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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 in-flight 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.

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"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	Indian Airlines	Palam	Caravelle	80	2
2	04.03.66	Canadian Pacific	Tokyo	DC-8	72	64
3	22.04.66	American Flyers	Ardmore	L-188	98	83
4	16.02 67	Garuda	Menado	L-188	92	22
* 5	05.03.67	VARIG	Monrovia	DC-8	90	51
6	06.11.67	TWA	Cincinnati	B-707	36	1
7	09.01.68	Ethiopian	Beirut	B-720	49	0
* 8	08.04.68	BOAC	Heathrow	B-707	127	5
9	12.06.68	Pan American	India	B-707	63	6
10	26.07.69	Air Algerie	Biskra	Caravelle	37	33
11	19.04.70	SAS	Rome	DC-8	65	0
12	06.05.70	Somali	Mogadiscio	Viscount	30	5
* 13	27.11.70	Capitol Inter.	Anchorage	DC-8	229	47
* 14	28.12.70	Trans Caribbean	St Thomas	B-727	55	2
* 15	07.06.71	Allegheny	New Haven	CV-580	31	28
16	06.09.71	Pan International	Hasloh	BAC 1-11	121	21
17	18.04.72	East African	Addis Ababa	SVC-10	107	43
* 18	08.12.72	United	Chicago	B-737	63	43
* 19	20.12.72	North Central	Chicago	DC-9	45	10
20	22.01.73	Alia	Kano	B-707	202	176
21	31.05.73	Indian Airlines	Palam	B-737	65	48
* 22	11.07.73	VARIG	Orly	B-707	134	123
23	23.07.73	Ozark	St Louis	FH-227	45	39
24	20.12.73	Lufthansa	Delhi	B-707	109	0
* 25	30.01.74	Pan American	Pago Pago	B-707	101	96
26	15.03.74	Sterling	Teheran	Caravelle	96	15
27	11.09.74	Eastern	Charlotte	DC-9	82	72
28	20.22.74	Lufthansa	Nairobi	B-747	157	59
29	23.11.74	JAT	Belgrade	DC-9	50	0
30	11.06.75	Air France	Bombay	B-747	394	0
* 31	12.11.75	Overseas National	JFK	DC-10	139	0
32	05.04.76	Alaska	Ketchikan	B-727	50	1
33	27.04.76	American	St Thomas	B-727	89	37
34	04.06.76	Air Manila	Guam	L-188	45	45
35	16.11.76	Texas International	Denver	DC-9	86	0
36	02.03.77	Iraqi	Baghdad	B-707	60	0
* 37	27.03.77	Pan American	Tenerife	B-747	405	335
38	27.03.77	KLM	Tenerife	B-747	248	248
39	04.04.77	Southern	New Hope	DC-9	85	63
40	27.09.77	Japan Airlines	Kuala Lumpur	DC-8	79	34
41	03.10.77	Capitol Inter.	Shannon	DC-8	259	0
42	19.11.77	TAP	Funchal	B-727	164	131
43	11.02.78	Pacific Western	Cranbrook	B-737	49	42
44	15.02.78	Sabena	Tenerife	B-707	196	0
* 45	01.03.78	Continental	Los Angeles	DC-10	202	4
46	03.03.78	Iberia	Santiago	DC-8	222	0
47	02.04.78	VASP	Sao Paulo	B-737	42	0
48	17.12.78	Indian Airlines	Hyderabad	B-737	132	1
49	13.03.79	Alia	Doha	B-727	64	44
50	26.04.79	Indian Airlines	Madras	B-737	67	0
* 51	07.10.79	Swissair	Athens	DC-8	154	14
52	27.02.80	China Airlines	Manila	B-707	135	2
* 53	29.08.80	Saudia	Riyadh	L-1011	301	301
54	04.11.80	TAAG	Benguela	B-737	134	0
* 55	19.11.80	Korean	Seoul	B-747	226	15
* 56	21.11.80	Continental	Yap Island	B-727	73	0
57	17.02.81	Air Cal	Santa Ana	B-737	110	0
58	27.07.81	Aeromexico	Chihuahua	DC-9	66	30
59	17.03.82	Air France	Sanaa	A-300	124	0
60	26.08.82	Southwest	Ishigaki	B-737	138	0
* 61	13.09.82	Spantax	Malaga	DC-10	393	51
62	11.03.83	Avensa	Barquisimeto	DC-9	50	23
* 63	02.06.83	Air Canada	Cincinnati	DC-9	46	23
64	11.06.83	United	Chicago	B-727	142	0
65	02.07.83	Altair	Milan	Caravelle	89	0
66	07.12.83	Aviaco	Madrid	DC-9	42	42
67	07.12.83	Iberia	Madrid	B-727	93	51
68	18.12.83	Malaysian	Kuala Lumpur	A-300	247	0
69	10.03.84	UTA	Ndjamena	DC-8	23	0
* 70	22.03.84	Pacific Western	Calgary	B-737	119	0
71	30.08.84	Air Cameroon	Douala	B-737	118	2
72	13.10.84	Cyprus Airways	Zurich	B-707	10	0
* 73	22.08.85	British Airtours	Manchester	B-737	137	55
74	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)

	Date	Operator	Aircraft Type	Fire Deaths	LIVES SAVED Fire Blocking	 Floor Prox. Lights	 Smoke Hoods *
5	05.03.67	VARIG	DC-8	45	29	9	7
8	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-727	2	0	0	0
15	07.06.71	Allegheny	CV-580	27	0	1	0
18	08.12.72	United	B-737	27	10	5	12
19	20.12.72	North Central	DC-9	10	2	7	1
22	11.07.73	VARIG	B-707	121	18	4	99
25	30.01.74	Pan American	B-707	92	0	1	0
31	12.11.75	Overseas Nat.	DC-10	0	0	0	0
37	27.03.77	Pan American	B-747	190	0	0	0
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	298	0	0
55	19.11.80	Korean	B-747	12	12	0	0
56	21.11.80	Continental	B-727	0	0	0	0
61	13.09.82	Spantax	DC-10	50	50	0	0
63	02.06.83	Air Canada	DC-9	23	23	0	0
70	22.03.84	Pacific Western	B-737	0	0	0	0
73	22.08.85	British Airtours	B-737	55	17	3	35
		TOTALS		1022	477	39	179
					47%	4%	18%
		TOTALS ASSUMING LOSS OF LIFE IN VARIG B-707 ACCIDENT AVERTED BY LAVATORY FIRE PRECAUTIONS		1022	459	35	80
					45%	3%	8%

* 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)

	Date	Operator	Aircraft Type	Fire Deaths	LIVES SAVED No Effect	Delay	Reduced Rate
					*	**	***
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.

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

	Date	Operator	Aircraft Type	Fire Deaths	Potential Benefit	Likelihood of Use	Net Benefit
						*	**
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	B-737	55	35	Mod	18
		TOTALS		1022	179		134
					18%		13%
		TOTALS, ASSUMING LOSS OF LIFE IN VARIG B-707 ACCIDENT AVERTED BY LAVATORY FIRE PRECAUTIONS		1022	80		35
					8%		3%

* See Appendix II
** Lives Saved

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

	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	0	Neg	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	Neg	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	0
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	Neg	0
48	17.12.78	Indian Airlines	Hyderabad	B-737	132	1	1	1	Mod	1
49	13.03.79	Alia	Doha	B-727	64	44	20	4	Neg	0
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	4	Neg	0
66	07.12.83	Aviaco	Madrid	DC-9	42	42	42	8	Neg	0
67	07.12.83	Iberia	Madrid	B-727	93	51	51	9	Low	3
71	30.08.84	Air Cameroon	Douala	B-737	118	2	2	1	Mod	1
					TOTAL		1475	228		49
								18%		4%

* Where the number of fire related deaths is not known, it is pessimistically assumed that all fatalities were fire-related.

** 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.

4. 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.

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

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 built-up.

   (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.

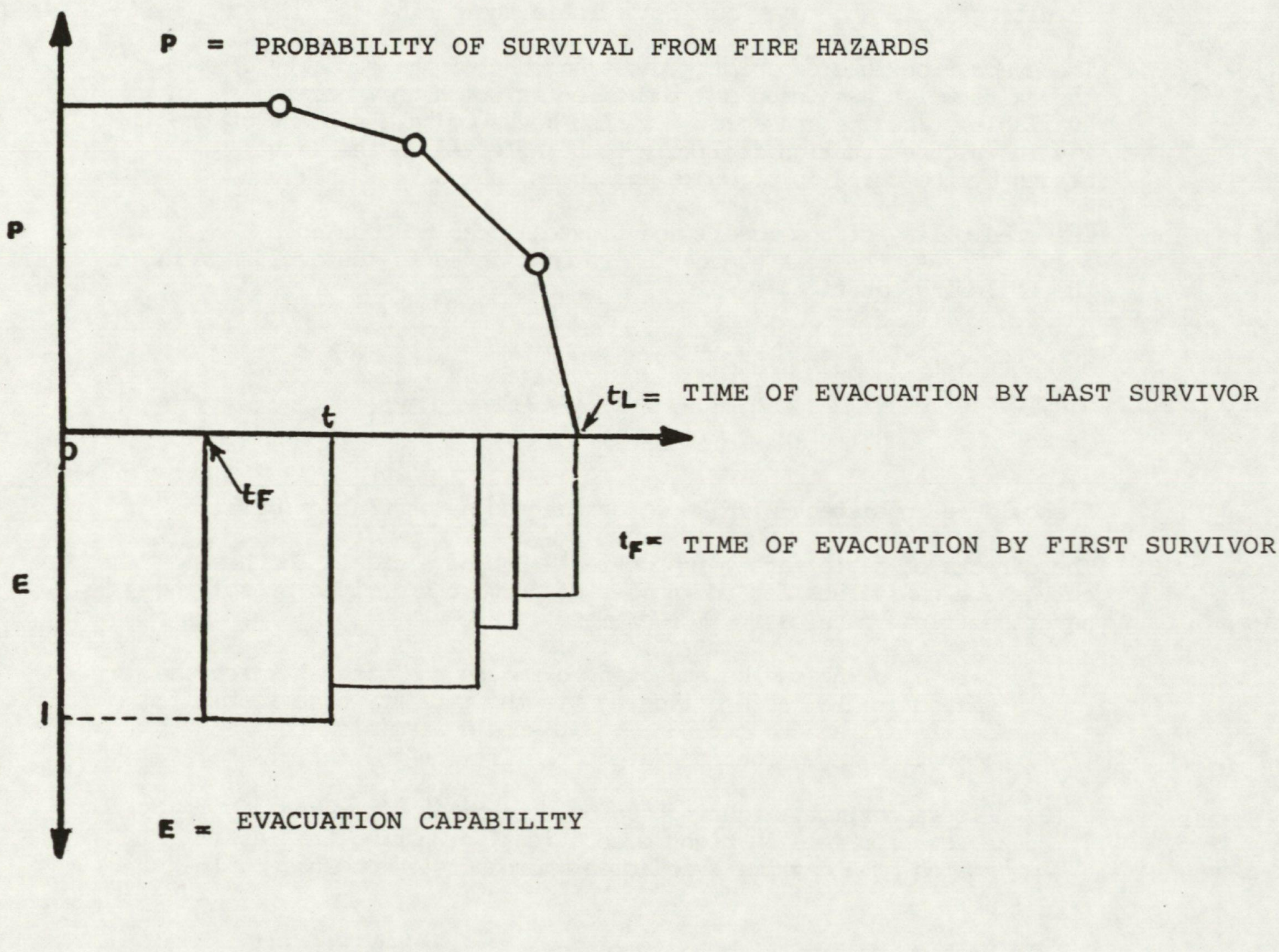
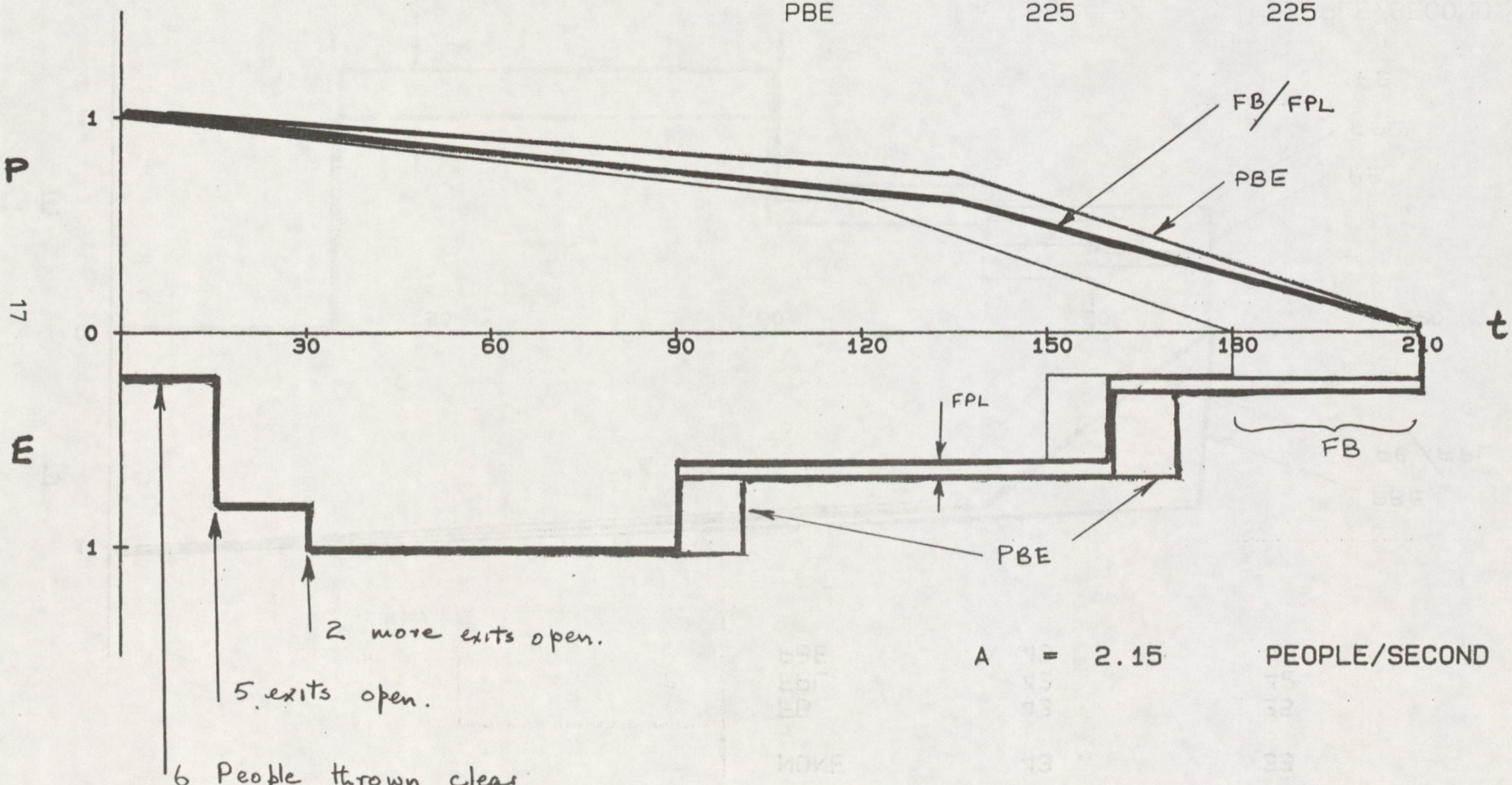

P = PROBABILITY OF SURVIVAL FROM FIRE HAZARDS
P
t
tL = TIME OF EVACUATION BY LAST SURVIVOR
O
tF
tF = TIME OF EVACUATION BY FIRST SURVIVOR
E
1
E = EVACUATION CAPABILITY

FIGURE 1.

CAPITOL AIRWAYS DC-8 11/27/70

IMPROVEMENT	PASSENGERS	SURVIVORS
NONE	225	178
FB	225	196
FPL	225	201
PBE	225	225

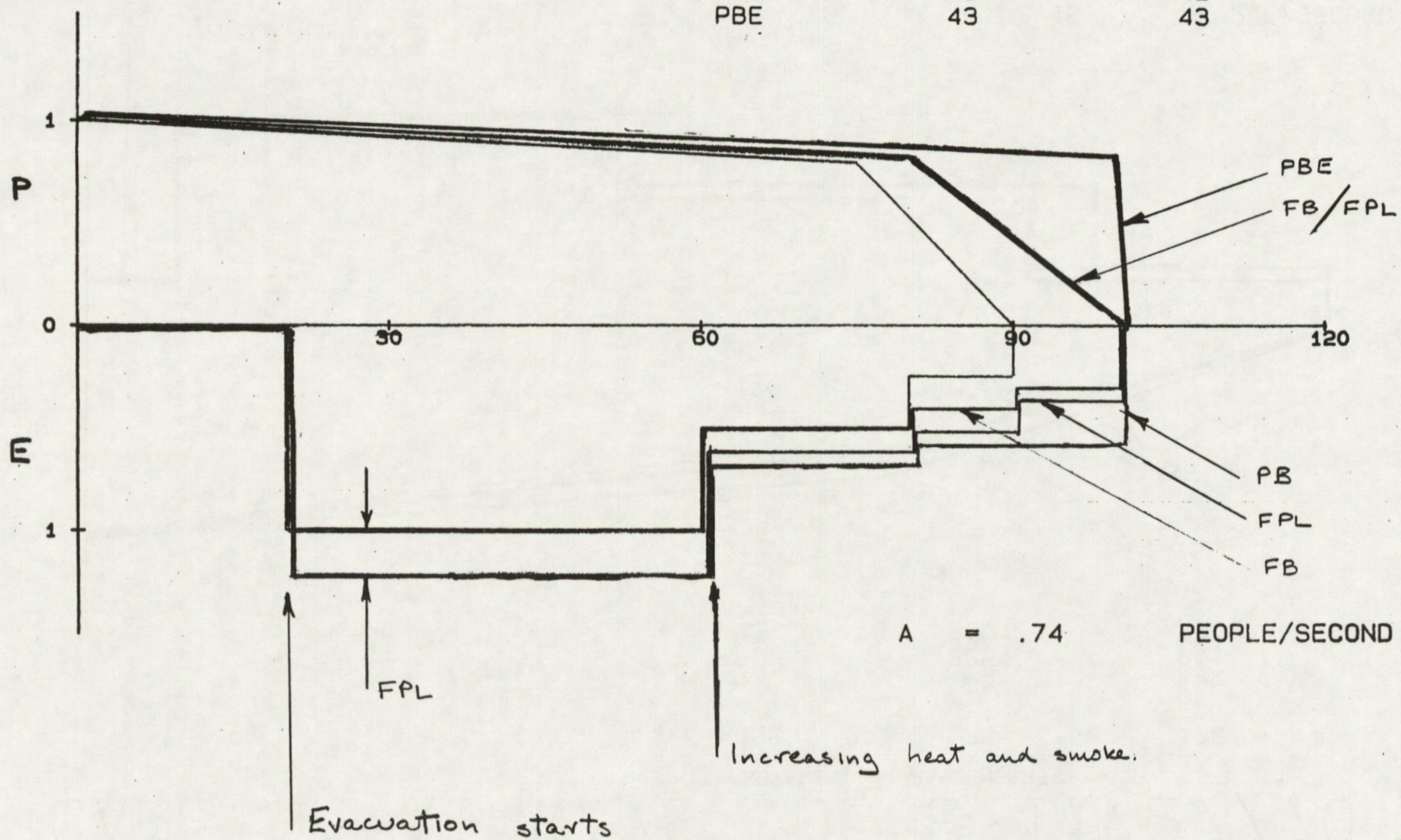


A = 2.15 PEOPLE/SECOND

FIGURE 2.

NORTH CENTRAL DC-9 12/20/72

IMPROVEMENT	PASSENGERS	SURVIVORS
NONE	43	33
FB	43	35
FPL	43	42
PBE	43	43



A = .74 PEOPLE/SECOND

FIGURE 3

APPENDIX II: ACCIDENT SUMMARY

	Date	A/C Type Operator Place	Occu-pants	Fatal-ities	Circumstances	Cabin crash damage	Fire Origin & Spread	Evacuation	Exits Used	Evacuation time	Fire related deaths	Likely Smoke Hood Use
1	15.02.66	Caravelle Indian Airlines Palam (Delhi)	80	2	Undershoot	Nil	Post crash fuel fire	Unpremed-itated	Not known	Time not known Complete	Nil	Mod
2	04.03.66	DC-8 Canadian Pacific Tokyo	72	64	Impact with sea wall on landing	Severe	Scattered fire, scattered wreckage	Escape	None	-	Not known	Neg
3	22.04.66	L-188 American Flyers Ardmore	98	83	Struck high ground on approach	Extreme	Scattered wreckage, scattered fire	None Rescue from wreckage	None	-	Nil (all fatal-ities due to injuries)	Neg
4	16.02.67	L-188 Garuda Menado	92	22	Heavy landing Gear collapse	Minor	External spilt fuel Penetrated cabin rapidly	Unpremed-itated	Right front Flight deck	Time not known Incomplete	Not known some at rear exit	Low
5	05.03.67	DC-8 VARIG	90	51	Undershoot High rate of descent	Severe	Fuel fire, entering mid cabin during ground slide	Escape	Left front Left rear	Time not known Incomplete	Not known Some likely	Neg
6	06.11.67	B-707 TWA Cincinnati	36	1	Take off aborted from V_R	Major	Right wing which had separated	Unpremed-itated	Fwd galley	Time not known Complete	Nil	Neg
7	09.01.68	B-720B Ethiopian	49	0	Nose wheel collapse	Nil. On runway	Wheels, slow	Unpremed-itated	Not known	Time not known	Nil	-
8	08.04.68	B-707 BOAC	127	5	Engine fire on take-off. aircraft returned	Nil On runway	No 2 engine pylon	Premed-itated	Front left right Over-wing two right, one left	Time not known	Yes	High
9	12.06.68	B-707 Pan American	63	6	Undershoot Hit Tree	Not known	Not known	Unpremed-itated	Not known	Time not known Incomplete	Not known	Mod
10	26.07.69	Caravelle Air Algerie Biskra	37	33	In flight fire. Emergency landing attempted	Not known	Elect-rical	Premed-itated	Not known		Not known	Very High
11	19.04.70	DC-8 SAS Rome	65	0	Uncontained engine failure during takeoff	Nil On runway	No 2 Engine No 2 fuel tank	Unpremed-itated	Window exits. Aux doors fwd and aft.	31-60 secs.	Nil	—
12	06.05.70	Viscount Somali Magadiscio	30	5	Crash/loss of control due to underfloor fire	Not known	Under floor	Premed-itated	Main door aft	Time not known Incomplete	5	Mod
13	27.11.70	DC-8 Capitol Int Anchorage	229	47	Unsuccessful take off on ice with wheels locked	Severe	Left wing root	Unpremed-itated	All fwd exits except fwd galley. 3 over wing. Break at rear	Time not known. Incomplete	Yes Number not known	Mod
14	28.12.70	B-727 Trans-Carib bean St Thomas	55	2	Unsuccessful recovery from bounce on landing	Severe	Left wing root, Rapid	Unpremed-itated	Fwd galley, aft, Main break in fuselage	Time not known Incomplete	2 burns 1 - trapped	Low
15	07.06.71	CV-580 Allegheny New Haven	31	28	Struck bldgs on approach	Major	External fuel fire Rapid	Unpremed-itated	Left over wing	Time not known Incomplete	27	Mod
16	06.09.71	BAC 1-11 Pan-Int. Hasloh Hamburg	121	21	Power loss on both engines Forced landing on autobahn	Extreme	External fuel fire (after all pax left)	Premed-itated	4 over wing Fuse-lage break	Time not known Complete	Nil	Neg
17	18.04.72	SVC-10 East African Addis Ababa	107	43	Rejected take off	Extreme	Post crash fuel fire	Unpremed-itated	None Break in fuse-lage	Time not known Incomplete	All	Low
18	08.12.72	B-737 United Chicago	63	43	Struck bldgs on approach	Severe	Fuel fire at centre section	Escape and rescue	Not known	Time not known Incomplete	High pro-portion	Low
19	20.12.72	DC-9 North Central Chicago	45	10	During take off collided with aircraft crossing runway	Assume negli-gible	Not known but post crash	Unpremed-itated	Not known	Time not known Incomplete	Probably all 10	High
20	22.01.73	B-707 Alia Kano	202	176	Gear failure on landing A/C swerved off runway	Not known	Not known	Unpremed-itated	Not known	Time not known Incomplete	Not known	Mod
21	31.05.73	B-737 Indian Airlines Palam, New Delhi	65	48	NDB approach Descent below MDA. Undershoot in trees 3 km short.	Not known	Not known	Unpremed-itated	Not known	Time not known Incomplete	Not known	Low
22	11.07.73	B-707 VARIG Near Orly Paris	134	123	Forced landing due to in-flight fire	Minor	Toilet	Not carried out	Both flight deck windows, Front left & right	Not carried out	123	Very High
23	23.07.73	FH-227B Ozark St Louis	45	39	Downdraught on approach Crashed in trees	Extreme	Scattered small fires, Probably little or no fire in cabin	Escape	-	-	Unlikely Most were impact	Neg
24	20.12.73	B-707 Lufthansa Delhi	109	0	Undershoot	Minor	Fuel, left wing	Unpremed-itated	Right side	Time not known Complete	Nil	-
25	30.01.74	B-707 Pan American Pago Pago	101	96	Undershoot into trees	Minor	External fuel fire on stbd side	Unpremed-itated	Left over-wing only	Time not known Incomplete	All except one crew member	Mod
26	15.03.74	Caravelle Sterling Teheran	96	15	Right gear collapse during taxy for takeoff	Nil, On runway	Right wing fuel. Heavy fire JP-1	Unpremed-itated 81 serious injuries	Exits on left side	Time not known Incomplete	Not known	Mod

No	Date	A/C Type Operator Place	Occupants	Fatalities	Circumstances	Cabin crash damage	Fire Origin & Spread	Evacuation	Exits Used	Evacuation time	Fire related deaths	Likely Smoke Hood Use
27	11.09.74	DC-9 Eastern Charlotte	82	72	Undershoot into trees	Extreme	Fuel fed post crash fire	Escape	Cock pit window holes in fuselage	Time not known. Incomplete	40	Low
28	20.11.74	B-747 Lufthansa Nairobi	157	59	Stall after take off	Major	Left wing	Unpremeditated	No 2 right No 3 right	Time not known Incomplete	Some possible but also impact	Low
29	23.11.74	DC-9 JAT Belgrade	50	0	Undershoot	Minor	Slow "after several minutes"	Unpremeditated	Not known	Time not known Complete	Nil	-
30	11.06.75	B-747 Air France Bombay	394	0	Take off Tyre failure	Nil On runway	Right body gear slow	Unpremeditated	Not known	Time not known Complete	Nil	-
31	12.11.75	DC-10 Overseas National JFK	139	0	Engine bird ingestion during take-off. Aborted from V_1. Gear collapsed	Minor	Right wing	Unpremeditated	Right front	Time not known. Complete	Nil	-
32	05.04.76	B-727 Alaska Ketchikan	50	1	Overrun following long fast touchdown on wet runway.	Severe	Post crash fire Relatively slow	Escape	Main cabin door. Both left over-wing. Holes in fuselage	Not known	Nil (one impact)	Neg
33	27.04.76	B-727 American St Thomas	89	37	Overrun following long landing	Severe	Post crash fire Right wing. Rapidly into cabin through breaks	Escape	Both left over-wing Breaks in fuselage	1-1$^1/_2$ mins Incomplete	Combination of impact smoke and burns	Mod
34	04.06.76	L-188 Air Manila Guam	45	45	Engine failure on take off. Impact with high ground	Severe	Fuel fire Rapid (Part JP4 -27%)	None	-	Not started	34 smoke and burns	Neg
35	16.11.76	DC-9	86	0	Take-off rejected after V_R	Neg	Left wing	Unpremeditated	All except left over-wing	2 min complete	Nil	High
36	02.03.77	B-707 Iraqi Baghdad	60	0	Landing in bad visibility No 4 engine struck ground Wing rupture	Nil	Right wing and two right engines	Unpremeditated	Not known	Time not known Complete	Nil	-
37	27.03.77	B-747 Pan American Tenerife	405	335	While taxying on runway, hit by 747 taking off. (See No 38)	Extreme	General Rapid	Unpremeditated	2Left Breaks in fuselage	1 minute Incomplete	Not known	Neg
38	27.03.77	B-747 KLM Tenerife	248	248	Collision on ground (See No 37)	Extreme	Fuel fire Rapid	None	-	-	Not known	Neg
39	04.04.77	DC-9 Southern New Hope	85	63	Both engines stopped by hail encounter Forced landing on road.	Extreme	Post crash fuel. Rapid Also petrol at petrol station	Escape and rescue	Breaks in fuselage	-	20 smoke and burns. 9 burns and impact. Remainder impact only	Neg
40	27.09.77	DC-8 Japan Airlines Kuala Lumpur	79	34	Undershoot Collision with high ground	Severe	Post crash fuel fire	Escape	Breaks in fuselage	>2 min Incomplete	Not known	Neg
41	03.10.77	DC-8 Capitol Int. Shannon	259	0	Tyres burst during take-off. Aborted. Stop on runway	Nil On runway	Right gear	Unpremeditated	Main and aux doors Emergency window exits	61-90 sec Complete	Nil	-
42	19.11.77	B-727 TAP Funchal Madeira	164	131	Landed long and overrun	Extreme or severe	Not known	Not known Escape and rescue	Not known	Not known	Not known	Neg
43	11.02.78	B-737 Pacific Western Cranbrook	49	42	Crash during go around due to thrust reverser deploying in flight on one engine	Extreme	General post crash fire	Escape	Right rear door Breaks in fuselage	-	Some	Neg
44	15.02.78	B-707 Sabena Tenerife	196	0	Hard/undershoot landing	Nil/ minor likely	Not known	Unpremeditated	Not known	Not known	Nil	-
45	01.03.78	DC-10 Continental	202	4	Rejected take off from V_1 due to tyre failures	Nil On runway	Left wing fuel fed Rapid	Unpremeditated	All on right side	5 mins complete	2 smoke and burns Others not known	Mod
46	03.03.78	DC-8 Iberia Santiago Spain	222	0	Deep touch-down and overrun	Severe/ major likely	Not known	Unpremeditated	Not known	Time not known Complete	Nil	-
47	02.04.78	B-737 VASP Sao Paulo	42	0	Gear-up landing	Nil/ minor likely	Power/ Plant	Unpremeditated Orderly No injuries	Main doors fore and aft	31-60secs Complete	Nil	-
48	17.12.78	B-737 Indian Airlines Hyderabad	132	1	Descent after take-off	Severe	Post crash fuel fire under rear cabin	Unpremeditated	Main doors front and aft	Not known Marginally complete	1 burns	Mod
49	13.03.79	B-727 Alia Doha	64	44	In go around forced to the ground by wind shear	Extreme	General post crash fire	Escape/ rescue	-	-	20 (24 impact)	Neg
50	26.04.79	B-737 Indian Airlines Madras	67	0	Bomb explosion during descent Fast landing and overrun	Severe	Wing	Premeditated	Main fore and aft	Time not known Complete	Nil	-

Date	A/C Type Operator	Occu-pants	Fatal-ities	Circumstances	Cabin crash	Fire Origin	Evacuation	Exits Used	Evacuation time	Fire related	Likely Smoke Hood Use
51 07.10.79	DC-8 Swissair Athens	154	14	Overrun during landing	Major	Post-crash fuel fire Right wing root	Unpremed-itated	Front left (slide failed after 40/50 had escaped	$3^1/_2$ - $4^1/_2$ mins	14	Mod
52 27.02.80	B-707 China Airlines Manila	135	2	Undershoot	Not known	Not known	Unpremed-itated	Not known	Time not known Incomplete	2	Mod
53 19.08.80	L-1011 Saudia Riyadh	301	301	In flight fire Burned out after landing	Nil on runway	Under floor rear fuselage	Not carried out Delay in stopping	-	-	All	Very high
54 4.11.80	B-737 TAAG Benguela	134	0	Undershoot	Minor	Left engine right wing	Unpremed-itated	Not Known	Time not Known Complete	Nil	-
55 19.11.80	B-747 Korean Seoul	226	15	Undershoot	Severe	Post crash fuel fire	Unpremed-itated	All?	>2 mins Incomplete	All	Mod
56 21.11.80	B-727 Continental Yap Island	73	0	Undershoot with gear failure	Minor	Right side Rapid	Unpremed-itated	Left over-wing (Cargo comp in fwd cabin) Crew ignorant of ventral door operation	55 secs	Nil	Low
57 17.02.81	B-737 Air Cal Santa Ana	110	0	Touchdown during go around with gear retracting	Minor On runway	Left engine (separ-ated) and left wing root Not severe	Unpremed-itated	All left side	<90 sec complete	Nil	-
58 27.07.81	DC-9 Aeromexico Chihuahua	66	30	Landed 150m to right of runway. Strong squalls and showers	Extreme/ rear Minor/ fwd	Cabin (JP4 fuel)	Unpremed-itated	Main and aux doors	5 min	Not known	Mod
59 17.03.82	Airbus A300 Air France Sanaa	124	0	Uncontained engine failure during takeoff Aborted. Fuel tank penetrated	Nil On runway	Spilled fuel Rapid	Unpremed-itated	Rt fwd left rear entry doors	2-3 min Complete	Nil	-
60 26.08.82	B-737 Southwest Ishigaki Isl.	138	0	Overrun on landing into trees	Not known	Not known	Unpremed-itated	Not known	75 mins	Nil	-
61 13.09.82	DC-10 Spantax Malaga	393	51	Rejected take-off	Nil	Engine Fuel fed post crash	Unpremed-itated	Main doors front & rear One or more would not open	>5 mins Incomplete	51	Mod
62 11.03.83	DC-9 Avensa Barquisimeto	50	23	Hard landing	Extreme	Engines Fuel fed post crash	Unpremed-itated	Breaks in fuselage	>5 mins	22	Neg
63 02.06.83	DC-9 Air Canada Cincinnati	46	23	In-flight fire	Nil On runway	Toilet	Premed-itated	Front left and right 3 over wing	Time not known Incomplete	23	Very high
64 11.06.83	B-727 United Chicago	142	0	No 1 engine failed during takeoff. No 2 damaged. Abort	Nil	Not	Unpremed-itated	Not known	Time not known Complete	Nil	-
65 02.07.83	Caravelle Altair Milan	89	0	No 2 engine exploded at 80 kt on take-off	Nil On runway	Power/ Plant	Unpremed-itated	Main left Fwd door	Time not known Complete	Nil	-
66 07.12.83	DC-9 Aviaco Madrid	42	42	While taxying hit by 727 taking off (See No 67)	Extreme	Wing	None	None	-	Not known	Neg
67 07.12.83	B-727 Iberia Madrid	93	51	Aircraft at V_1 collided with DC-9 on runway (See No 66)	Extreme/ Severe Aft cabin minor	Wing	Unpremed-itated	Main and aux doors Break in fuselage	Time not known Incomplete	Not known	Low
68 18.12.83	Airbus A300 Malaysian Kuala Lumpur	247	0	Hit trees in undershoot. Came to rest 1000m before runway	Nil	Wing	Unpremed-itated	Main door fwd	Time not known Complete	Nil	-
69 10.03.84	DC-8 UTA Ndjamena	23	0	Explosion in aft cargo compartment during loading	Nil. On ramp	Aft cargo comp.	Unpremed-itated	Not known	Time not known Complete	Nil	-
70 22.03.84	B-737 Pacific Western Calgary	119	0	Engine failure with fuel tank penetration	Nil. On runway	Left engine wing Rapid	Unpremed-itated	All right side Left front	3 mins Complete	Nil	-
71 30.08.84	B-737 Air Cameroon Douala	118	2	During taxy to tale-off, engine comp. disc burst. Fuel tank punctured	Nil. On runway	Right wing/ engine Fuel spill	Unpremed-itated	Not known	Not known	Not known	Mod
72 13.10.84	B-707 Cyprus Zurich	10	0	Fire in fwd hold on ground	Nil On ramp	Fwd hold	Unpremed-itated	Entry door	Time not known Complete	Nil	-
73 22.08.85	B-737 British Airtours Manchester	137	55	Uncontained engine failure during takeoff Fuel tank punctured	Nil On runway	Left wing	Unpremed-itated	Fwd left and right, Right over-wing	Incomplete	55	Mod
74 30.11.85	L-188 Mandala Medan Indonesia	45	0	Wheels up landing (intentional)	Not known Minor likely	Not known	Premed-itated ?	Not known	Time not known Complete	Nil	-