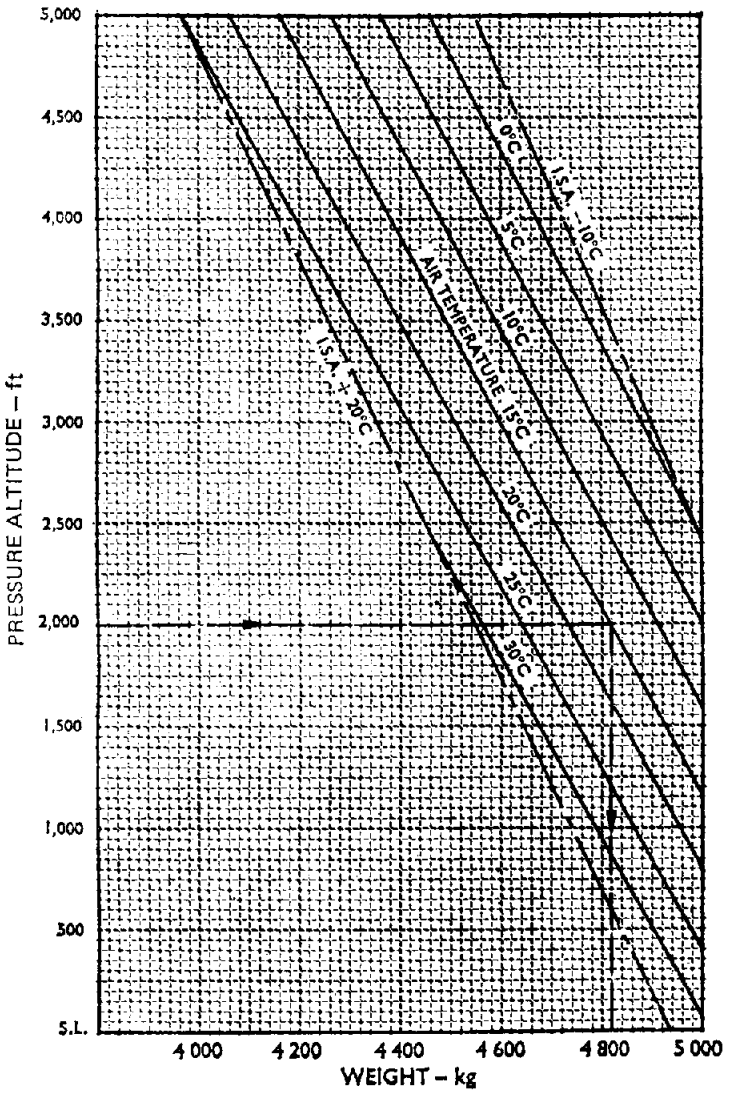
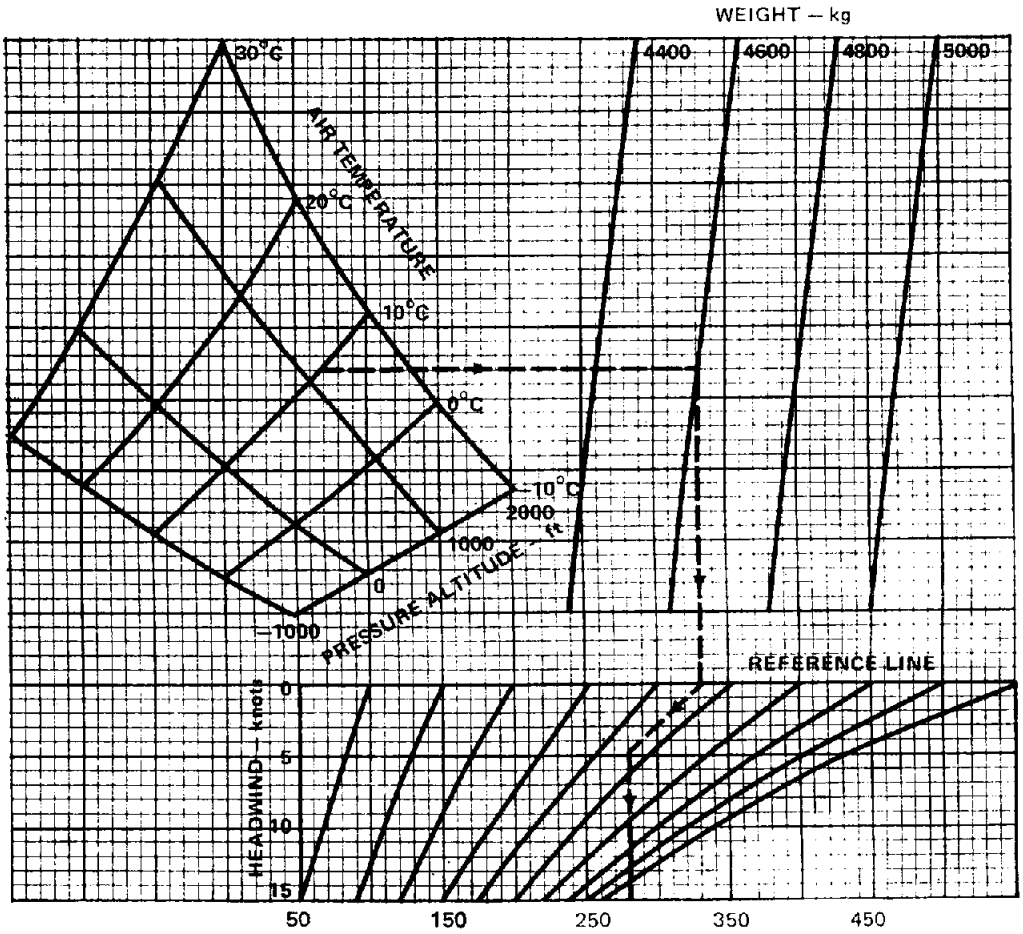


FIGURE 2 MAXIMUM TAKE-OFF AND LANDING WEIGHT FOR ALTITUDE AND TEMPERATURE

ACB 29.1587 (continued)

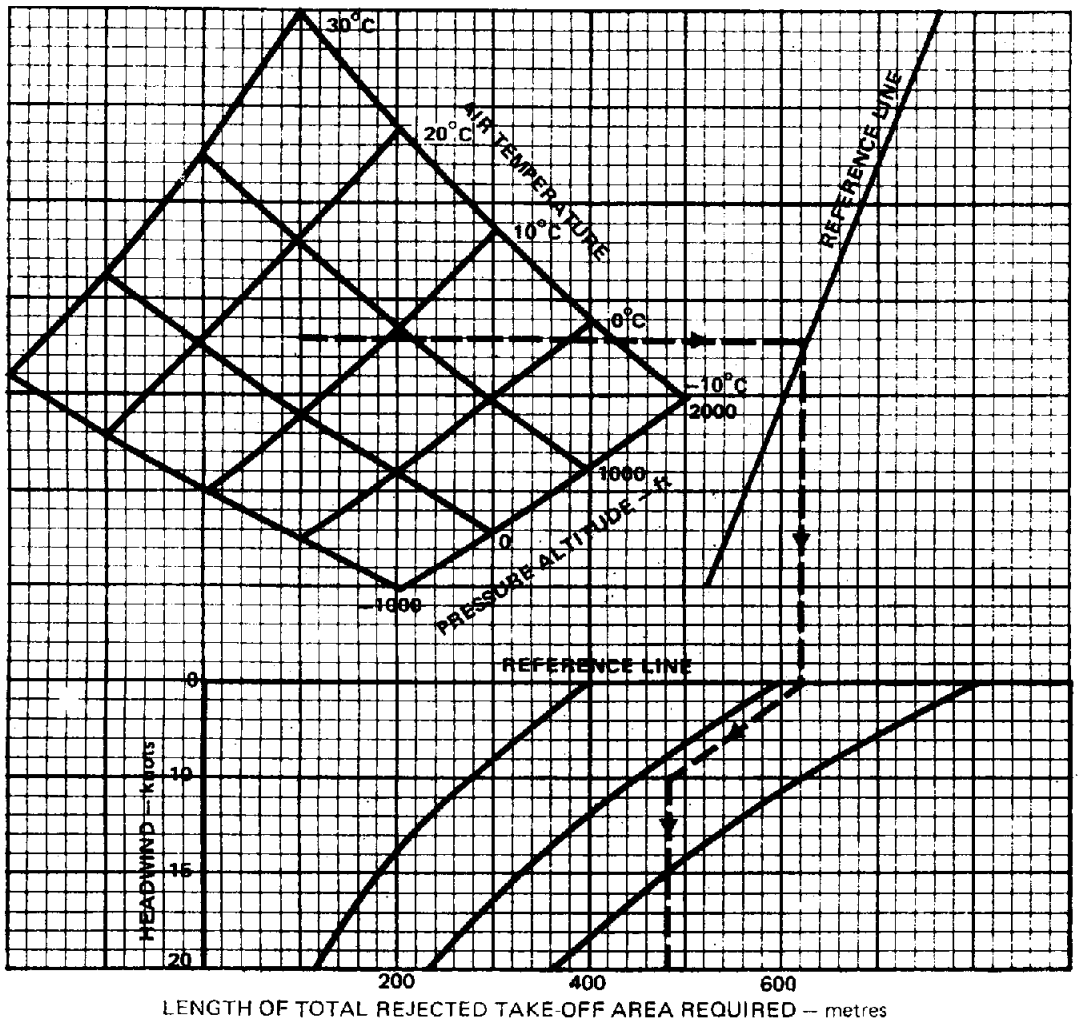
(f) *Sub-section 5.4 – Take-off and Landing Climb Gradients.* This Sub-section should include the gradients of climb for the conditions prescribed in Subpart B. An example of a graph suitable for the presentation of gross gradients of climb is shown in Figure 7, which illustrates the en-route gradient of climb with one engine inoperative.

(g) *Sub-section 5.5 – Take-off Spaces and Areas.* This Sub-section should include the Take-off Spaces and Areas derived in accordance with section 29.59. Any factor required by operational performance rules should be included in the scheduled data and a statement that the factors are included should be given in the Flight Manual. An example of graphs suitable for the presentation of the Take-off Space Required is shown in Figure 3 and the presentation of the Rejected Take-off Area Required is shown in Figure 4.



NOTE: Minimum width of Take-off Space Required shall be 30 m.

FIGURE 3 TAKE-OFF SPACE REQUIRED



NOTE: The minimum width of the Rejected Take-off Area Required shall be 30 m.

FIGURE 4 REJECTED TAKE-OFF AREA REQUIRED

(h) *Sub-section 5.6 Net Take-off Climbout Path.* This Sub-section should include the Net Take-off Climbout Paths derived in accordance with paragraph 29.59(d).

(i) The presentation should be in the form of a series of graphs such that the position of the end of each sector can be determined in terms of co-ordinates from a defined datum and thus enable the flight path profile to be drawn by joining these points by straight lines.

(ii) Where the effect of a significant banked turn is scheduled in accordance with paragraph 29.59(d)(6), the value of the radius of such a turn appropriate to the maximum altitude and air temperature for which take-off data are scheduled should be given.

ACB 29.1587 (continued)

(iii) An example of a graph suitable for the presentation of the Net Take-off Climbout Path is shown in Figure 5. Additional graphs giving corrections for the use of anti-icing devices, etc. should be included where necessary.

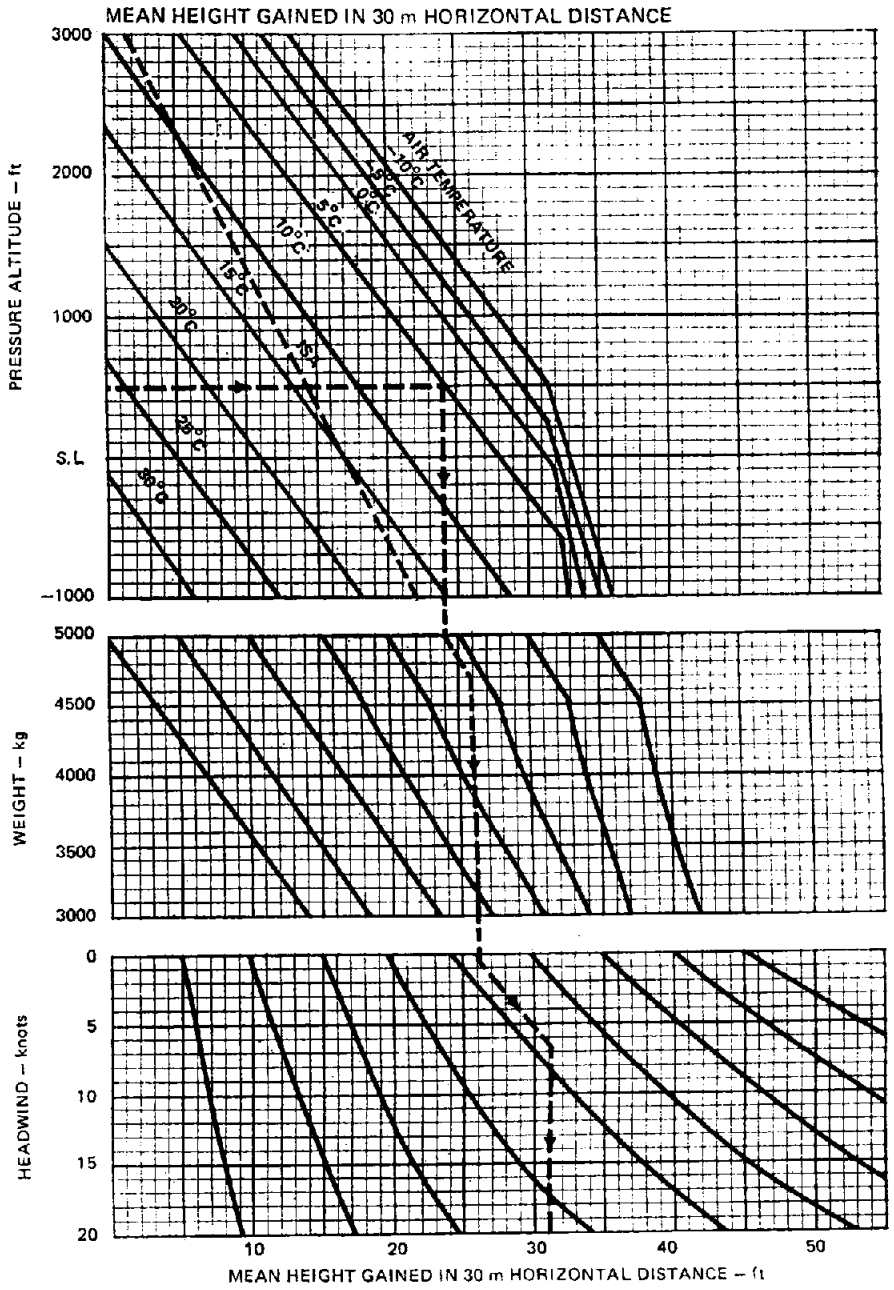


FIGURE 5 NET TAKE-OFF CLIMBOUT PATH

ACB 29.1587 (continued)

(j) *Sub-section 5.7 – En Route.* This Sub-section should include:—

(i) the all-engines-operating gross rates of climb and corresponding gradient of climb,

(ii) the net rate and gradient of climb with one engine inoperative, derived in accordance with section 29.67.

An example of the graphical presentation of the all-engines operating gross rate of climb is shown in Figure 6 and an example for the one-engine-inoperative en-route net gradient of climb is shown in Figure 7. Additional graphs giving corrections for the use of anti-icing devices, etc., should be incldued where necessary.

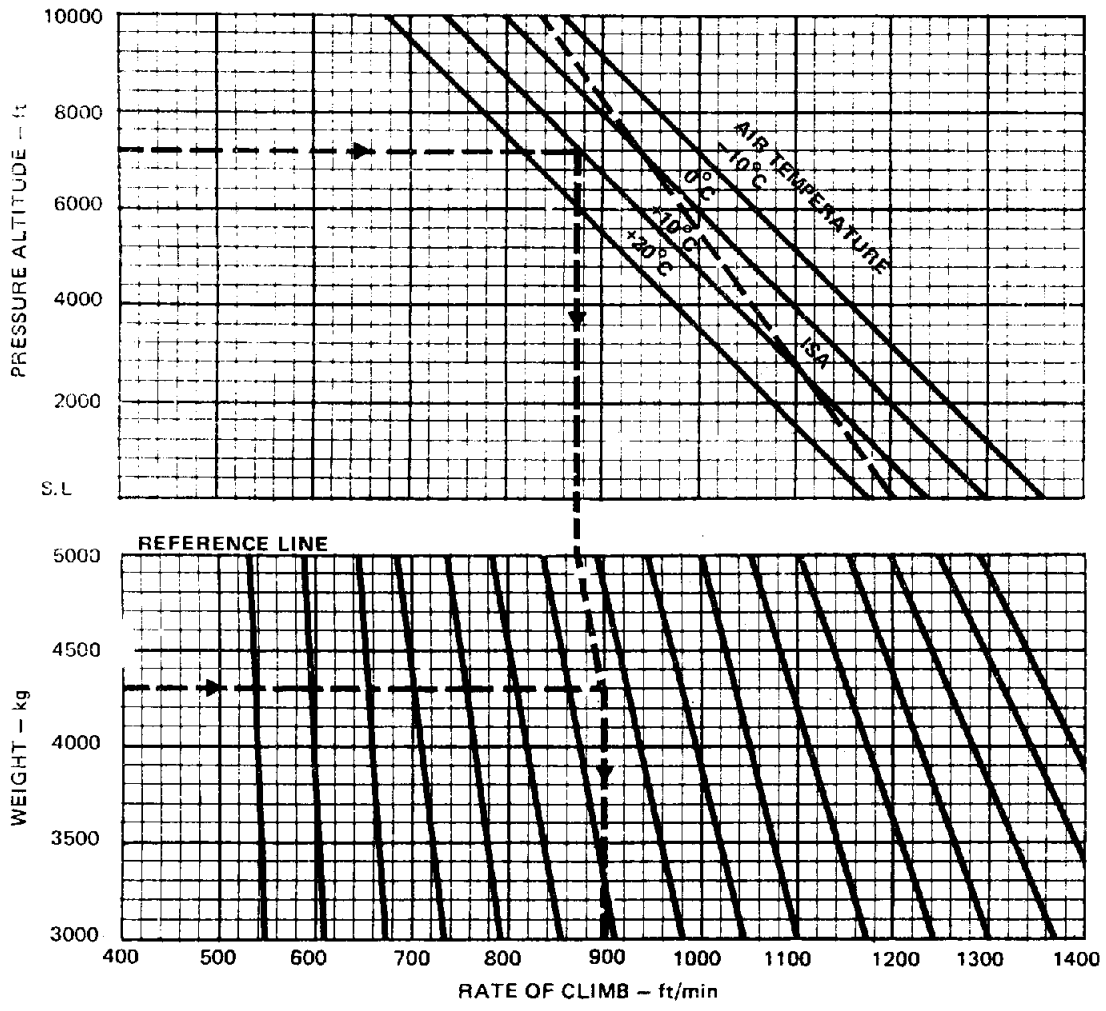


FIGURE 6 EN-ROUTE CLIMB — ALL ENGINES OPERATING

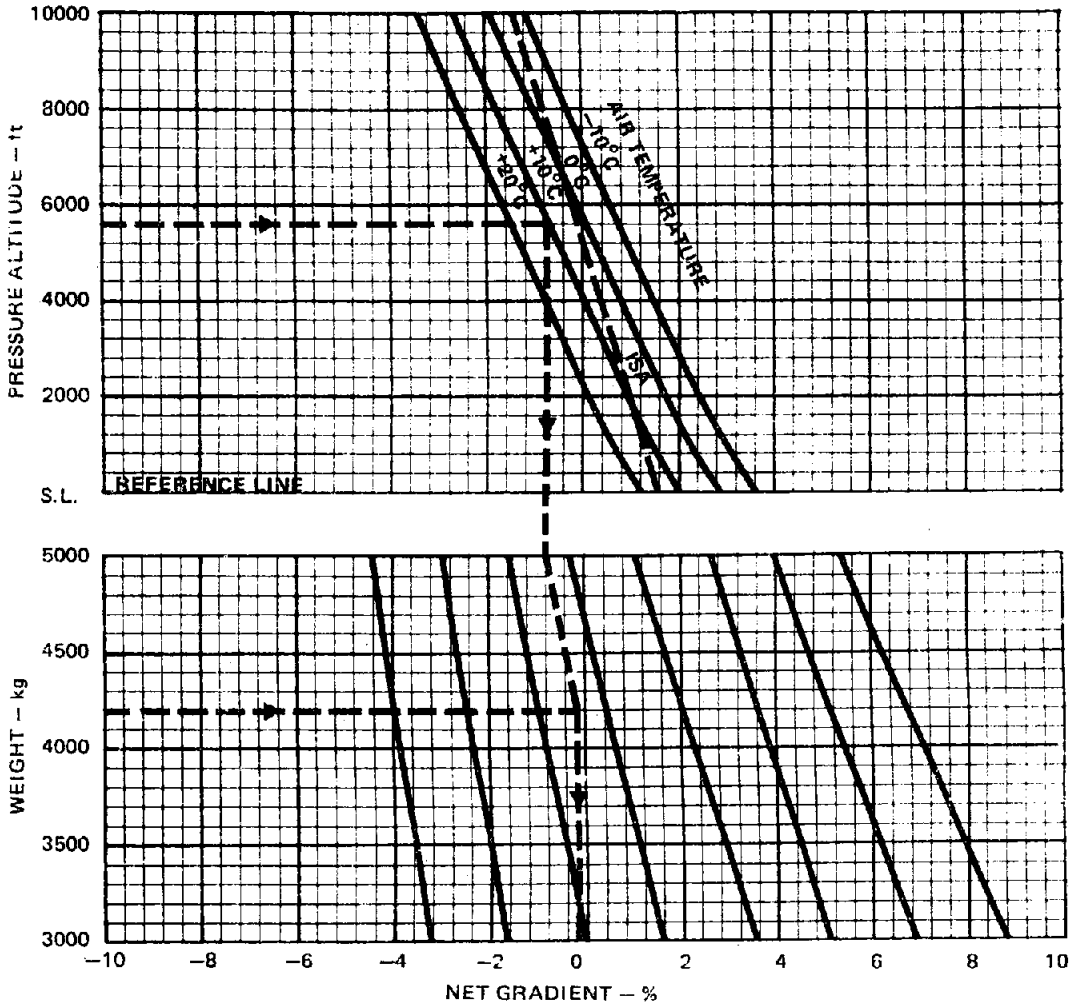


FIGURE 7 EN-ROUTE NET GRADIENT OF CLIMB — ONE ENGINE INOPERATIVE

(k) *Sub-section 5.8 - Landing Procedures and Speeds.* This Sub-section should include the items prescribed in (i) to (iii).

(i) The recommended procedures and speeds for the achievement of the landing performance.

(ii) A statement of the Critical Power-unit, if any.

(iii) A statement of the maximum cross-wind component for landing. This component should be appropriate to a wind speed measured at a height of 10 m.

(l) *Sub-section 5.9 - Landing Spaces.* This Sub-section should include the Landing Distance Required derived in accordance with section 29.75. The data should include the effect of the factors required by operational performance rules and a statement that the factors are included should be given in the Flight Manual. The graphical presentation of landing spaces should be similar to that for the Take-off Space Required as shown in Figure 4, including a note giving the minimum width of the landing space.

(m) *Sub-section 5.10 - Gross performance data.* This Sub-section should include the Gross Performance necessary for the evaluation of the airworthiness flight test climb performance results as prescribed in paragraph 29.1587(a)(8) and should be presented in terms of rate of change of pressure altitude.

ACB 29.1587 (continued)

(4) *Group B Rotorcraft.* The Performance Section of the Flight Manual for Group B rotorcraft should be presented in accordance with the general requirements of paragraphs (1) and (2) and the detailed requirements of this paragraph (4).

(a) *Method of scheduling data*

(i) The information should be presented in graphical form with supporting text which should include an explanation of the use of the graphs and examples of typical calculations.

(ii) Each Sub-section should contain information appropriate to all the alternative powers and configurations which are approved for the rotorcraft.

(iii) Where graphical presentation is used for Group B rotorcraft, the examples given for Group A rotorcraft in paragraph (3) should, where appropriate, be followed.

(b) *Sub-division of the Section.* The Section should be divided into Sub-sections as follows:—

General
Take-off and Landing Procedures
Take-off and Landing WAT Curves
Take-off Spaces and Areas
Take-off Flight Paths
En Route, Climb and Autorotative Glide Curves
Landing Spaces
Climb Performance Data.

(c) *General.* The general items prescribed in (i) to (vi) should be included.

(i) A representative cruising true air speed derived in accordance with paragraph 29.1587(b)(9).

(ii) The type of engine(s) for which the performance is valid and, if appropriate, the type of propellers.

(iii) A statement indicating whether the performance information in the Flight Manual may be extrapolated or not, and the extent, if any, of the extrapolation permitted.

(iv) If any of the scheduled performance information has been derived from calculations which took advantage of the test extrapolations, a statement indicating the ranges covered by such extrapolation.

(v) Graphs or tables to enable speeds when expressed in IAS to be corrected to EAS. These should take into account the effect of rotorcraft attitude and flight condition, if significant (see Figure 1).

(vi) A statement of the maximum value of the static error correction to be applied to the altimeter reading or a graph showing variations.

(d) *Take-off and Landing Procedures.* The items prescribed in (i) to (iv) should be included.

(i) A graph showing the envelope of forward speed and height within which, in zero wind, a landing can be made without hazard to the occupants after loss of power (see section 29.79).

(ii) The recommended procedures and speeds required to enable the take-off and landing performance to be achieved.

(iii) A statement of the Critical Power-unit (if applicable).

(iv) A statement of the maximum cross-wind component for take-off and for landing. This component should be appropriate to a wind speed measured at a height of 10 m.

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(e) *Take-off and Landing WAT Curves.* The Take-off and Landing WAT Curves derived in accordance with paragraph 29.65(a)(3) should be included.

(f) *Take-off Spaces and Areas.* The Take-off Spaces and Areas derived in accordance with paragraph 29.63(b) should be included. Any factor required by operational performance rules should be included in the scheduled data, and a statement that the factors are included should be given in the Flight Manual.

(g) *Take-off Climbout Paths.* The Take-off Climbout Paths derived in accordance with section 29.64 should be included.

(i) Where the presentation is in graphical form it should consist of a series of graphs such that the position of the end of each sector can be determined in terms of co-ordinates from a defined datum and thus enable the flight path profile to be drawn by joining these points by straight lines.

(h) *En Route.* The en-route climb detailed in (i) and (ii) and derived in accordance with section 29.65, should be included.

(i) The all-engines-operating pressure rates of climb and the performance ceiling.

(ii) The gradient of climb or descent with one engine inoperative, and the gradient of descent with total loss of power.

NOTE: In the case of single-engined rotorcraft this should be expressed as the autorotational gliding distance covered during descent through a given altitude at Maximum Take-off Weight in zero wind and in standard air temperature.

(j) *Landing Spaces.* The Landing Space Required derived in accordance with paragraph 29.75(c) should be included. Any factor required by operational performance rules should be included in the scheduled data and a statement that the factors are included should be given in the Flight Manual.

(k) *Climb Performance Data.* The performance necessary for the evaluation of the airworthiness flight test climb performance results as prescribed in paragraph 29.1587(b)(10) should be included and should be presented in terms of rate of change of pressure altitude.

ACB 29.1587(a)(7) Cruising speeds

(1) For rotorcraft with more than two Power-units, it may be necessary to schedule the information with two Power-units inoperative.

(2) The "representative cruising airspeed" of paragraph 29.1587(a)(7) is usually related to a representative cruising altitude; only one such speed is to be quoted for a given rotorcraft type.

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Appendix B

The probability of encountering pilot-induced oscillations which might prove hazardous should be Extremely Remote. The disturbance should be introduced with the rotorcraft in trimmed steady flight in smooth air and with the other primary flight controls fixed, by moving one primary flight control sharply to an out-of-trim position and immediately returning it to its original trim position at which it is then held fixed.

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