UK CIVIL AVIATION AUTHORITY
ENGINE TYPE CERTIFICATE DATA SHEET NO. 1044

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CIVIL TYPE APPROVAL OF RB211-535C-37, 535E4-37, 535E4-B-37 and 535E4-C-37

1. CONSTRUCTOR: ROLLS-ROYCE plc
DERBY

2. CERTIFICATION:

The above mentioned engines are approved for use in civil aircraft classified in the Transport Category (Passenger) subject to compliance with Notes at Item 11 of Data Sheet and the appropriate installation requirements of British Civil Airworthiness Requirements. Type Certificates 068 and 079/2 apply.

Certification Basis: For 535C-37, 535E4-37 and 535E4-B-37,

BCAR Section C, Issue 6, dated 15 June 1966 together with Blue Papers 415, 435, 436, 464, 468, 474, 476, 480, 481, 482, 499, 506, 544, 551 (para 3.2.2 only) and 554.

For 535E4-C-37

JAR-E Change 6 dated 28th August 1981.

Special Conditions: Ingestion of Rain and Hail
Medium and Large Bird Requirements
Propulsion System Electronic Controls

Exemptions

JAR-E change 6 Chapter C3-4 Section 24.1 Engine Calibration in Reverse Thrust.
JAR-E Change 6 Chapter C3-2 Section 2.2.1.(c) Scavenge filters Oil System General.

Equivalent Safety Findings

JAR-E740 150 Hour Endurance Test
JAR-E740(f)(1) 150 Hour Endurance Test - Test Conditions
JAR-E600 (b) & (c), E630(a), E830, E870, Overtemperature and Exhaust Gas Overtemperature Tests.
JAR-E800 Bird Strike/Ingestion

Elect to Comply

Rolls-Royce have elected to comply with the following JAR-E change 10 requirements.

E140	Test Observations
E150	Conditions Applicable to All Tests
E160	Conditions Applicable to Endurance Tests
E170	Endurance Tests - Inspection Checks and Calibration
E600	Conditions Applicable to All Tests
E610	Conditions Applicable to Endurance Tests
E620	Performance Correlations
E630	Tests - General
E690	Engine Bleeds
E720	Continuous Ignition
E730	Engine Calibration Tests
E740	Endurance Test
E745	Engine Acceleration
E750	Starting Tests
E830	Overspeed
E840	Compressor and Turbine Rotor Integrity Tests
E870	Exhaust Gas Overtemperature Test

3. ENGINE PARTICULARS:

3.1 Build Standard Specified in:

DIS 1094 Issue B plus Mod 72-6633	for 535C-37
DIS 2015 Issue 1(or later approved issues)	for 535E4-37
DIS 2106 Issue 3 (or later approved issues)	for 535E4-B-37
DIS 2224 Issue 1 (or later approved issues)	for 535E4-C-37

3.2 Description

By-pass turbo-jet

By-pass ratio:

535C-37	4.46:1
535E4-37, 535E4-B-37 and 535E4-C-37	4.40:1

3.3 Compressor

LP, Single stage fan
IP, 6 stage, axial flow
HP, 6 stage axial flow

Overall Pressure ratio: (nominal at Sea Level ISA Conditions)

535C-37	21.2:1
535E4-37, 535E4-B-37 and 535E4-C-37	25.0:1

3.4 Combustion Annular Chamber

3.5 Turbine LP, 3 stage, axial flow
IP, Single stage, axial flow
HP, Single stage, axial flow

3.6 Overall Dimensions

Length:

535C-37	4573.5mm (180.1in)
(from front of nose spinner to rear of jet pipe nozzle)	
535E4-37, 535E4-B-37 and 535E4-C-37	5035.9mm (198.2in)
(from front of nose spinner to rear of common nozzle)	

Width: (maximum over fan casing)

535C-37	2216mm (87.3in)
535E4-37, 535E4-B-37 and 535E4-C-37	2276mm (89.6in)

Height: (from lowest point on gearbox to top face of engine mounting pad)

535C-37	2413mm (95.0in)
535E4-37, 535E4-B-37 and 535E4-C-37	2416mm (95.1in)

3.7 Engine Dry Weight
(as defined in Chapter 1 of the DIS but excluding intake, cowls, thrust reverser assembly, exhaust afterbody/jet pipe and nacelle systems)

535C-37	3484kg (7680lb)
535E4-37, 535E4-B-37 and 535E4-C-37	3449kg (7603lb)

4. RATINGS:

Static sea-level ratings, which already include the losses due to scrubbing drag over nacelle afterbody and strut, nacelle cooling and ventilation flow including thrust reverser leakage and the IDG oil-cooler airflow, established under the following conditions:-

a) International Standard Atmospheric conditions at sea-level.

b) All optional air bleeds closed.

c) Aircraft service equipment drives unloaded.

d) 100% intake recovery corrected from the datum air intake system defined by Roll-Royce Nacelle Control Document NCD 1009 or approved alternatives.

e) Turbine gas temperature measured by 34 thermocouples located in the LP NGV's and fitted with ballast resistors as defined in Rolls-Royce Report PTR58723.

f) Fuel having a minimum calorific value of 42.8 MJ/Kg (18,400 Btu/lb).

(b)

4.1 Thrust ratings, kN(lbf)

Maximum Take-off at sea level equivalent to the normal sea-level take-off rating for the 535C-37, 535E4-37, 535E4-B-37, 535E4-C-37.

	535C-37	535E4-37	535E4-B-37	535E4-C-37	535E4-C-37 with SB73-D716
Take-off	163.4 (36720)	176.3 (39610)	189.3 (42540)	189.3 (42540)	189.3 (42540)
(Bare engine equiv.)	166.4 (37400)	178.4 (40100)	192.0 (43100)	192.0 (43100)	192.0 (43100)

Maximum Take-off at sea level equivalent to the rating at 5000ft altitude for the 535C-37, 3000ft for the 535E4-37, sea level for the 535E4-B-37 and 420ft for the 535E4-C-37.

Take-off	179.2 (40265)	185.0 (41560)	189.3 (42540)	192.4 (43250)	192.4 (43250)
(Bare engine equiv.)	182.3 (40970)	187.3 (42084)	192.0 (43100)	195.1 (43840)	195.1 (43840)

Maximum Continuous Thrust

Max. Continuous	149.1 (33500)	156.6 (35205)	156.6 (35205)	156.6 (35205)	156.6 (35205)
(Bare engine equiv.)	152.0 (34150)	158.6 (35640)	158.6 (35640)	158.6 (35640)	158.6 (35640)

At maximum continuous rating, the engines are flat rated to ISA +10°C at all flight conditions.

At take-off rating, the engines are flat rated as follows:-

535C-37
(a) up to 3400ft, ISA +13.9^{o}C
(b) between 3400ft and 5000ft, varies linearly between ISA +13.9^{o}C and ISA +17.2^{o}C
(c) between 5000ft and 9000ft, ISA +17.2^{o}C
(d) between 9000ft and 10000ft, varies linearly between ISA +17.2^{o}C and ISA +13.9^{o}C
(e) between 10000ft and 15000ft, ISA +13.9^{o}C

535E4-37
(a) up to 10000ft, ISA +13.9°C
(b) between 10000ft and 12500ft, varies linearly between

ISA +13.9^{o}C and ISA +20°C
(c) between 12500ft and 15000ft, ISA +20°C

535E4-B-37 (a) At sea-level, ISA +10°C
(b) between sea-level and 4000ft, varies approximately linearly between ISA +10°C and ISA +13.9^{o}C
(c) between 4000ft and 10000ft, ISA +13.9^{o}C.
(d) between 10000ft and 12500ft, varies linearly between ISA +13.9^{o}C and ISA +20°C
(e) between 12500ft and 15000ft, ISA +20°C.

535E4-C-37 (a) at sea-level, ISA + 12.5ºc.
(b) between sea-level and 420ft, varies linearly between ISA + 12.5ºC and ISA + 16.2ºC.
(c) between 420ft and 820ft, ISA + 16.2ºC.
(d) between 820ft and 1200ft, varies linearly between ISA + 16.2ºC and ISA + 12.9ºC.
(e) between 1200ft and 4000ft, varies linearly between ISA + 12.9ºC and 13.9ºC.
(f) between 4000ft and 10000ft, ISA + 13.9ºC.
(g) between 10000ft and 12500ft, varies linearly between ISA + 13.9ºC and ISA+ 20ºC.
(h) between 12500ft and 15000ft, ISA + 20ºC.

5. ACCEPTANCE LIMITATIONS:

The Acceptance Limitations for Production Pass-off and Repair/Overhaul are defined in the latest edition of Rolls-Royce report PTR 58723 - (Doc No. DHN 124943, ETCDS Test Bed Acceptance Limits).

This report defines the Trimmer values which establish the constant Turbine Gas Temperature(TGT) operating limits for varying Turbine Entry Temperatures which is a function of engine modification standard.

6. OPERATING LIMITATIONS:

The following operating limitations are applicable when the accuracy of the installed engine instrumentation is in accordance with Rolls-Royce Report APS 1034 for the 535C-37 and APS 1039 for the 535E4-37, 535E4-B-37 and 535E4-C-37.

6.1 Rotational Speed (%)

100% HP = 10,611 rpm 100% IP =7000 rpm 100% LP = 4500rpm

6.1.1 Maximum for take-off (5 min limit)

	535C-37	535E4-37	535E4-B-37	535E4-C-37	535E4-C-37 with SB73-D716
HP	94.6	99.0	99.0	99.0	99.7
IP	101.9	100.3	100.3	100.7	101.7
LP	110.0	108.8	108.8	108.8	108.8

6.1.2 Maximum Continuous

	535C-37	535E4-37	535E4-B-37	535E4-C-37	535E4-C-37 with SB73-D716
HP	93.0	95.8	95.8	95.8	95.8
IP	99.3	98.0	98.0	98.0	98.0
LP	108.5	108.4	108.4	108.4	108.4

6.1.3 Maximum Overspeed (20 sec limit)

	535C-37	535E4-37	535E4-B-37	535E4-C-37	535E4-C-37 with SB73-D716
HP	95.6	100.2	100.2	100.2	101.5
IP	102.9	101.3	101.3	102.3	103.3
LP	111.0	110.0	110.0	110.0	110.0

6.1.4 Low Idle (Minimum) see Note 12.1

6.1.5 Maximum for reverse thrust

	535C-37	535E4-37	535E4-B-37	535E4-C-37	535E4-C-37 with SB73-D716
HP (60 sec limit)	100	-	-	-	-
HP (40 sec limit)	-	84.3	84.3	84.3	84.3

6.2 Turbine Gas Temperature (°C)

	535C-37	535E4-37	535E4-B-37	535E4-C-37	535E4-C-37 with SB 73-D716
6.2.1 Momentary max. during starts on the ground	570	570	570	570	570
6.2.2 Momentary max. during re-lights in flight +	570	570	570	570	570
6.2.3 Maximum for take-off (5 min limit) ▲	850	850	877	877	877
6.2.4 Maximum Continuous	795	795	795	795	795
6.2.5 Maximum overtemp. (20 sec limit)	870	870	897	897	897

▲ These operating limitations may be used for up to 10 minutes in the event of engine failure. (BCAR Section C Issue 13)

\+ For the RB211-535E4 series, during the use of the Immediate Relight Procedure (ref: Chapter 4 of Operating Instruction manual F-211 (535E4)-B the momentary maximum limitation for each mark during relight is equal to the maximum take off TGT limit quoted in paragraph 6.2.3 for that mark.

6.3 Fuel

6.3.1 Approved Fuels:

For list of fuels and fuel additives approved for use in the engines, see relevant Operating Instructions.

6.3.2 Minimum pressure at engine inlet (measured at inlet to engine LP fuel pump):

Not less than 5 lbf/sq in abs. plus true fuel vapour-pressure with zero vapour/liquid ratio between sea-level and 45,000ft altitude.

6.3.3 Temperature at inlet to LP fuel pump (°C)

	535C-37	535E4-37, 535E4-B-37 and 535E4-C-37
(a) Maximum	49	49
(b) Minimum	Minus 54	Minus 54

6.3.4 Minimum drainage period (seconds) from closing fuel cock after a false start	30	30

6.4 Oil

6.4.1 Approved Types:

Aeroshell Turbine Oil 500 (also known as Royco Turbine Oil 500)
Aeroshell Turbine Oil 560
Castrol Aero 5000 Gas Turbine Oil
BP Turbo Oil 25
BP Turbo Oil 2197
BP Turbo Oil 2380
Mobil Jet Oil II
Mobil Jet Oil 254
Mobil Jet Oil 291

Note: Oil of the above types, when reclaimed to the approved Rolls-Royce standards for the appropriate viscosity grade, are approved for use.

6.4.2 Temperature at combined scavenge return (^{o}C)

	535C-37	535E4-37	535E4-B-37	535E4-C-37
(a) Minimum for starting	Minus 40	Minus 40	Minus 40	Minus 40
(b) Minimum for opening-up	Minus 10	zero	zero	Zero
(c) Maximum for unrestricted use	160	170	177	177

6.4.3 Pressure (lbf/sq. in.)

The minimum pressures vary linearly between the following listed HP rpm conditions:

		535C-37	535E4-37, 535E4-B-37, and 535E4-C-37
(a) Minimum acceptance for flight			
(i)	at 50% HP rpm	25	25
(ii)	at 70% HP rpm	35	35
(iii)	at 93% HP rpm	40	40
(b) Minimum to complete flight			
(i)	at 50% HP rpm or less	18	18
(ii)	at 70% HP rpm	25	25
(iii)	at 93% HP rpm	35	35

6.4.4 Consumption (Imp pt/hr)

a) Overall in flight, maximum for unrestricted operation	2.0	2.0
b) Overall In-Flight, maximum for stage lengths of 2 hours or less	2.0	3.4

Note: The calculation of oil consumption and subsequent fault isolation procedures detailed in the Aircraft Maintenance Manual section 79-31-00 must be followed prior to the application of the increased short sector oil consumption limit.

6.4.5 Capacity (Imp pt)

(a) Nominal total oil system capacity	63.0	64.0
(b) Nominal oil tank capacity	34.0	34.0
(c) Usable oil (including effect of altitude) minimum	33.8	32.0

6.5 Thrust Reverser

5.5.1 Approved Hydraulic Fluid: Monsanto Skydrol 500B
Monsanto Skydrol 500B4
Chevron Hyjet W
(or alternatives complying with Boeing Specification BMS3-11 Revision E)

7 COMPRESSOR AIR BLEEDS FOR AIRCRAFT SERVICES:

The Boeing installation for these engines, will incorporate an automatic scheduling system which will select the appropriate bleed supply source in response to a signal sensing HP compressor delivery pressure (P4).
Bleed air is extracted from the HP2 delivery port at engine power settings above that giving a P4 greater than 94 lbf/sq.in. (gauge) for the 535C-37 and 107 lbf/sq.in. (gauge) for the 535E4-37, 535E4-B-37 and 535E4-C-37 between sea-level and 31,000 ft and 75 lbf/sq.in. (gauge) for the 535C-37 and 91 lbf/sq.in. (gauge) for the 535E4-37, 535E4-B-37 and 535E4-C-37 above 31,000ft.

At power settings below these pressures bleed is extracted from the HP6 bleed port with the exception of the nose cowl anti-icing air which is always taken from the HP2 port. This nose cowl anti-icing air is approximately 1.5% of HP compressor flow and is included in the maximum bleed flow values quoted below for HP2 bleed.

In the aircraft system the cabin air bleed is passed through a pre-cooler with the required degree of cooling adjusted by valves controlling the fan delivery off-take cooling air supply. The valves respond to the temperature of the cabin air bleed.

The compressor air bleeds are to be used in accordance with the Rolls-Royce instructions and such that the Operating Limitations are not exceeded.

7.1 Maximum rpm at which bleed may be used: Unrestricted

7.2 Air Delivery for aircraft services:

			535C-37	535E4-37, 535E4-B-37 and 535-E4-C-37
7.2.1	Maximum HP6 bleed (% gas generator compressor flow)			
	(a)	Normal Operation		
		Low Idle to change over point	4.0	5.5
	(b)	Abnormal Operation		
		Low Idle to change over point	10.0	9.4
7.2.2	Maximum HP2 bleed (% gas generator compressor flow)			
	(a)	Normal Operation		
		(i) Low Idle to change over point	1.5	2.3
		(ii) Change over up to Maximum Continuous	4.0	4.8
		(iii) Maximum Continuous	4.0	3.6
		(iv) Maximum Continuous to Take-off	2.0	2.0
	(b)	Abnormal Operation		
		(i) Low Idle to Change over	2.3	2.3
		(ii) Changeover up to Maximum Continuous	7.6	7.7
		(iii) Maximum Continuous	7.6	5.4
		(iv) Maximum Continuous to Take-off	2.4	2.5
7.2.3	Maximum Fan Bleed (% Fan flow)			
	(a)	Normal and Abnormal Operation		
		Low Idle to Take-off	1.0	1.0

8 EQUIPMENT

For identification of equipment approved for use on these engines refer to latest approved issues of DIS 1094 for the 535C-37, DIS 2015 for the 535E4-37 and DIS 2106 for the 535E4-B-37 and DIS 2224 for the 535E4-C-37.

9 SPECIAL FEATURES:

8.1 A thrust reverser system, excluding control and hydraulic supply system, is incorporated to reverse the fan stream and is included in this approval.

8.2 535C-37 engine approval includes fitment of either a heated or non-heated spinner.

8.3 An optional feature is a supervisory control system by which electronic trimming of fuel is applied through the prime hydro-mechanical fuel flow regulator via a torquemotor in order to control the engine at throttle-selected values of Engine Pressure Ratio. The software of this system meets "critical" standard of RTCA DO-178.

10 MANUALS:

	535C-37	535E4-37, 535E4-B-37 and 535E4-C-37
Operating Instructions	F-211(535)-B	F-211(535E4)-B
Maintenance	Boeing 757 Aircraft Maintenance Manual D633N193	Boeing 757 Aircraft Maintenance Manual D633N193
Installation	EL2811A	EL2811A
Engine (including Thrust reverser)	E-211(535)-5RR	E-211(535E)-6RR
Time Limit	T-211(535)-5RR	T-211(535)-6RR

11 ENGINE VARIANTS:

The RB211-535C-37 was approved originally on 3 September 1981. It has installation features to suit the Boeing 757 aircraft, and was certificated as a reduced thrust derivative of previously approved RB211-22 and RB211-524 series engines.

The RB211-535E4-37 was approved originally on 30 November 1983. It has installation features to suit the Boeing 757 aircraft and was certificated as a derivative of previously approved RB211 series engines.

The RB211-535E4-B-37 was approved on 12 January 1989, it is a variant of the existing 535E4-37 which incorporates various modifications to permit an increase in Take-off rating over a redefined Take-off ambient envelope.

The RB211-535E4-C-37 was approved on 2 February 2001, it is a variant of the existing 535E4-B-37 which incorporates various modifications to permit a Take-off `Bump' rating at a range of ambient conditions at 620ft.

12 NOTES:

12.1 The crew drills for ground starting must include a statement that at stabilised Low Idle, LP rotational speed should not be below 22.5% for the 535C and 19.8% for the 535E4-37, 535E4-B-37 and 535E4-C-37.

12.2 The RB211-535E4-37, 535E4-B-37 and 535E4-C-37 engines comply with the aircraft engine emission requirements of BCAR section M issue 1 as amended by Blue Paper M847 and the recommendations of ICAO Annex 16 Vol II. The 535E4-C-37 complies with ICAO Annex 16 Volume II (second edition 1993).

12.3 In respect of Extended Range Operations, the qualifying standard and approved maximum rule time for the RB211-535C-37 and RB211-535E4-37 engines, eligible for use in the Boeing 757 aircraft, are defined in CAA approved document ANR 117.

Note: Information in respect of the aircraft is included in the aircraft configuration control document.