**Civil Aviation Authority** 



# CAA Paper 87017

Smoke hoods: net safety benefit analysis

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#### 1. INTRODUCTION

In survivable or partly survivable accidents, fatalities can arise because people are unable to escape from the fire either because they are trapped or because of the rapid progress of the fire. However, over the years, the overwhelming majority of fire related deaths have been caused by the inhalation of smoke and toxic fumes, including incapacitation or disorientation leaving people vulnerable to fire assault. Strenuous efforts have been made and continue to be made to improve aircraft materials in order to extend survival time by delaying the release of smoke and toxic fumes. These measures include revised standards for the flammability of seats, which are normally satisfied by the incorporation of a fire-blocking layer encapsulating the foam cushions, and this is now complete on all UK passenger aircraft. Revised standards for wall and ceiling panels have been adopted but the benefit will not be fully realised for some years.

The provision of low level escape path lighting with clear exit markings is expected to reduce disorientation in heavy smoke and to facilitate a more orderly and rapid evacuation. Compliance with this standard will be achieved on all UK passenger aircraft before the end of 1987.

Other improvements such as revised standards for the flammability of cargo-hold liners are in the pipe-line.

In the US, the mandatory provision of passenger protective breathing equipment was considered in the late sixties and early seventies, but was rejected largely on the grounds that it would probably slow down evacuation and expose to fire assault people who might otherwise have escaped. However with improvements to smoke hoods over the years leading to the present availability of compact light-weight units usable by untrained personnel, re-examination of the case for their application to aircraft passengers was warranted. The trigger was provided by the tragic accident to a British Airtours Boeing 737 aircraft at Manchester in August 1985 when 55 people died, all but twelve due to inhalation of smoke and fumes. The Accident Investigation Branch of the Department of Transport has commissioned a comprehensive assessment of available protective breathing equipment and is expected to recommend strongly its adoption for passengers when the report of the investigation into the accident is published, despite the fact that the Manchester accident occurred prior to the implementation of either fire blocking or floor proximity lighting.

In 1986 the CAA convened a meeting with representatives of the other three authorities known to have an interest in smoke hoods for passengers - FAA, DGAC (France) and Transport Canada. The four authorities agreed on a collaborative work programme, a part of which included a net safety benefit study for smoke hoods, ie an assessment of the safety benefit, and any likely offset due perhaps to delays in evacuation induced by its use. It is that study which is reported in this paper.

# 2. PRINCIPLES OF THE ANALYSIS

It was agreed by the four authorities that the net safety benefit should be assessed by reference to past accidents. Whilst it was accepted that actions have in most cases been taken to address the causes, no better approach was available for defining a credible spectrum of accidents to be considered, particularly in respect of cabin crash damage and fire origins.

It was also agreed that, in assessing the benefit attributable to smoke hoods, the standard of the aircraft in terms of fire-hardening and escape provisions should be assumed to be representative of aircraft in service now. In particular, the group concluded that the assessment should be as realistic as practicable and that smoke hoods should not be given credit for the saving of life which it is reasonable to expect from recent cabin safety improvements, such as fire blocking of seats, floor proximity escape path lighting, lavatory smoke detectors and fire extinguishers.

The accidents to be considered were those known to the four participating authorities which

- (1) involved transport aircraft certificated to carry more than 30 passengers
- (2) occurred during passenger operations, ie excluding cargo, positioning and training flights
- (3) occurred over the twenty year period commencing in 1966
- (4) either involved passenger fatalities due to fire, or did not involve passenger fatalities but where the aircraft cabin was destroyed or severely damaged by fire.

Accidents in which impact was non-survivable were to be excluded. Accidents arising from sabotage or terrorist action were also to be excluded.

It was recognised that the analysis should take account of any delay to evacuation attributable to the donning of smoke-hoods, and any extension of the evacuation time due to wearing this equipment. Conflicting data was available on these effects, and consequently CAA assisted with programmes of testing which was set in hand by Linacre College, Oxford and, more recently, by the FAA's Civil Aeromedical Institute (CAMI), to produce consistent and usable data.

The analysis cannot take account of possible psychological factors such as the sense of false security which can be engendered by safety equipment.

#### 3. ACCIDENTS

The FAA volunteered to carry out the accident analysis and, based on a review of ICAO, CAA and FAA data banks, the group agreed the full list of accidents meeting the criteria given in paragraph 2 above. This list comprises 74 accidents with 2686 fatalities to passengers and crew. (See Table 1). It is broken down as follows:-

0	fatalities	25 accidents
1-5	fatalities	10 accidents
5-50	fatalities	23 accidents
50-100	fatalities	10 accidents
100-200	fatalities	3 accidents
200+	fatalities	3 accidents

In compiling this table it was decided that Eastern Bloc aircraft should be omitted because of difficulties in obtaining sufficiently detailed information.

Although in principle the list excludes non-survivable accidents, some of those which are included could reasonably be so regarded.

Two accidents in which there was loss of control at altitude as a result of fire have been excluded. In neither case is it known whether control was lost because of the fire damage to the aircraft or its systems or due to incapitation of the flight crew. If it were the latter, improved standards for flight crew breathing equipment might have enabled controlled flight to be maintained, in which case passenger protection might also have provided a benefit.

The FAA offered to carry out the analysis, at its Technical Centre making use of a computer based mathematical model. However, application of this technique which is described in Appendix I requires a level of detail which was not available in all cases, since accident investigation reports are not always published and, even where they are the information on the fire and the evacuation may be incomplete. Consequently the FAA analysts concluded that they could only analyse some twenty of the accidents listed in Table 1. These are marked with an asterisk \*, but it will be noted that they include the most important accidents with almost half of the fatalities.

#### 4. FAA ANALYSIS

The essence of the FAA analysis method is that it models cabin survivability and evacuation rate as functions of time, and this permits improvements to be applied to these functions successively for:-

- fire blocking,
- floor proximity lighting,
- lavatory fire detectors and extinguishers, and
- smoke hoods.

The number of survivors is computed in each case, indicating the benefit which might have been expected if that accident had occurred to an aircraft meeting today's cabin safety standards. Only passengers and cabin crew are included since flight crew are already provided with smoke protection.

The FAA were able to provide to other members of the group both the computer programme for the analysis, and the models for each of the accidents analysed. Because the model is a numerical interpretation of the written description of the sequence of events, the assumptions are open to question. However, by exercising the programme and reviewing it with the analysts other members of the group were able to build up confidence in the method, and an understanding of the individual models. The result was that only small changes were made subsequently during a review by the whole group. In any case the group recognised that, since an individual accident is not likely ever to be repeated in detail, undue speculation on the actual effect on that accident of certain safety improvements would be a nugatory exercise. The computer model allows a more objective approach whereby each accident report considered is regarded as a scenario which could represent broadly the circumstances that might surround a future accident. The results of the analysis are given in Table 2, and explanatory comment is given below:-

## (a) Basic Model

Varying the basic model for each accident within reasonable limits does not significantly change the assessed benefits attributable to the cabin safety improvements.

#### (b) Fire Blocking (FB)

The delay to the involvement of the seats in a fire will delay the build-up of smoke and toxic fumes in the cabin, and Reference 1 gives test results indicating the magnitude of this delay for a range of fire scenarios. The consequence of this delay is not only that the cabin remains survivable for longer but also that peak evacuation rates can be sustained for longer before the effect of dense smoke slows down this process. The degree to which this improvement would have changed the outcome varies from accident to accident, but the improvements assumed are well within the findings of Reference 1. The analysis estimates that of 1022 fire related deaths, 477 would have been saved had fire blocking layers been present (47%). However this figure is heavily influenced by one particular accident, the Saudia L-1011. In reaching a conclusion on the likely impact of fireblocking on this accident, the Group did not only have access to the official report, but was also able to take advice from a fire-expert who assisted with the investigation. Essentially the fire penetration into the cabin from the underfloor cargo hold was in such a position as to restrict the cabin fire to seats initially. If that accident were excluded from the analysis 179 out of the remaining 724 of the fire related deaths would have been prevented by fire blocking layers (25%).

# (c) Floor Proximity Lighting (FPL)

The analysis assumes that floor proximity escape path lighting would have enhanced the evacuation rate at night and during the latter stages of an evacuation when dense smoke would have been present, and Reference 2 shows that a reasonable measure for this improvement is 20%. The estimated effect of this is that 39 of the fire related deaths in these twenty accidents would have been saved (4%).

# (d) Lavatory Smoke Detection/Fire Extinguishers

The estimates of lives saved by fire blocking and floor proximity lighting given above assume that lavatory fire precaution would have been ineffective in preventing the inflight fire to the VARIG Boeing 707 which crash-landed near Orly Airport in France in 1973. If, however, it is assumed that these precautions would have prevented the fire, the effect on the totals would have been to reduce slightly the contribution of fire-blocking and floor proximity lighting to the saving of life.

#### (e) Smoke Hoods (PPBE)

Assuming that passenger protective breathing equipment (PPBE) of an appropriately high standard is available, its essential contribution would be a substantial improvement to survivability in the cabin fire atmosphere. It would not be expected to improve evacuation rates but would sustain evacuation up to the point where the cabin becomes unsurvivable even with smoke hoods. Applying these improvements to the accident models results in an estimated potential saving of 179 fire related deaths out of 1022 due to this equipment (18%) This proportion is modest, not because of any assumed limitations as to the protection provided by smoke hoods, but rather because of the contributions that would already have been made by other improvements. In the absence of fire blocking or floor proximity lighting, the contribution which would have been made by smoke hoods could have been very substantial indeed.

It has been suggested that smoke hoods would delay evacuation due to the time taken for donning, or that they would slow down evacuation. In the Linacre College trials at Teesside using Type I floor-level doors the wearing of smoke hoods did not reduce the evacuation rate (Reference 3), whereas in the CAMI trials at Oklahoma City, using Types III and IV hatches, the rate appears to have been reduced by about 25% (Reference 4).

No delay due to donning was identified in the Linacre College trials because many of the test subjects put their hoods on while the smoke in the cabin was building up, but before the evacuation was commanded. This, it could be argued, is probably realistic. The CAMI trials did not attempt to measure the donning effect. Consequently the derivation of the net safety benefit assumes that the wearing of smoke hoods does not delay or slow down the evacuation. However, Table 3 shows the estimated effect on the contribution made by smoke hoods if

- there were to be a delay of 15 seconds to the evacuation due to donning the hoods, or
- the evacuation rate were to be reduced by 10%.

These estimates emphasise the point that if smoke hoods did become required equipment it would be of paramount importance to ensure that by design and briefing they are quick and easy to find and don, and that effects on vision and hearing should be minimal.

### (f) Likelihood of Smoke Hood Use

The potential saving of life estimated above would only be realised if the protection provided by the smoke hoods were perfect, and if everybody who would benefit were to make use of them. Whilst design and testing can ensure that the hoods are realistic and that the protection provided is commensurate with the threat posed by smoke and fumes, only limited steps can be taken to promote high usage. Ready availability, ease of donning and adequate briefing would help but even if there is no actual resistance by passengers to the wearing of hoods, it would be unrealistic to assume that all passengers in all accidents will remain so self-possessed and rational that all will make use of the smoke hoods. Many survivable accidents involve high impact loads and severe destruction of the cabin so that many of the survivors are likely to be disorientated and alarmed. The circumstances in the British Airtours B737 accident at Manchester in 1985 and the BOAC B707 accident at Heathrow in 1968 where the aircraft came to a standstill on a runway/taxyway, on their wheels, using normal braking, is by no means the rule. Consequently, it should be expected that in some accidents little use would be made of smoke hoods. A distant parallel is the use of life jackets, and experience has shown that, in unpremeditated ditchings, the degree to which they are used is disappointing.

The benefit analysis would be incomplete without attempting to make some allowance for this factor. The circumstances of each accident were reviewed, with particular reference to the degree of crash damage, and the likelihood of smoke hood use was assessed, as follows (See Appendix II).

"Very High"	(100%)	eg	in-flight fires where use is premeditated;
"High"	(75%)	eg	No cabin damage;
"Moderate"	(50%)	eg	Little or no cabin damage but rapidly developing fire threat;

"Low" (25%) eg Major to severe cabin damage, including complete fracture;

"Negligible" (0%) eg Severe/extreme damage, the cabin in many cases ending up in a number of pieces.

These factors can be applied to the results of the FAA analysis given in Table 2, giving a final estimate of the smoke hood benefit for these 20 accidents as 134 out of the 1022 fire related deaths (See Table 4).

#### 5. REMAINING ACCIDENTS

The detailed analysis above of 20 accidents still leaves 54 out of the original list of 74 accidents in Table 1 unaccounted. Of these, 22 were without fatality but the remaining 32 gave rise to 1475 fatalities.

This report would clearly be incomplete if these were not taken into account, but the problem is that the level of detail available makes it impracticable to use the technique used in paragraph 4 above to identify the contributions of fire blocking, floor proximity lighting and smoke hoods. However, an approximation is given in Table 5 as follows:-

- 1. All fatalities are assumed to have been fire related unless there is specific information in the report, so that the figures given are an over-estimate.
- 2. The overall proportion of fire blocking/floor proximity lighting/smoke hoods benefits found in paragraph 4 is assumed to apply (See Table 2). Thus, for each accident, the <u>potential</u> saving of life by smoke hoods can be determined.
- 3. Applying the method described in paragraph 4e, an assessment of the likelihood of smoke hood use can be made for each accident and applied to the potential saving of life, giving an estimate of the net saving.

The conclusion is that in 32 fatal accidents an estimated 49 fatalities are likely to have been prevented if smoke hoods had been provided.

That this represents a lower percentage of the total than in the accidents analysed by the FAA method (paragraph 4) is largely due to the very large contribution in that case attributed to smoke hoods in the VARIG B707 accident.

#### 6. CONCLUSIONS

Combining the results of paragraphs 4 and 5, it is concluded that the provision of effective passenger smoke hoods in public transport aircraft of more than 30 seats would result in a modest saving of life. The analysis show that the saving might be expected to be of

the order of 9 fire related deaths per year world-wide if the accident/fire history of the past twenty years were broadly repeated. This total would be massively reduced if credit were taken for lavatory fire precautions in the VARIG B707 near Orly in 1973.

The analysis also shows that even if the wearing of smoke hoods were to result in a delayed or slower evacuation, the net benefit would remain positive, but reduced.

Since UK passenger transport is about 5% of the world total, the UK saving can be expected to be in the order of one life every two years. By comparison, analysis of the two UK accidents in that period (British Airtours at Manchester and BOAC at Heathrow) suggest a likely saving of 19 lives, or 1 life per year.

The analysis can be criticised on the following grounds:-

- 1. The spectrum of accidents which occurred over the past twenty years may not be a good guide to the future. However, no better measure is available.
- 2. No account is taken of the growth of aviation which has more than doubled in this period. This appears to have been offset by the generally improved safety achieved by newer aircraft.
- 3. No credit is given for the possible influence of smoke hoods in reducing panic and inducing more orderly evacuation. This may have influenced the outcome in some but by no means all accidents.
- 4. Wearers of smoke hoods in non-critical levels of smoke are subject to some small levels of risk associated with hood malfunction eg the oxygen supply.
- 5. The safety benefit presented above assumes no delay or adverse effect on evacuation when hoods are worn. This is based on the Linacre College and CAMI trials in which the subjects were inevitably preconditioned to the wearing of hoods. This result may not be repeated in a truly unpremeditated situation.

However these factors would be unlikely to change the essential conclusion of the study that the contribution of the mandatory carriage of passenger smoke hoods on aircraft would be modest.

#### REFERENCES

1. FAA REPORT

"Aircraft Seat Fire Blocking Layers: Effectiveness and Benefits Under Various Scenarios".

DOT/FAA/CT-83/43,

February 1984

# 2. FAA REPORT

"Emergency Cabin Lighting Installations: An Analysis of Ceiling vs Lower Cabin-mounted Lighting During Evacuation Trials."

## FAA-AM-81-7 February 1981

- 3. Unpublished data from Linacre College, Oxford, investigation into aircraft evacuation with passengers wearing smoke hoods, Teesside, April 1987. Report expected.
- 4. Unpublished data from the FAA Civil Aeromedical Institute, Oklahoma City, investigation into the effects of smoke hoods on evacuation rates through Types III and IV exits, August 1987. Report expected.

# TABLE 1: ACCIDENTS TO CIVIL TRANSPORT AEROPLANES (1966 TO 1988) IN WHICH THERE WERE FIRE RELATED DEATHS OR DESTRUCTION OF THE AIRCRAFT BY FIRE.

		Date	Operator	Place	Aircraft Type	Occupants	Fatalities
	1	15 02 66	Todion Ainline				
	2	15.02.00	Indian Airlines	Palam	Caravelle	80	2
	2	22 04 66	Canadian Pacific	lokyo	DC-8	72	64
	1	16 02 67	American Flyers	Ardmore	L-188	98	83
*	5	05 03 67	VADIC	Menado	L-188	92	22
	6	06 11 67	TUA	Monrovia	DC-8	90	51
	7	00.11.07	TWA Ethiopian	Cincinnati	B-707	36	1
*	à	09.01.00	POAC	Beirut	B-720	49	0
	9	12 06 68	Ban Amonican	Heathrow	B-707	127	5
	10	26 07 60	Air Algonia	India	B-707	63	6
	11	19 04 70	sac sac	BISKra	Caravelle	37	33
	12	06.05.70	Somali	Kome	DC-8	65	0
*	13	27.11.70	Canital Inton	Mogadiscio	Viscount	30	5
* 1	14	28.12.70	Trans Caribboan	Anchorage	DC-8	229	47
* 1	15	07.06.71	Allegheny	St Inomas	B-/2/	55	2
1	16	06.09.71	Pan International	Hew naven	CV-580	31	28
1	17	18.04.72	Fast African	Addic Ababa	BAC 1-11	121	21
* ]	18	08.12.72	United	Chicago	SVC-10 P 727	107	43
* ]	19	20.12.72	North Central	Chicago	D-/3/	63	43
2	20	22.01.73	Alia	Kano	DC-9 P 707	45	10
2	21	31.05.73	Indian Airlines	Palam	D-/U/ P 737	202	176
* 2	22	11.07.73	VARIG	Orly	D=/3/ R 707	05	48
2	23	23.07.73	Ozark	St Louis	D=/0/	134	123
2	24	20.12.73	Lufthansa	Delhi	R 707	45	39
* 2	25	30.01.74	Pan American	Pago Pago	B-707	109	0
2	26	15.03.74	Sterling	Teheran	Caravollo	101	96
2	27	11.09.74	Eastern	Charlotte		96	15
2	28	20.22.74	Lufthansa	Nairohi	B-747	82	12
2	29	23.11.74	JAT	Relarade	DC_0	157	59
3	30	11.06.75	Air France	Bombay	B_747	50	0
* 3	1	12.11.75	Overseas National	JEK	DC-10	394	0
3	2	05.04.76	Alaska	Ketchikan	B-727	139	0
3	13	27.04.76	American	St Thomas	B-727	50	1
3	4	04.06.76	Air Manila	Guam	1_100	89	3/
3	5	16.11.76	Texas International	Denver	DC_0	45	45
3	6	02.03.77	Iragi	Baghdad	B-707	00	0
* 3	7	27.03.77	Pan American	Tenerife	B-747	405	225
3	8	27.03.77	KLM	Tenerife	B-747	405	335
3	9	04.04.77	Southern	New Hone	DC_9	240	248
4	0	27.09.77	Japan Airlines	Kuala Lumpur	DC-8	00	03
4	1	03.10.77	Capitol Inter.	Shannon	00-0	250	34
4	2	19.11.77	TAP	Funchal	B-727	164	121
4	3	11.02.78	Pacific Western	Cranbrook	B-737	104	131
4	4	15.02.78	Sabena	Tenerife	B-707	106	42
* 4	5	01.03.78	Continental	Los Angeles	DC-10	202	0
4	6	03.03.78	Iberia	Santiago	DC-8	202	4
4	7	02.04.78	VASP	Sao Paulo	B-737	12	0
4	8	17.12.78	Indian Airlines	Hyderabad	B-737	132	1
4	9	13.03.79	Alia	Doha	B-727	64	44
50	0	26.04.79	Indian Airlines	Madras	B-737	67	44
* 5	1	07.10.79	Swissair	Athens	DC-8	154	14
5	2	27.02.80	China Airlines	Manila	B-707	134	2
* 5	3	29.08.80	Saudia	Rivadh	L-1011	301	301
5	4	04.11.80	TAAG	Benquela	B-737	134	301
* 5	5	19.11.80	Korean	Seoul	B-747	226	15
* 51	6	21.11.80	Continental	Yap Island	B-727	73	15
5	7	17.02.81	Air Cal	Santa Ana	B-737	110	0
5	8	27.07.81	Aeromexico	Chihuahua	P-30	56	20
5	9	17.03.82	Air France	Sanaa	A-300	124	30
60	0	26.08.82	Southwest	Ishigaki	B-737	129	0
* 6	1	13.09.82	Spantax	Malaga	DC-10	303	51
6	2	11.03.83	Avensa	Barquisimeto	DC-9	50	22
* 63	3	02.06.83	Air Canada	Cincinnati	DC-9	46	23
64	4	11.06.83	United	Chicago	B-727	142	0
6	5	02.07.83	Altair	Milan	Caravelle	80	0
66	6	07.12.83	Aviaco	Madrid	DC-9	42	42
67	7	07.12.83	Iberia	Madrid	B-727	03	51
68	В	18.12.83	Malaysian	Kuala Lumpur	A-300	247	0
69	9	10.03.84	UTA	Ndjamena	DC-8	23	0
* 70	0	22.03.84	Pacific Western	Calgary	B-737	119	0
71	1	30.08.84	Air Cameroon	Douala	B-737	118	2
72	2	13.10.84	Cyprus Airways	Zurich	B-707	10	õ
* 73	3	22.08.85	British Airtours	Manchester	B-737	137	55
74	ŧ	30.11.85	Mandala	Medan	L-188	45	0

# TABLE 2: ESTIMATE FOR POTENTIAL SAVING OF LIFE IN FIRE ACCIDENTS WITH SAFETY IMPROVEMENTS (FAA ANALYSIS)

=

LIVES SAVED

	Date	Operator	Aircraft Type	Fire Deaths	Fire Blocking	Floor Prox. Lights	Smoke Hoods *
5	05.03.67	VARIG	DC-8	45	29	9	7
10	08.04.68	BOAC	B-707	5	0	4	1
13	27.11.70	Capitol Inter.	DC-8	47	18	5	24
14	28.12.70	Trans Caribbean	B-/2/	2	0	0	0
10	09 12 72	Allegneny	CV-580	27	0	1	0
10	00.12.72	United North Control	B-/3/	21	10	5	12
19	20.12.72	North Central	DC-9	10	2	1	1
25	20 01 74	VARIG Dan Amarican	B-/0/	121	18	4	99
25	JU.UL. 74	Pan American	B-/0/	92	0	1	0
27	12.11.75	Overseas Nat.	DC-10	100	0	0	0
37	27.03.77	Pan American	B-/4/	190	0	0	0
4J 51	07.10.70	Continental	DC-10	4	0	0	0
52	10 00 00	Swissair	DC-8	14	0	0	0
55	10 11 00	Saudia	L-1011	298	298	0	0
55	21 11 00	Continental	B-747	12	12	0	0
50	12 00 02	Continental	B-121	0	0	0	0
62	13.09.02	Spantax	DC-10	50	50	0	0
70	02.00.03	All Canada Decific Western	DC-9	23	23	0	0
70	22.03.84	Pacific Western	B-/3/	0	0	0	0
13	22.08.85	Britisn Airtours	B-/3/	55	17	3	35
		TOTALS		1022	477	39	179
					47%	48	18%
	•	TOTALS ASSUMING L	OSS OF LIFE	1022	459	35	80
		AVERTED BY LAVATO PRECAUTIONS	RY FIRE		45%	38	88

\* Assumes 100% use of smoke hoods (See Table 4)

# TABLE 3: POTENTIAL SAVING OF LIFE BY SMOKE HOODS: EFFECT OF DELAYED EVACUATION OR REDUCED EVACUATION RATE (Assumes 100% use of smoke hoods)

					LIVES	S SAVED	
	Date	Operator A	Aircraft Type	Fire Deaths	No Effect	Delay	Reduced Rate
				The second second	*	**	***
5	05.03.67	VARIG	DC-8	45	7	7	7
8	08.04.68	BOAC	B-707	5	1	1	0
13	27.11.70	Capitol Inter.	DC-8	47	24	1	2
14	28.12.70	Trans Caribbean	B-727	2	0	0	0
15	07.06.71	Allegheny	CV-580	27	0	-2	-1
18	08.12.72	United	B-737	27	12	11	9
19	20.12.72	North Central	DC-9	10	1	-7	1
22	11.07.73	VARIG	B-707	121	99	99	99
25	30.01.74	Pan American	B-707	92	0	-6	0
31	12.11.75	Overseas Nat.	DC-10	0	0	0	0
37	27.03.77	Pan American	B-747	190	0	-42	-7
45	01.03.78	Continental	DC-10	4	0	0	0
51	07.10.79	Swissair	DC-8	14	0	0	0
53	19.08.80	Saudia	L-1011	298	0	0	0
55	19.11.80	Korean	B-747	12	0	0	0
56	21.11.80	Continental	B-727	0	0	0	0
61	13.09.82	Spantax	DC-10	50	0	0	0
63	02.06.83	Air Canada	DC-9	23	0	0	0
70	22.03.84	Pacific Western	B-737	0	0	0	0
73	22.08.85	British Airtours	B-737	55	35	35	35
			TOTALS	1022	179	97	145

\* See Table 2 \*\* 15 seconds delay \*\*\* 10% reduction in evacuation rate.

	Date	Operator	Aircraft Type	Fire Deaths	Potential Benefit	Likelihood of Use	Net Benefit
	S. March	and the second second		a seened		*	**
5	05.03.67	VARIG	DC-8	45	7.	Neg	0
8	08.04.68	BOAC	B-707	5	1-	High	1
13	27.11.70	Capitol Inter.	DC-8	47	24	Mod	12
14	28.12.70	Trans Caribbean	B-727	2	0	LOW	0
15	07.06.71	Allegheny	CV-580	27	0	Mod	0
18	08.12.72	United	B-737	27	12	Low	3
19	20.12.72	North Central	DC-9	10	1	High	1
22	11.07.73	VARIG	B-707	121	99	V High	99
25	30.01.74	Pan American	B-707	92	0	Mod	0
31	12.11.75	Overseas Nat.	DC-10	0	0	Neg	0
37	27.03.77	Pan American	B-747	190	0	Neg	0
45	01.03.78	Continental	DC-10	4	0	Mod	0
51	07.10.79	Swissair	DC-8	14	0	Mod	0
53	19.08.80	Saudia	L-1011	298	0	V High	0
55	19.11.80	Korean	B-747	12	0	Mod	0
56	21.11.80	Continental	B-727	0	0	Neg	0
61	13.09.82	Spantax	DC-10	50	0	Mod	0
63	02.06.83	Air Canada	DC-9	23	0	V High	0
70	22.03.84	Pacific Western	B-737	0	0	Neg	0
73	22.08.85	British Airtours	s B-737	55	35	Mod	18
		TOTALS		1022	179		134
					18%		13%
		TOTALS, ASSUMING	G LOSS OF	1022	80		35
		ACCIDENT AVERTE	D BY		88		3%
		LAVATORY FIRE PRECAUTIONS					

# TABLE 4: NET SMOKE HOOD BENEFIT ALLOWING FOR LIKELIHOOD OF USE (ACCIDENTS ANALYSED BY FAA METHOD)

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\* See Appendix II \*\* Lives Saved

	Date	Operator	Place	Aircraft Type	Occupants	Fatalities	Fire Deaths	Potential Benefit	Likelihood of Use	Net Benefit
							*	**	***	
1	15.02.66	Indian Airlines	Palam	Caravelle	80	2	2	1	Mod	1
2	04.03.66	Canadian Pacific	Tokyo	DC-8	72	64	64	12	Neg	0
3	22.04.66	American Flyers	Ardmore	L-188	98	83	0	0	Neg	0
4	16.02.67	Garuda	Menado	L-188	92	22	22	4	LOW	1
6	06.11.67	TWA	Cincinnati	B-707	36	1	0	0	Neg	0
9	12.06.68	Pan American	India	B-707	63	6	6	1	Mod	1
10	26.07.69	Air Algerie	Biskra	Caravelle	37	33	33	6	V High	6
12	06.05.70	Somali	Mogadiscio	Viscount	30	5	5	1	Mod	1
16	06.09.71	Pan International	Hasloh	BAC 1-11	121	21	21	4	Neg	0
17	18.04.72	East African	Addis Ababa	SVC-10	107	43	43	8	LOW	2
20	22.01.73	Alia	Kano	B-707	202	176	176	32	Mod	16
21	31.05.73	Indian Airlines	Palam	B-737	65	48	48	9	LOW	3
23	23.07.73	Ozark	St Louis	FH-227	45	39	0 1	0	Nea	0
26	15.03.74	Sterling	Teheran	Caravelle	96	15	15	3	Mod	2
27	11.09.74	Eastern	Charlotte	DC-9	82	72	40	7	Low	2
28	20.11.74	Lufthansa	Nairobi	B-747	157	59	59	11	Low	3
32	05.04.76	Alaska	Ketchikan	B-727	50	1	0	0	Nea	0
33	27.04.76	American	St Thomas	B-727	89	37	37	7	Low	2
34	04.06.76	Air Manila	Guam	L-188	45	45	34	6	Neg	õ
38	27.03.77	KLM	Tenerife	B-747	248	248	248	45	Neg	0
39	04.04.77	Southern	New Hope	DC-9	85	63	29	5	Neg	0
40	27.09.77	Japan Airlines	Kuala Lumpur	DC-8	79	34	34	6	Neg	0
42	19.11.77	TAP	Funchal	B-727	164	131	131	24	Neg	0
43	11.02.78	Pacific Western	Cranbrook	B-737	49	42	15	3	Nor	0
48	17.12.78	Indian Airlines	Hyderabad	B-737	132	1	1	ĩ	Mod	1
49	13.03.79	Alia	Doha	B-727	64	44	20	Ā	Nor	Ô
52	27.02.80	China Airlines	Manila	B-707	135	2	2	1	Mod	1
58	27.07.81	Aeromexico	Chihuahua	DC-9	66	30	30	5	Mod	3
62	11.03.83	Avensa	Barquisimeto	DC-9	50	23	22	A	Nor	0
66	07.12.83	Aviaco	Madrid	DC-9	42	42	42	8	Nor	0
67	07.12.83	Iberia	Madrid	B-727	93	51	51	a	Tou	2
71	30.08.84	Air Cameroon	Douala	B-737	118	2	2	1	Mod	1
					TOTAL		1475	228		49
	* Where assume	the number of fire d that all fatalit	related death	ns is not kn -related.	nown, it is	pessimistic	ally	18%		48

#### TABLE 5: NET SMOKE HOOD BENEFIT ALLOWING FOR LIKELIHOOD OF USE (FATAL ACCIDENTS NOT ANALYSED BY FAA METHOD)

\*\* 18% of fire-related deaths - see paragraph 4e and Table 2.

\*\*\* See Appendix II

#### APPENDIX I: FAA MODEL

- (NOTE: The FAA intends to publish the analysis they carried out, together with a description of this model. However, since they will not be able to do that in the time-scale of this CAA report, it has been agreed that their analysis method and results may be included in this report).
- 1. The accident is described by two curves estimating
  - (i) Probability of survival within the cabin from fire hazards, as a function of time - P (t),
  - (ii) Evacuation rate capability as a function of time E (t)
- 2. The survivability curve is constructed from available knowledge of the speed with which the fire progressed and the way in which the resulting smoke and fumes built up within the cabin.
- 3. The evacuation rate capability takes account of the capacity of the exits which were used and the times at which they became available or became unusable. It also seeks to take account of the way in which evacuation is likely to be affected in the latter stages by the build-up of smoke and fumes.
- The credibility of the model (see figure 1) can be checked by solving for A, the peak evacuation rate achieved in the accident, in the following equation.

Number of survivors =  $A \int_{0}^{tL} P.E.(t) dt$  (1)

- 5. A should be consistent with known evacuation demonstration data.
- 6. The effects of cabin safety improvements can be assigned to these curves and new values for the number of survivors derived by solving equation (1) in each case. For example
  - (1) fire blocking can be expected to reduce the rate at which the hazard in the cabin builds up (ie the rate at which P (t) declines), and to extend  $t_L$ . It should also slow the reduction in evacuation rate capability in the latter stages.
  - (2) floor proximity lighting can be expected to increase evacuation rate in night evacuations, or during the latter stages of a daytime evacuation where dense smoke has builtup.
  - (3) Protective breathing equipment should make substantial improvements to the hazard in the cabin while at the same sustaining evacuation.
- 7. Figures 2 and 3 show typical sets of curves as derived by application of this model.



FIGURE 1.





Like Smo Hoo Use	Low	Mod	Weg	Low	Low	High		Mod	ě	Very High		Neg			Mod	Mod
Fire related deaths	2 burns 1 - trapped	21	E	IIV	High pro- portion	Probably all 10		Not known	Not known	123		Unlikely Most were inpact			A11 except one crew	Not known
time tion	not wn mplete	n not m mplete	n not n lete	n not m mplete	m mplete	n not m mplete		n m mplete	n not m mplete	fed out				n n olete	n not mplete	r not m mplete
ts Evac	ley, kno ley, kno in Inco ak in elage	t Time r know	9 know e- Comp ak	ak know Inco e-	wn know Inco	wn know Inco		wn know Inco	wn know Inco	h Not ght carr	dows.	•		ht Time e know Comp	t Time r- know g Inco	ts Time know t Inco
ton Ext Use	-b Present	d- Lef	4 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1	d- Non Bre fus	Not kno	d- Not kno		d- Not kno	d- Not kno	f11 f11	E C C C C	•		d- Rig sid	d- Lef win onl	d- Ext ous lef s sid
Evacuat	Unpreme	Unpreme	Premed- itated	Unpreme	Escape and rescue	Unpreme		Unpreme	Unpreme	Not carried out		Escape		Unpreme	Unpreme	Unpreme itated 81 seri injurie
Fire Origin & Spread	Left wing root, Rapid	External fuel fire Rapid	External fuel fire (after al pax left)	Post crash fuel fire	Fuel fire at centre section	Note known but	. post crash	Not known	Kot known	Toilet		Scattered small fires, Probably little or	no fire in cabin	Fuel. left wing	External fuel fire on stbd side	Right wing fuel. Heavy fire JP-1
Cabin crash damage	Severe	Major	Extreme	Extreme	Severe.	Assume negl1- g1ble		Not known	Not known	Minor		Extreme	-	Minor	Minor	N11. On runway
Circumstances	Unsuccessful recovery from bounce on landing	Struck bldgs on approach	Power loss on both engines Forced landing on autobahn	Rejected take off	Struck bldgs on approach	During take off collided	with aircraft crossing runway	Gear failure on landing A/C swerved off runway	NDB approach Descent below MDA. Undershoot in trees 3 km short.	Forced landing due to in- flight fire		Downdraught on approach Crashed in trees		Undershoot	Undershoot into trees	Right gear collapse during taxy for takeoff
Fatal- ities	2	28	21	3	<b>\$</b> 3	10		176	48	123		39		0	96	15
Occu- pants	55	31	121	107	63	45		202	65	134		45		109	101	96
A/C Type Operator Place	8-727 Trans-Carib bean St Thomas	CV-580 Allegheny New Haven	BAC 1-11 Pan-Int. Hasloh Hamburg	SVC-10 East African Addis Ababa	8-737 United Chicago	DC-9 North Central	Chicago	8-707 A11a Kano	B-737 Indfan Afrlfnes Palam, New Delhi	8-707 VARIG	Paris	FH-2278 Ozark St Louis		8-707 Lufthansa Delhi	8-707 Pan American Pago Pago	Caravelle Sterling Teheran
Date	28.12.70	07.06.71	06.09.71	18.04.72	08.12.72	20.12.72		22.01.73	31.05.73	11.07.73		23.07.73		20.12.73	30.01.74	15.03.74
	13	15	16	1	18	19		20	12	22		53		- 24	25	26
Likely Smoke	Mod	Neg	Neg	Low	Neg		feg		5		-	24		T		
	:		:		ş		-	•	H		Mo	High	1	Mo	¥	
Fire	deaths N11	Not known	Mil (all fatal- fites due to	Not known some at rear exit	Not known Some 11kely		E	•	Yes Hi		Not Moc known	Not Ver known Hig	-	5 . Mo	Yes Mo Number	known
Evacuation Fire	deaths Time not Nil known Complete	- Not known	- Mil (all fatal- fites due to	Time not Not known known some at Incomplete rear exit	Time not Not known known Some Incomplete likely		Time not Nil N known Complete	Time not Nil - known	Time not Yes Hi known		Time not Not Mor known known Incomplete	Not Ver known Hig	31-60 Mil -	Time not 5 Mo	Incomplete Time not Yes Mo known. Number	Incomplete Now
Exits Evacuation Fire Used time related	deaths Not Time not Nil known known Complete	None - Not known	Kone - Nil (all fatal- fites due to	Right Time not Not known front known some at Flight Incomplete rear exit deck	Left Time not Not known Front known Some Left Incomplete likely rear		Fud Time not Nil ) galley known Complete	Not Time not Nil - known known	Front Time not Yes HI left known Tight known Over- wing two	right. one left	Not Time not Not Mo known known known Incomplete	kot Not Ver known Hi	Window Nil - exits. 31-60 Aux doors secs. fwd and	aft. Main Time not 5 Mo door known	aft Incomplete All Time not Yes Mo Fiel known. Number	earts incomprete not field galley. galley. areak at rear
Evacuation Exits Evacuation Fire Used time related	deaths Unpremed- Not Time not Nil itated known Complete	Escape None - Not known	None None – M11 Rescue Kone – M11 from A12 from 114s vreckage due to	Unpremed- Right Time not Not known 1 itated Front known some at deck incomplete rear skit	Escape Left Time not Not known front known Some Left Incomplete likely rear		Unpremed- Fwd Time not Nil N itated galley known Complete	Unpremed- Not Time not Nil - itated known known	Premed- Front Time not Yes Hi itated right known Over- wing two	right, one left	Unpremed- Not Time not Not Mou itated known known incomplete	Premed- Not Ver Itated known Hig	Unpremed- Window Nil itated exits. 31-60 Aux doors secs. fud and	aft. Premed- Main Time not 5 Mo itated door known	aft Incomplete Unpremed- All Time not Yes Mo Itated Frid knom. Number	earts incomplete not earcept fed 3 over 8 rear at rear
Fire Evacuation Exits Evacuation Fire Origin Used time related	4 Spread deaths Post Unpremed- Not Time not Nil crash itated known known frag	Scattared Escape None - Not fire known scattered	scattered None · - N11 Scattered None · - N11 veckage from 11 scattered from 11es fite vreckage 11es	External Unpremed- Right Time not Not known spilt fuel ftated front known some at Penetrated filght Incomplete rear exit cabin	reproty Fuel Escape Left Time not Not known fire Escape Left Time not Some antering Left Incomplete Tikely mid cabin rear	during ground s11de	Right Unpremed- Fwd Time not Nil N wing itated galley known had	separated Wheels, Unpremed- Not Time not Nil - slow itated known known	No 2 Premed- Front Time not Yes Hi engine itated laft known pylon over- ving tvo	right. one left	Not Unpremed- Not Time not Not Mov known itated known known known	Elect- Premed- Not Ver rical itated known Hig	No 2 Unpremed- Window Nil - Kindow 31-60 Nil - No 2 Aux dor's secs. Tuel and and and and tue tuel and and the secs.	tank aft. Under Premed- Nain Time not 5 No floor itsted door known	aft incomplete Left Unpremed-All Time not Yes Mo wing itated Fud known. Number	root exits incomplete not exits incomplete known fid galley. 3 over 8 reak at rear
Cabin Fire Evacuation Exits Evacuation Fire crash Origin Used time related	damage & Spread deaths Mil Pott Unpremed- Not Time not Nil reach itated known known known fire	Severe Schtered Escape None - Not fies scattered	Extreme Scattered None - N11 Extreme Scattered None - N11 scattered from 114s fire wreckage due to	Minor External Unpremed- Right Time not Not known split fuel itated front known some at Penetrated Filght incomplete rear exit	reproty Severe Fuel Escape Left Time not Not known fire, front known Some entering Left Incomplete 11kely maid cabin rear	during ground slide	Major Right Unpremed- Fwd Time not Mil N wing itated galleyknown which had	separated Mil. Wheels, Unpremed- Not. Time not. Mil - slow slow itated known known runway	N11 No 2 Premed- Front Time not Yes H1 On engine itated Tert known runway pylon Over- wing two	right. one left	Not Not Unpremed- Not Time not Not Mon known known itated known known known Incomplete	Not Elect- Premed- Not Wer known rical itated known Hig	N11 No 2 Unpremed- Window N11 - On Engine itated exits. 31-60 N11 - rumway No 2 Aux doors secs.	tank aft. Not Under Premed- Main Time not 5 Mo known floor itated door known	aft Incomplete Severe Left Unpremed-All Time not Yes Mo Ving Itated fwd known. Number	root extept incomplete Not extept incomplete known galley. 3 over Break at rear
Circumstances Cabin Fire Evacuation Exits Evacuation Fire crash Drigin Used time related	damage & Spread deaths Undershoot N1 Post Unpramed- Not Time not N11 Crash 1tated known known known fire fire	Impact with Severe Scattered Escape None - Not see wall on Severe Scattered Landing scattered	Struck high Extreme Scattered None - Nil ground on Extreme Scattered None None - Nil scattered From 1514 fire wreckage Gue 10	Heavy landing Minor External Unpremed- Right Time not Not known Gear collapse split fuel iteted front known some at Penetrated teted fight Incomplete rear exit	rapioly Undershoot Severe Fuel Escape Left Time not Not known High rate of fire, front known Some descent entering Left Incomplete likely mid cabin rear	ground stored s11de	Take off Major Right Unpremed- Fud Time not Mil N aborted from wing itated galley known VR had h	separated Nose wheel Mil. Wheels, Unpremed- Not Time not Nil - collapse On slow itated known known runway	Engine fire Nil No 2 Premed- Front Time not Yes Ni on take-off. On engine itated left known aircraft runway pylon over- returned ving two	right. one left	Undershoot Not Not Unpremed- Not Time not Not Mon Hit Tree known known itated known known known Incomplete	In flight Not Elect- Premed- Not Wot Ver fire. known rical itated known known Hi Emergency landia attempted	Uncontained Nil No 2 Unpremed- Window Nil - engine failure On Engine itated exits. 31-60 Au during takeoff runway No 2 Aux doors secs.	tank aft. Crash/loss of Not Under Premed- Main Time not 5 No control due to known floor ittated door known	underfloor fire aft Incomplete Unsuccessful Severe Left Unpremed- All Time not Yes Mo take off on wing trated fwd known. Number	Ice with root exits incomplete not wheels the root except incomplete known locked a lock a alley a lock a area area area area area area area a
Fatal- Circumstances Cabin Fire Evacuation Exits Evacuation Fire fities crash Origin Used time related	damage & Spread deaths 2 Undershoot Wil Post Undershoot Wil Time not Wil crash itated known known and the fred	64 Impact with Severe Scattered Escape None - Not sea wall on Severe Scattered Ianding scattered	83 Struck high Extreme Scattered None - Mil ground on Scattered None - Mil approach scattered from fits fite wreckage fits	22 Heavy landing Minor External Unpremed- Right Time not Not known Sear collapse spiit feel tated front known some at Penetrated deck incomplete rear exit	51 Undershoot Severe Fuel Escape Left Time not Not known High rate of Severe Fuel Escape Left Time not Not known descent entering Left Incomplete 11kely mild cabin rear	ground s11de	1 Take off Major Right Unpremed- Fud Time not Nil 1 aborted from wing itated galley known VR had had	separated 0 Nose wheel N11. Mheels, Unpremed- Not Time not N11 - collapse On slow itated known known runway	5 Engine fire N11 No 2 Premed- Front Time not Yes N1 on take-off. On engine itated left known aircraft runway pyion itated over- returned ving ving returned ving ving ving ving	right. one left	6 Undershoot Not Not Unpremed- Not Time not Not Mo Hit Tree known known itated known known known incomplete	33 In flight Not Elect- Premed- Not Ver Ver Fire. known rical itated known known Hi Emergency landing attempted	0 Uncontained Nil No 2 Unpremed- Window Nil - engine failure On Engine itated exits. 31-60 during takeoff runway No 2 Aux doors secs.	tank aft. 5 Crash/loss of Not Under Premed- Main Time not 5 No control due to known floor itated door known	underfloor fire aft incomplete 47 Unsuccessful Severe Left Unpremed-All Time not Yes Mo take offon Mumber All	Ice with root exits incomplete not wheels incomplete not wheels incomplete the snown locked a lock a sing. and a set is a set in the stream at rear
Occu- Fatal- Circumstances Cabin Fire Evacuation Exits Evacuation Fire pants tiles tiles crash Origin Evacuation Eiged	damage & Spread deaths 20 2 Undershoot W11 Post Uppremed- Not Time not W11 Cresh itsted known known of W11 Tited known know	72 64 Impact with Severe Scattered Escape None - Not sea wall on Scattered Escape None - Known landing scattered	98 83 Struck high Extreme Scattered None - NI ground on Extreme Scattered None - NI approach Extreme from 6a1 fite wreckage from 1168	92 22 Neavy landing Minor External Unpremed- Right Time not Not known 50 Gear collapse spit ted front known some at 70 Penetrated Flight Incomplete rear exit	90 51 Undershoot Severe Fuel Escape Left Time not Not known High rate of fire, Escape Left Time not known Some descent entering Left Incomplete likely maid cabin rear	during ground silde	36 1 Take off Major Right Unpremed- Fwd Time not Nil N aborted from wing itated galley known VR had had	separated 49 O Nose wheel Nil. Wheels, Unpremad- Not Time not Nil - collapse Onl slow itated known known runway	127 5 Engine fire N1 No 2 Premed- Front Time not Yes N1 aircreft On engine itated left known aircreft runway pyion itated over- returned ving ving troo	right. one left	63 6 Undershoot Not Not Unpremed- Not Time not Not Mon Hit Tree known known itsted known known known Incomplete	37 33 Inflight Not Elect-Premed-Not Not Ver Fire. known rical itated known known Hi Emergency landing attempted	65 0 Uncontained Nil No 2 Unpremed- Window Nil - engine failure On Engine itated exits. 31-60 during takeoff runway No 2 Aux doors secs.	tank aft. 30 5 Crash/loss of Not Under Premed- Main Time not 5 No control due to known floor Pramed- door known	underfloorfire aft incomplete 229 47 Unsuccessful Severe Left Unpremed-All Time not Yes Mo take off on ving itated fud known. Number	Ice with root exits incomplete not wheels field except incomplete not increase in the strong increase in the strong increase incr
A/C Type Occu- Fatal- Circumstances Cabin Fire Evacuation Exits Evacuation Fire Deerator pants ities crash Origin Used time related	Place damage & Spread deaths deaths Caravelle 80 2 Undershoot N11 Post Uppremed- Not Time not N11 Indian to the not N11 Indian free free to complete Palam	(Delhi) (Delhi) (DC-8 72 64 Impact with Severe Scattered Escape None - Not Eanadian 72 64 Impact with Severe Scattered Escape None - Not perfits a scattered	10xyo 10	L-188 92 22 Heavy landing Minor External Unpremed- Right Time not Not known Garuda 92 Cear collapse split fuel itated front known some at Penetrated fight Incomplete rear exit	DC-8 90 51 Undershoot Severe Fuel Escape Left Time not Not known VARIG 90 51 Undershoot Severe Fuel Escape Left Time not Not known VARIG descent entering Left Incomplete 11kely mid cabin rear	ground stored s11de	8-707 36 1 Take off Major Right Unpremed- Fwd Time not Mil N TWA aborted from Wing itated galley known Cincinnati VR which itated gallete had	separated 8-7208 49 0 Mose wheel Mil. Wheels, Unpremed- Not Time not Mil - Ethiopian 40 collapse 0 slow itated known known	8-707 127 5 Engine fire Nil No 2 Premed- Front Time not Yes Nil 80AC 127 5 Engine fire Nil No 2 Premed- Front Time not Yes Nil aircraft runway pylon litated left known returned runway pylon cycr- ving two	right. one left	8-707 63 6 Undershoot Not Not Unpremed Not Time not Not No. Pan American Nit Tree known known itated known known known American	Caravelle 37 33 Infiight Not Elect-Premed-Not Not Ver Air Algerie Tre. known rical itated known known Hi Biskra Emergency alading . attempted	DC-8 65 0 Uncontained Nil No 2 Unpremed- Window Nil – SAS engine failure On Engine itated exits. 31-60 Nil – Rome during takeoff runway No 2 Aux doors secs.	tank aft. Viscount 30 5 Crash/loss of Not Under Premed- Main Time not 5 No Somali to control due to known floor ittated door known	Magadiscio underfloorfire aft Incomplete DC-8 229 47 Unsuccessful Severe Left Unpremed-All Time not Yes Mo Captol Int take offon wing itated fwd known. Number	Anchorage New Not root ants incomplete Not wheels the stop and and stop at rear

APPENDIX II: ACCIDENT SUMMARY

Likely Smoke Hood Use	Neg	Neg		Neg		Neg	Neg		Mod			Pow	Neg	
Fire related deaths	Not known	20 smoke and burns. and and	Remainde impact only	Not known	5	Not known	Some	IIN	2 smoke and burns Others not	known Ni 1	L IN	1 burns	20 (24 impact)	K11
cuation				omplete	90 sec plete	F		Ę	ins plete	e Mu plete	60secs plete	gin- ly plete		e wn plete
ed Eva	•	eaks - iselage		eaks >2 Inconstruction	d Community x cors er- ndow fts	t Not own know	ght - ar or eaks	selage t Not own know	1 on 5 m ght com de	composition to the composition of the composition o	fin 31-f ors Com d t	in Not ors know ont Mar d al t comy	•	in Time re not d know t Comp
ation Ey Us				8-5	- Addu a a a	A No	2 1 9 8 ÷	- on - bed	si si	ned- No	y No fo	Ado Ado		- Ma an af
Evacu	None	Escap		Escape	Unpred	Not known Escape and rescue	Escape	Unpren itated	Unpren itated	Unprem itateo	Unpren Itated Orderl injuri	Unprem	Escape rescue	Premed
Fire Origin & Sprea	Fuel fire Rapid	Post crash fuel. Rapid Also petrol	petrol station	Post crash fuel fire	Right gear	Not known	General post crash fire	Not known	Left wing fuel fe Rapid	Not known	Power/ Plant	Post crash fuel fire under rear cabin	General post crash fire	Wing
Cabin crash damage	Extreme	Extreme		Severe	N11 On runway	Extreme or severe	Extreme	Nil/ minor likely	Nil On runway	Severe/ major 11kely	minor likely	Severe	Extreme	Severe
Circumstances	Collision on ground (See No 37)	Both engines stopped by hail encounter Forced landing on road.		Undershoot Collision with high ground	Tyres burst during take- off. Aborted. Stop on runway	Landed long and overrun	Crash during go around due to thrust reverser deploying in	Tilght on one engine Hard/undershoot landing	Rejected take off from V <sub>1</sub> due to tyre failures	Deep touch- down and overrun	Gear-up landing	.Descent after take-off	In go around forced to the ground by wind shear	Bomb explosion during descent Fast landing and overrun
Fatal- ities	248	5		38	•	131	42	0	*	0	0	-	\$	0
Occu- pants	248	88		5 1		164	49	196	202	222	42	132	5	67
A/C Type Operator Place	8-747 8-747 KLM Tenerife	DC-9 Southern New Hope		DC-8 Japan Airlines Kuala Lumpu	DC-8 Capitol Int Shannon	B-727 TAP Funchal Madeira	B-737 Pacific Western Cranbrook	B-707 Sabena Tenerife	DC-10 Continental	DC-8 Iberia Santiago Spain	8-737 VASP Sao Paulo	B-737 Indian Airlines Hyderabad	B-727 Alfa Doha	8-737 Indian Airlines Madras
Date	38 27.03.77	39 04.04.77		40 27.09.77	41 03,10.77	42 19.11.77	43 11.02.78	44 15.02.78	45 01.03.78	46 03.03.78	47 02.04.78	48 17.12.78	49 13.03.79	50 26.04.79
tkely Smoke Hood Jse								_						
the	13	Ľ				e		ŏ			o		0	
1-4		ssible t also pact	_			e act)		on Mact	5	*	Ŧ	•	2	
e rele deal	ot 40 lete	ot Some possible but also impact	at Mil	111	E .	Mil N (one impact)		combin- M ation ete of impact smoke	burns	34 N smoke and burns	tin .	- 111	Not Ne Ne	
s Evacuation Fir- time rel	Time not 40 known. w Incomplete	age Time not Some known possible Incomplete but also	Time not Nil known Complete	Time not Nil known Complete	Time not Nil known. Complete	Not N11 N known (one impact)	age	1-11/2 Combin- M mins ation Incomplete of impact	ge burns	Mot 34 M started smoke and burns	2 mín Níl Hi complete	Time not Nil - known Complete	1 minute Not Ne Incomplete known	2
on Exits Evacuation Fire Used time relideal	Cock Time not 40 pit known. window Incomplete	fuselage No 2 Time not Some right known possible No 3 Incomplete but also right impact	. Not Time not Nil known known Complete	Not Time not Nil known known Complete	Right Time not Nil front known. Complete	Main Not Nil n cabin known (one door, impact)	iert over- ving. Noles in fuselage	Both 1-11/2 Combin- M left mins/2 combin- M over- Incomplete of impact Breaks smoke	fuselage burns	- Not 34 M started smoke burns	All 2 min Wil Hi except complete	over- wing Not Time not Wil - known known	Zteft 1 minute Not Ne Breaks Incomplete known	fuselage
Evacuation Exits Evacuation Fir- Used time relident	Escape Cock Time not 40 pit known. window Incomplete	fuselage Unpremed- No 2 Time not Some itated No 3 Incomplete but also right incomplete but also	Unpremed- Not Time not Nil itated known known Complete	Unpremed- Not Time not Nil Itated known known Complete	Unpremed- Right Time not Nil Itated fromt known. Complete	Escape Main Not Mil N cabin known (one door, finpact) 1y Both	over- ving. Moles to tuselage	Escape Both 1-11/2 Combin- M left mins ation over- incomplete of wing Breaks smoke	fuselage burns	None - Not 34 M started smoke burns	Unpremed- All 2 min Wil Hi itated except complete	ving Wing Unpremed- Not Time not Nil - itated known known Complete	Unpremed- 2Left 1 minute Not Ne itated Breaks Incomplete known	fuselage
Fire Evacuation Exits Evacuation Fir- Origin Used Vilme rel. & Spread	Fuel Escape Cock Time not 40 fed Bit known. Post bindow Incomplete cresh holes Incomplete	Left Unpremed- No 2 Time not Some wing Itated No 3 Incomplete but also right incomplete but also	Slow Unpremed- Not Time not Nil "after itated known known several Complete	minutes- Right Unpremed- Not Time nof Nil body itsted known known known	slow Right Unpremed- Right Time not Nil wing itated front known. Complete	Post Escape Main Not Nil N Fresh Escape Main Not Nil N Fresh Goor, Anown (one Relatively Both	over- over- ving- holes fuselage	Post Escape Both 1-11/2 Combin- M crash Escape Both 1-11/2 Combin- M left mins ation Ving timpet Ming timpet Breaks smoke	into fuselage burns cabin fuselage burns breaks	uel None - Not 34 M Repid - started smole and Part purns	eft Unpremed- All 2 min Wil Hi ving itated except complete	over- wing tight Unpremed- Not Time not Nil - ind itated known known nud tight	ngines eneral Unpremed- 2.Left 1 minute Not Ne apid itated Breaks incomplete known Ne	fuselage
Cabin Fire Evacuation Exits Evacuation Fir- crash Origin Used time rel damage & Spread deal	Extreme Fuel Escape Cock Time not 40 fed pit known. Post nidew Incomplete fissh holes	Major Left Unpremed- No 2 Time not Some wing itated No 3 Incomplete but also right incomplete but also	Minor Slow Unpremed- Not Time not Mil "after itated known known several Complete	minuces" Mil Right Unpremed- Not Time not Mil on body Itated known known known	slow Minor Right Unpremed- Right Time not Mil wing itated front known. Complete	Severe Post Escape Main Not Nil n Crash Escape Main Not Nil n fire door cabin known (one fire door impact)	orom over- ving. Noles fuselage	evere Post Escape Both 1-11/2 Combin- M crash left mins ation fifte over- incomplete of Right wing Breaks smoke	into fuselage burns cabin fuselage burns breaks	evere Fuel None - Not 34 M Raid smoke and (Part Durns -27%)	eg Left Unpremed- All 2 min Mil Hi wing itated except complete	11 Right Unpremod- Not Time not Mil - wing itated known known known and toto too	engines erreme General Unpremed- 2Left 1 minute Not Ne Rapid itated Breaks Incomplete known	fuselage
umstances Cabin Fire Evacuation Fir crash Origin Used time rel damage & Spread	shoot Extreme Fuel Escape Cock Time not 40 trees post bildow Incomplete crash holes holes	after Major Left Unpremed- No 2 Time not Some off Major Left Unpremed- No 2 Time not Some No 3 Incomplete but also right impact	shoot Minor Slow Unpremed- Not Time not Nil "after itated known known several Complete	minutes off Mil Right Unpremed- Not Time not Nil On body itated known known known re runway gear	slow e bird Minor Right Unpremed- Right Time not Nil g take- hoorted hoorted borted Stortes Stortes	un Severe Post Escape Main Not Nil n Filog Cash Escape Main Not Nil n fast fire door impact) downon Relatively Soth	over- ving. bioles in fuselage	In Severe Post Escape Both 1-11/2 Combin- M ring crash Escape Both 1-11/2 Combin- M if of the of ation fire over- Incomplete of Right wing Incomplete of Ning, Breaks smoke	tato fuselage burns cabin fuselage burns breaks	e Severe Fuel None - Not 34 M e Rapid - started smole and Jpar	ff Neg Left Unpremed- All 2 min Mil Hi ed wing itated except complete VR	over- ving 1 Nil Right Unpremed- Not Time not Nil - Not time not Nil - ngine two right	engines e taxying Extreme General Unpremed- 2.Left 1 minute Not Ne ay, Rapid itated Breaks Incomplete known Ne	off. fuselage 338)
- Circumstances Cabin Fire Evacuation Exits Evacuation Fir- crash Origin Used View rel damage & Spread deal	Undershoot Extreme Fuel Escape Ock Time not 40 into trees Extreme Fuel Escape Ock Time not 40 post Post Prindow Incomplete	Stall after Major Left Unpremed- No 2 Time not Some take off Major Left Unpremed- No 2 Time not Some take off Major Left Unpremed- No 3 Incomplete but also right incomplete but also	Undershoot Minor Slow Unpremed- Not Time not Mil after itated known known several complete	minutest Take off Mil Right Unpremed- Not Time not Nil Tyre On body itated known known known filure runmay gear	slow Engine bird Minor Right Unpremed- Right Time not Nil Ingestion wing itated front known. during take Complete from Y. Boorted from Y. Gam	Overrun Severe Post Escape Main Mot Mil n following Carash Escape Main Mot Mil n long fast fire cabin known (one touchdown on Relatively Both	ver	Overrun Severe Post Escape Both 1-11/2 Combin- M following free crash left mins ation long free over- Incomplete of Right wing Breaks smoke	into fuselage burns through breaks	Engine Severe Fuel Mone - Mot 34 M failure fire Rapid - started smoke on take Rapid - started smoke of . JP4 Migh -27%) figh -27%	Take-off Neg Left Unpremed- All 2 min Wil Hi rejected wing itated except complete after Vg	unding in Mil Right Unpremed- Not Time not Mil - bad visibility and itated known known known and No 4 engine two too	yround Wing rupture While taxying Extreme General Unpremed- ZLeft 1 minute Not Ne Anile taxying Extreme Rapid itated Breaks Incomplete known	taking off. fuselage (See No 38)
<ul> <li>Fatal- Circumstances Cabin Fire Evacuation Exits Evacuation Fire ities</li> <li>ities crash Origin Used time reliance</li> <li>deal</li> </ul>	72 Undershoot Extreme Fuel Escape Cock Time not 40 into trees Extreme Fuel Escape Cock Time not 40 post price for the formation incomplete	59 Stall after Major Left Unpremed- No 2 Time not Some take off Major Left Unpremed- No 2 Time not Some possible No 3 Incomplete but also right known	0 Undershoot Minor Slow Unpremed- Not Time not Nil "after itated known known several Complete	0 Take off W11 Right Unpremed- Not Time not N11 Tyre On body itated known known known filure runway gear	0 Engine bird Minor Right Unpremed- Right Time not Nil ingetion wing itated from known. during take- off. Aborted from 1. Gear collapsed	1 Overrun Severe Post Escape Main Not Mil n following Crash Escape Main Not Mil n long fast fire cabin known (one touchown on Relatively Both mpact)	ver- ving. Noles in fuselage	37 Overrun Severe Post Escape Both 1-11/2 Combini M following crash Escape Both 1-11/2 Combini M long Right over Incomplete of Right wing Breaks smoke	thto the and t	45 Engine Severe Fuel None - Not 34 M filure Fire None - Not 34 M on take Rapid smoke and on take Rapid and Impet JP4 burns with -27%)	0 Take-off Neg Left Unpremed- All 2 min Wil Hi rejected wing itated except complete after VR	0 Landing in Nil Right Unpremed- Not Time not Nil - bad visbility and itated known known known Not 4 engine two struck right	Ming Ving rupture 335 Mhile taxying Extreme General Unpremed- 2Left 1 minute Not Ne on runway.	taking off. (See No 38)
Occu- Fatal- Circumstances Cabin Fire Evacuation Exits Evacuation Fir- pants ities crash Origin Used view rel damage & Spread deal	82 72 Undershoot Extreme Fuel Escape Cock Time not 40 into trees Extreme Fuel Escape Cock Time not 40 post pitt known. crash holes Incomplete	157 59 Stall after Major Left Unpremed- No 2 Time not Some possible take off Major Left Unpremed- No 3 Timeown possible right known possible right also	50 0 Undershoot Minor Slow Unpremed- Not Time not Nil "after itated known known several Complete	and the art will be a superior with the second of the second second with the second se	139 0 Engine bird Minor Right Unpremed- Right Time not Nil ingestion wing itated front known. during take- off. Aborted from Y1. Gear collapsed	50 1 Overrun Severe Post Escape Main Not Nil n following fast fire cabin known (one long fast fire door, impact) wething and severe post severe post	ver ennoy. a ton over- ving. bioles in fuselage	89 37 Overrun Severe Post Escape Both 1-11/2 Combin- M following Severe Post Escape Both 1-11/2 Combin- M long fire over Incomplete of landing Right wing Incomplete of Right wing Reaks smoke	tico fuselage burns cabin fuselage burns breaks	45 45 Engine Severe Fuel Mone - Not 34 M Failure Severe Fuel Mone - Not 34 M on take Rapid - started smoke on take	86 O Take-off Neg Left Unpremed- All 2 min Wi rejected wing itated except complete after VR	60 0 Landing in Nil Right Unpremed- Not Time not Nil - bad visibility and itated known known known No 4 engine two struck right	Ming Wing rupture 405 335 Mhile taxying Extreme General Unpremed- Zleft 1 minute Not Ne on runway, Rapid itated Breaks Incomplete known	taking off. fuselage (See No 38)
A/C Type Occu- Fatal- Circumstances Cabin Fire Evacuation Exits Evacuation Fir- Operator pants ities crash Origin Used view rel Place deal	4 DC-9 82 72 Undershoot Extreme Fuel Excape Cock Time not 40 Eastern 1 into trees Extreme Fuel Excape 01 known. Charlotte crash holes Incomplete crash holes incomplete	4 8-747 157 59 Stall after Major Left Unpremed- No 2 Time not Some Lufthansa 157 59 Stall after Major Left Unpremed- No 2 Time not Some Natrobi Natrobi	4 DC-9 50 0 Undershoot Minor Slow Unpremed- Not Time not Mil JAT after itated known known Beigrade complete	Minuces" 18-747 394 0 Take off Mil Right Unpremed- Not Time not Nil Air France Dn body Itated known known known Bombay filure runway gear	slow DC-10 139 0 Engine bird Minor Right Unpremed- Right Time not Mil Overses dringston wing itated front known. Mctional dring take dring take Complete From Y. Gaorted fron V. Gamplete collapsed	B-727 50 1 Overrun Severe Post Escape Main Not Mil A Alaska following Severe Post Escape Main Not Mil A Ketchikan long fast fire door, impact) Louchdown on Relatively Both	ver over ver ver ver ver ver ver ver ver ver	B-727 89 37 Overrun Severe Post Escape Both 1-11/2 Combin- M American following crash test ation long fifte over- Incomplete of ation St Thomas landing Right wing Incomplete of wing. Breaks smoke	thto fuselage burns through breaks	L-1881 45 45 Engine Severe Fuel None - Not 34 M Air Manila 45 failure Severe Fuel None - Not 34 M Guam on take Rapid smoke and off. (Part JP4 Migh -27%) proving around and and and and and and and and and and and	DC-9 86 O Take-off Neg Left Unpremed- All 2 min Mi rejected wing itated except complete after VR	8-707 60 0 Landing in Nil Right Unpremed- Not Time not Nil - Iraqi bad ving tated known known known each each each each each to tao complete to tao tao tao tao tao tao tao tao tao	yround Mig rupture B-747 405 335 Mhile taxying Extreme General Unpremed- 2Left 1 minute Not Ne Pan American Ath. 272	Tenerife taking off. fuselage (See No. 38)

Likely Smoke Hood Use	Very high			Neg	Low					pow		fod			
Fire related	23	LIN	118	Not known	vot cnown		Ξ	Ξ	Ŧ	ot nown	Ę	5	-		
cuation time	a not m mplete	not m olete	n n lete		not	mplete	not lete	not M	ete N	2.7	not N ete	plete 5	not N	e te	
its Eva	t know t know ht Inco	wn know Comp	t know Comp	1 8	n Time known	Incor ak elage	time knowr Compl	r time compl	3 min t Compl	n Not	y Time known Compl	Incom t,	Time T known	Comple	
ton Ext Use	Fro and 3 o win	d- Not kno	d- Mai lef Fwd door	None	1- Mair and	aux door Brea fus	- Main door fwd	- Not know	- All righ side	fron - Not know	Entr	- Fwd left right Right over-	wing Not known		
Evacuat	Premed- ftated	Unpreme	Unpreme	None	Unpremed		Unpremed	Unpremed	Unpremed	Unpremed. itated	Unpremed. itated	Unpremed- itated	Premed- itated	~	
Fire Origin	Toilet	Not	Power/ Plant	Wing	/ Wing	<u>=</u>	Wing	Aft cargo comp.	Left engine wing Rapid	Right wing/ engine fuel	Fwd hold	Left wing	Not known		
Cabin crash	N11 On runway	IN .	N11 On runway	Extreme	Extreme	aft cabi	EN .	Nil. On ramp	Nil. On runway	Nil. On runway	Nil On ramp	Ni 1 On runway	Not known	Minor	
Circumstances	In-flight fire	No 1 engine failed during takeoff. No 2 damaged. Abort	No 2 engine exploded at 80 kt on take- off	While taxying hit by 727 taking off (See No 67)	Aircraft at V1 collided	runway (See No 66)	Hit trees in undershoot. Came to rest 1000m before runway	Explosion in aft cargo compartment during loading	Engine failure with fuel tank penetration	During taxy to tale-off, engine comp. disc burst. Fuel	Fire in fwd hold on ground	Uncontained engine failure during takeoff Fuel tank punctured	Wheels up landing	(intentional)	
Fatal- ities	23	0	0	42	51		0	0	0	8	0	55	0		
Occu- pants	46	142	68	42	93		247	23	119	118	10	137	45		
A/C Type Operator	DC-9 Air Canada Cincinnati	8-727 United Chicago	Caravelle Altair Milan	DC-9 Aviaco Madrid	B-727 Iberia	0	Afrbus A300 Malaysian Kuala Lumpur	DC-8 UTA Ndjamena	B-737 Pacific Western Calgary	8-737 Air Cameroon Douala	3-707 Cyprus Curich	3-737 5-111sh 11rtours fanchester	-188 andala	ndonesia	
Date	<b>6</b> 3 02.06.83	54 11.06.83	5 02.07.83	6 07.12.83	7 07.12.83		8 18.12.83	9 10.03.84	0 22.03.84	1 30.08.84	2 13.10.84	3 22.08.85	4 30.11.85 L		
							0	•	-	-	~	~	-		
7.9	I		•					•	-	-		~	4		
ed Smoke Hood Use	Mod	Mod	ery htgh		9	Mod	Low.	•		2	7 bow		-	Mod	Neg
m fire Likely related Smoke Hood Use	14 Mod	2 Mod	All Very high	9	9	A11 Mod	Nil Low 6	•	7 	~	Not Mod known 7	7 - Lin	- THN	Mod 12	22 Neg
Evacuation Fire Likely time related Smoke Hood Use	a <sup>1</sup> /2 mins 14 Mod	Time not 2 Mod cnown late	All Very Algh	6 	nown omplete	2 mins All Mod ncomplete	5 secs N11 Low 6	•	n 90 sec N11 -	omplete 7	min Not Mod 7 known Mod 7	7. Janin Nil - Molete	imins Nil - 7,	imins 51 Mod complete	mins 22 Neg
Exits Evacuation Fire Likely Used time related Smole Hood Use	Front $\frac{3^{1}/2}{10^{2}}$ = 14 Mod left $\frac{4^{1}/2}{10^{2}}$ mins 14 Mod (silde failed after after had	escaped Not Time not 2 Mod known forcentiates	All Very	Mot Tiens and Mill	Known Known Complete	All? >2 mins All Mod Incomplete	Left 55 secs N11 Low 6 over- ving (Cargo	cabin Crew Crew Growt	door vertal door vertion All <90 sec Nil -	left : complete side :	Main 5 min Not Mod 7 and known Mod 7 doors	7. Rt fwd 2-3 min Nil - Teft Complete eart Adoors	Not 75 mins Nil - 7. known	Main >5 mins 51 Mod Joors Incomplete 51 Mod Front Incomplete 5 I rear She or word 5 out 6 pen	sreaks>5 mins 22 Neg n uselage
Evacuation Exits Evacuation Fire Likely Used time related Smoke Hood Use	Unpremed- Front $3\frac{1}{3}$ - 14 Mod itated left $4\frac{1}{2}$ mins it (side failed after 4050 had	escaped Unpremed- Not Time not 2 Mod itated known Trorwniae	Not All Very carried	ouc stopping stopping kot Time on uti	itated known known complete	Unpremed- All7 >2 mins All Mod Itated Incomplete	Unpremed- Left 55 secs Mil Low 6 itated over- ding (Cargo Comp	cabin cabin ignorant of	door and a second a s	itated left complete 7	Jnpremed- Main 5 min Not Mod 7 Leated and known Mod 7 aux doors	7 Mpremed- Rt fwd 2-3 min Nil - ltated Tefr Complete entry doors doors	Inpremed- Not 75 mins Nil - 7. Itated known 75 mins Nil -	Inpremed- Main >5 mins 51 Mod tated doors Incomplete Front front front one or more would not open	npremed- Breaks >5 mins 22 Neg tated fuselage
Fire Evacuation Earls Evacuation Fire Likely Origin Evacuation Used time related Smoke Hood Use	Post- Unpremed- Front 3/2 - 14 Mod crash itated left 41/2 mins fuel (silde fire failed after wing 40/50 had	escaped Not Unpremed- Not Time not 2 Mod known itated known Incompas	buder Not All Very Floor carried All Very	rear out fuselage Delay in stopping left Unpremand. Mot Tian not wil	engine itated known Known Complete 6	Ost Unpremed- All? >2 mins All Mod resh itated Incomplete All Mod fire	tight Unpremed- Left 55 secs Nil Low 6 side itated over- tapid (Cargo comp	cabin cabin Crew Ignorant of	door operation eft Unpremed- All <90 sec Nil -	ngine itated left complete ated) side complete ated) of the side complete tedio side complete tedio severe	abin Umpremed- Main 5 min Not Mod 7 JP4 itated and known Mod 7 uel) aux doors	7 pilled Unpremed- Rt fwd 2-3 min Nil - uel itated left Complete apid entry doors doors	ot Unpremed- Mot 75 mins Nil - 7. Nown itated known 75	ngine Unpremed- Main >5 mins 51 Mod and front front sst be or asch one or action tash more not open	igines Unpremed- Breaks >5 mins 22 Neg Lei fed itated in fuselage sst fuselage
Cabin Fire Evacuation Exits Evacuation Fire Likely crash Origin Evacuation Used time related Smoke Hood Use	Major Post- Unpremed- Front 31/2 - 14 Mod crash itated left 41/2 mins fuel (side fire failed Right after wing 40/50 had	escaped Not Not Unpremed- Not Time not 2 Mod known known itated known Incremiaea	til Under Not All Very n. floor carried All Very	umay rear out fuselage Delay in stopping finor Left linnemad- web Time and uit	engine itated known known complete	ievere Post Unpremed- All? >2 mins All Mod crash itated fire fire	linor Right Unpremad- Left 55 secs Nil Low 6 side itated over- Rapid (cargo Comp	cabin cabin Crew Strew Strew	door Left Unpremed- All <90 sec Nil -	n engine itated left complete umay (separ- sted) side complete and left wing revere Not severe	ktreme/Cabin Unpremed- Main 5 min Not Mod 7 ear (JP4 itated and known Mod 7 inor/fuel) atated ax doors	il Spilled Unpremed- Rt fwd 2-3 min Nil - i fuel Itated Teft Complete unway Rapid tated entry doors	ot Mot Unpremed- Not 75 mins Mil - 7 Nown known Itated known 5	1 Engine Unpremed- Main >5 mins 51 Mod fuel itated doors Incomplete 51 Mod foot front post å rear one or would oot open open	treme Engines Unpremed- Breaks >5 mins 22 Neg Fuel fed itated in post fuselage crash
nces Cabin Fire Evacuation Exits Evacuation Fire Likely crash Drigin Evacuation Used time related Smole Hood Use	uring Major Post- Unpremed- Front 31/2 - 14 Mod crash itated left 41/2 mins fuel itated iside fire failed Right after wing A0/50 had	escaped t Not Not Unpremed- Not Time not 2 Mod known known itsted known Incomnists	fire Nil Under Not All Very to on floor carried All Very	ing rumay rear fuselage Delayin stopping Minor Laft Unoreased Mot Time and wit	engine itated known Known of a strain of wing	Severe Post Unpremed- All? >2 mins All Wod crash itated Incomplete fire	Minor Right Unpremed- Left 55 secs Mil Low 6 side itated over- Rapid (croso comp	cabin) crew Sprorant of	door left Unpremed- All <00 sec Nil -	n Un engine itated left complete side complete ated) ated wing root Not severe	n Extreme/Cabin Unpremed- Main 5 min Not Mod 7 F rear (JP4 itated and known Known Minor/ fuel) aux tils fwd	1 Nil Spilled Unpremed- Rt fwd 2-3 min Nil - 7 ure On fuel itated left Complete coff runway Rapid tated tear tel anway Rapid entry ated	Not Not Unpremed- Not 75 mins Nil - 7. .o known known itated known	ke- Nil Engine Unpremed- Main 25 mins 51 Mod Fuel itated doors incomplete foot front post å rear one or more ovuld poen open	g Extreme Engines Unpremed- Breaks >5 mins 22 Neg Fuelfed itated in post fuselage crash
Circumstances Cabin Fire Evacuation Exits Evacuation Fire Likely crash Origin Evacuation Used time related Smoke Hood Use	Overrun during Major Post- Unpremed- Front 31/2 - 14 Mod landing crash itated left 41/2 mins fire filed Right after wing 40/50 root had	escaped Undershoot Not Not Unpremed- Not Time not 2 Mod known known itated known facconniaea	In flight fire Wil Under Not All Very Burned out on floor carried All Very high	arcerianoing rumay rear olut fuselage Delayin Undershoot Minor Left Unveened Not Time on Wil	engine itated Known Known Complete é	Undershoot Severe Post Unpremed- All? >2 mins All Mod crash itated Incomplete All Mod fuel fire	Undershoot Minor Right Unpremed- Left 55 secs Mil Low 6 with gear side itated over- with gear Rapid (Cargo Comp.	cabin cabin crew fgnorant	doortral doortation Touchdown Minor Left Unpremed- All <90 sec Mil -	during go Un engine itated laft complete around with runway (separ- geurnd with sted) side omplete retracting and left wing root Not severe	Landed 150m Extreme/ Cabin Unpremed- Main 5 min Not Mod 7 to right of rear (194 itated and known known runway. Strong sualls fud doors doors	Uncontained Nil Spilled Unpremed- Rt fwd 2-3 min Nil - engine fallure On fwel itated left Complete Aborted. Fwel runway Rapid entry tank penetrated doors	Overrun on Not Not Unpremed- Not 75 mins Nil - 7 landing into known known itated known 7 trees	Rejected take- Nil Engine Unpremed- Main >5 mins 51 Mod Fuel itated doors Incomplete 51 Mod feat front noomplete post a rear more would not open	Hard landing Extreme Engines Unpremed- Breaks >5 mins 22 Neg Fuel fed itated in post fuselage crash
Fatal- Circumstances Cabin Fire Evacuation Exits Evacuation Fire Likely ities crash Origin Evacuation Used time related Smoke Hood Use	14 Overrun during Major Post- Unpremed- Front 31/2 - 14 Mod Tanding crash itated left 41/2 mins fuel fiel field field after wing after wing after root had	escaped 2 Undershoot Not Not Unpremed- Not Time not 2 Mod known known itated known Incremises	301 in flight fire Nil Under Not All Very Burned out on floor carried All Very High	arcerianuing rumay rear fuselage Delayin 0 Undershoot Minor Left Unormand- web Tiam and ui	engine itated known known right ocmplete	<pre>15 Undershoot Severe Post Unpremed- All? &gt;2 mins All Mod crash itated fue fue fie</pre>	0 Undershoot Minor Right Unpremed- Left 55 secs Nil Low 6 with gear side itated over- failure Rapid itated (cargo comp	cabin) crew foreart of norant	door door Minor Left Unpremed- All 30 sec Mil -	around with runway (separ- gear ated) and left complete 7 gear ated) ated retracting and left wing revere Not severe	30 Landed 150m Extreme/ Cabin Unpremed- Main 5 min Not Mod 7 to right of rear (J04 itated and known known runway. Turnway. And Y uel) itated and and known add showers and showers	0 Uncontained Mil Spilled Unpremed- Rt fwd 2-3 min Mil - 7 engine fallure On fuel itated left Complete Aborted. Fuel runway Rapid entry tank penetrated doors	0 Overrun on Not Not Unpremed- Not 75 mins Mil - 7 landing into known known itated known 5 mins Mil - 7 trees	51 Rejected take- Nii Engine Unpremed- Main >5 mins 51 Mod fuel itated doors Incomplete fad front post brear crash more would opt	23 Hard landing Extreme Engines Unpremed- Breaks >5 mins 22 Neg Fuel fed itated in post fuselage crash
Occu- Fatal- Circumstances Cabin Fire Evacuation Exits Evacuation Fire Likely pants ities crash Origin Evacuation Used time related Smoke Hood Use	154 14 Overrun during Major Post- Unpremed- Front 3 <sup>1</sup> / <sub>2</sub> - 14 Mod landing crash itated left 4 <sup>1</sup> / <sub>2</sub> mins fuel (side 4 <sup>1</sup> / <sub>2</sub> mins fie failed Right after wing 40/50 had	escaped 135 2 Undershoot Not Not Unpremed- Not Time not 2 Mod known itsted known Tarcowniats	301 301 In fiight fire Nil Under Not All Very Burned out on floor carried All Very High	arcer landing rumway rear out fuselage Delay in stopping 134 0 Undershoot Winor Left Unoremand. Mot Time of vil	engine itated known Known of e	226 IS Undershoot Severe Post Unpremed- All? >2 mins All Mod crash itated Incomplete fuel fire	73 0 Undershoot Minor Right Unpremed- Left 55 secs Mil Low 6 with gear aide itated over- failure Rapid (croso comp	cantro canto Grew Sgnorant	doortral doortation 110 0 Touchdown Minor Left Unpremed- All <00 sec Nil -	auring go Un engine itated left complete around with runway (sear- gear ated) retracting and left wing rout Not severe	66 30 Landed 150m Extreme/Cabin Unpremed- Main 5 min Not Mod 7 to right of rear (JP4 itated and known known runway. Strong squalls fwd and showers f fwd	124 0 Uncontained Nil Spilled Unpremed- Rt Fwd 2-3 min Nil - 7 engine fallure On Fuel Itated left Complete Aborted. Fuel runway Rapid entry tank penetrated doors	138 O Overrun on Not Not Unpremed- Mot 75 mins Mil - 7. landing into known known itated known 7 mins Mil - 7.	393 51 Rejected take- Nil Engine Unpremed- Main 25 mins 51 Mod fuel tated doors incomplete feel itated front post a rear crash more would poen	50 23 Hard landing Extreme Engines Unpremed- Breaks >5 mins 22 Neg Fuel fed itated in post fuselage crash
A/C Type Occu- Fatal- Circumstances Cabin Fire Evacuation Exits Evacuation Fire Likely Operator pants ities crash Origin Evacuation Used time related Smoke Hood Use	DC-8 154 14 Overrun during Najor Post- Unpremed- Front 31/2 - 14 Mod Swissair landing tuel tated left 41/2 mins Hod Athens fire failed Right after dated wing work had	escaped B-707 135 2 Undershoot Not Not Unpremed- Not Time not 2 Mod China Airlines Airlines	Manila L-1011 301 301 In filght fire Nil Under Not All Very Sauda Barned out on floor carried All Very bioto	nuyadu arter tanung rumay rear olu fuselage Daut 8-737 134 0 Undershoot Minor Left Unnemand Mut Tian not Uti	TANG Benguela Complete vight Itated Known Known right Complete 6	8-747 226 15 Undershoot Severe Post Unpremed- All? >2 mins All Mod Korean Soul Incomplete All incomplete fire	B-727 73 0 Undershoot Minor Right Unpremed- Left 55 secs Mil Low 6 Continental with gear side itated over- Yap Island failure Rapid (Cargo Comp	cabin crew Grew Ignorant	door a contral door a contral door a contral door a contral of a contraction a contrac	Arr val during go Un engine itated laft complete Santa Ana around with runway (separ- gearnd with runway (separ- and laft and laft wing root Not severe	0C-9 66 30 Landed 150m Extreme/ Cabin Unpremed- Main 5 min Not Mod 7 Aeromexico to right of rear (1094 itated and known known 2hihuahua Strong sualls fud and showers fud	17 Strbus A300 124 0 Uncontained Wil Spilled Unpremed- Rt fwd 2-3 min Wil - Nit France engine failure On fwel itated left Complete Aborted. Fuel runway Rapid entry tank penetrated doors	1-737 138 0 Overrun on Not Not Unpremed- Not 75 mins Nil - 7. iouthwest landing into known known itated known 7 shigaki 1s1. trees	CC-10 393 51 Rejected take- N11 Engine Unpremed- Main >5 mins 51 Mod pointex off feel itated doors Incomplete 51 Mod feal front normplete 51 Mod feal feal feal feal feal feal feal feal	C-9 50 23 Hard landing Extreme Engines Unpremed- Breaks >5 mins 22 Neg vensa arquisimeto post fuselage crash