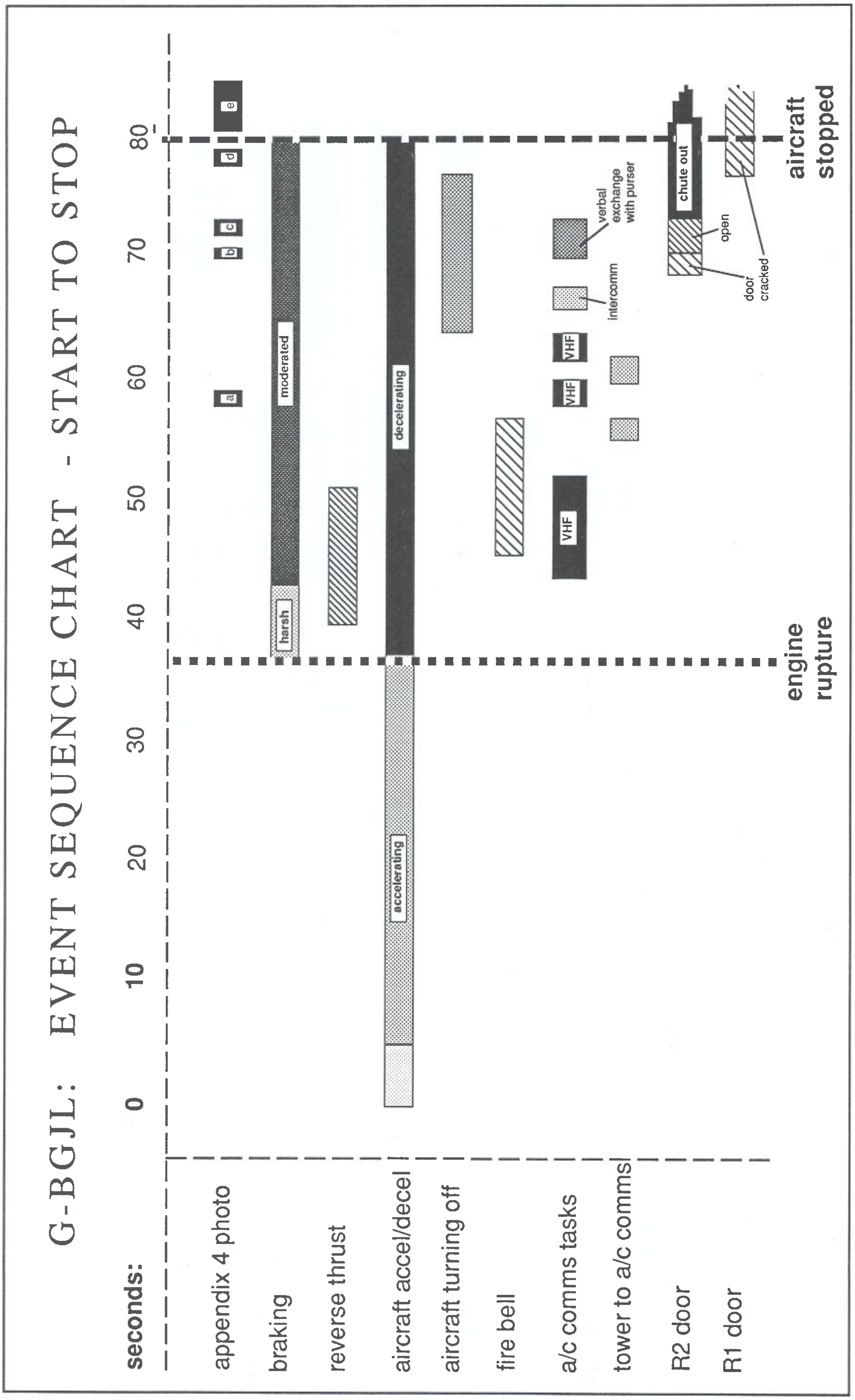
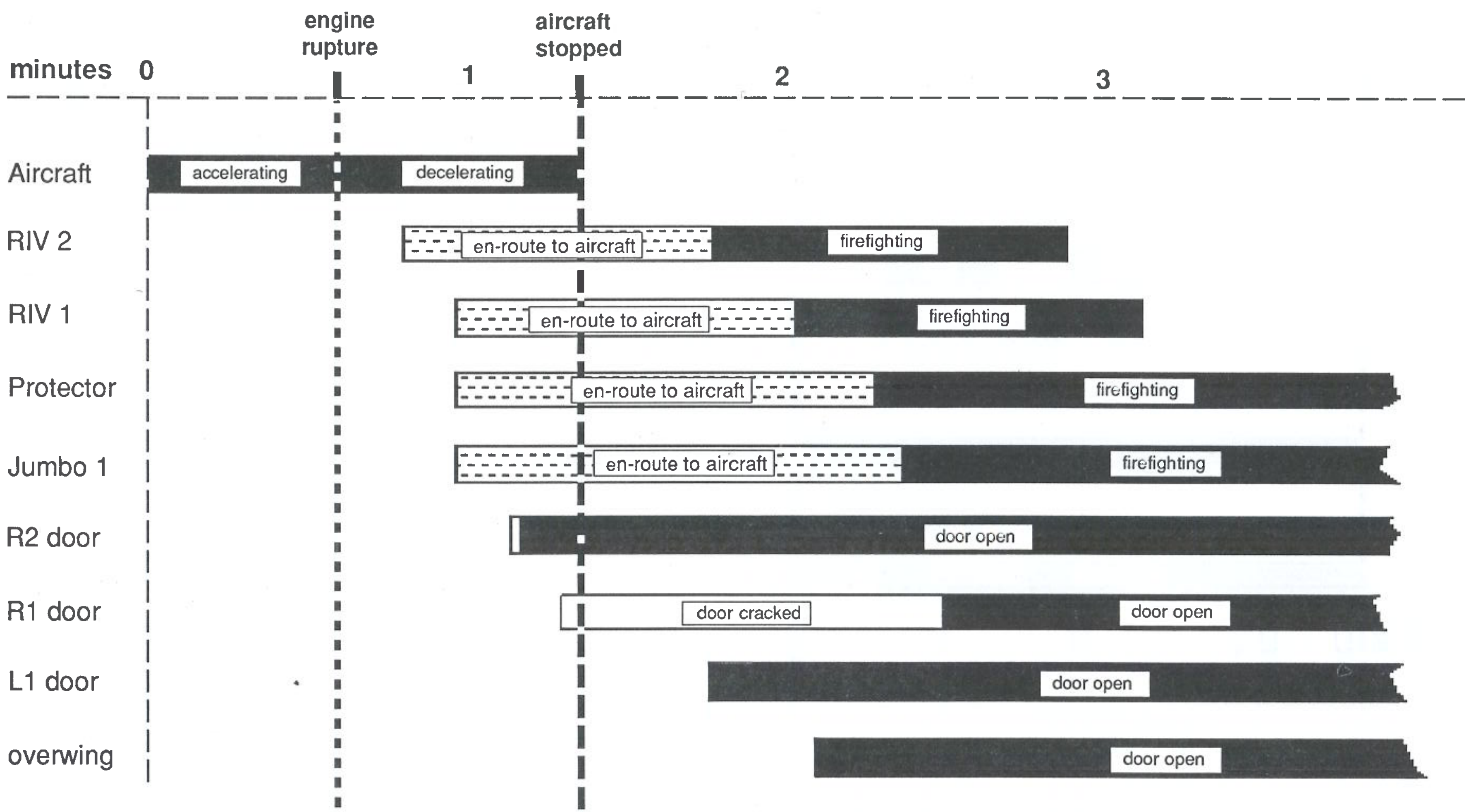
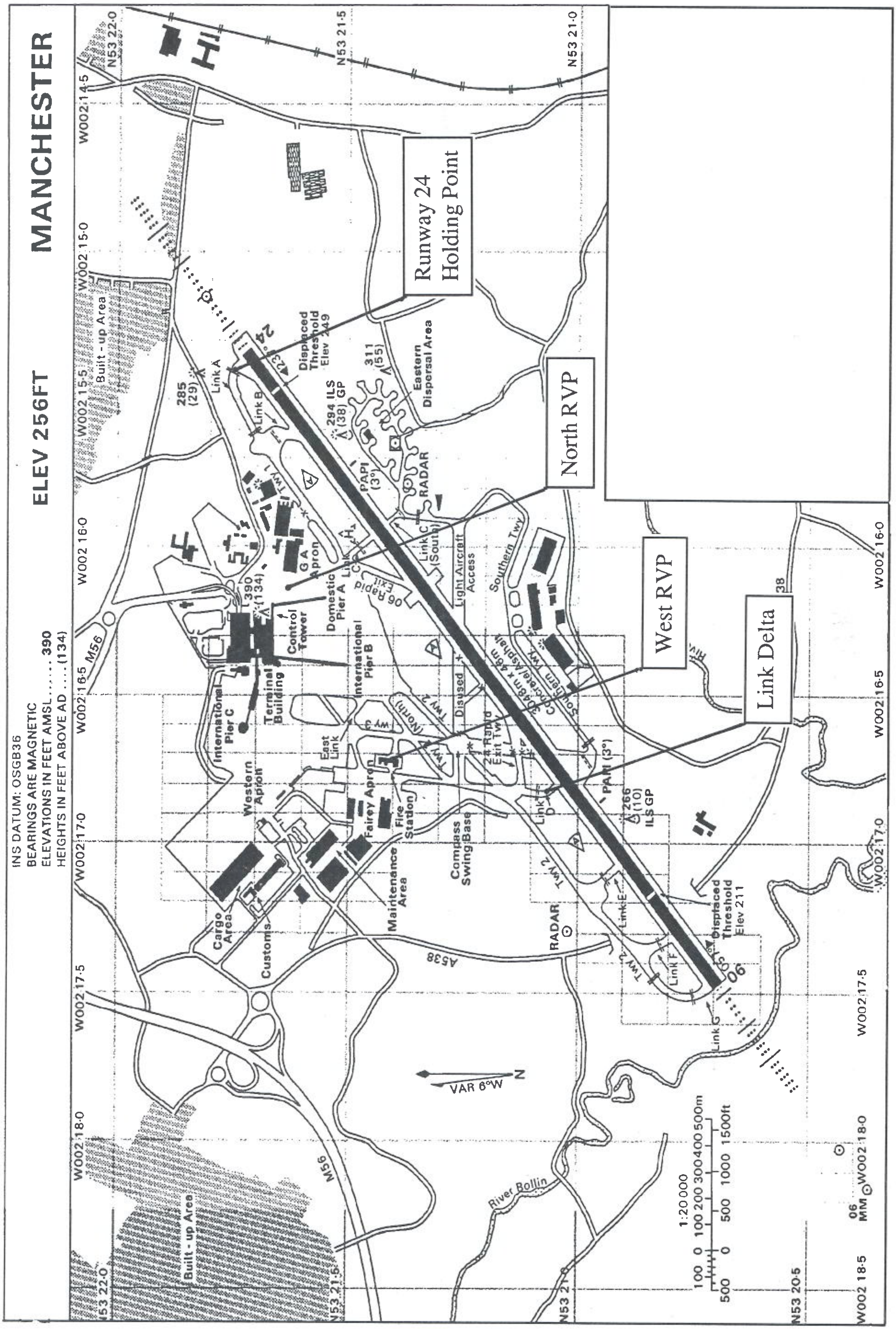

G-BGJL: EVENT SEQUENCE CHART - START TO STOP
seconds:
0
10
20
30
40
50
60
70
80
appendix 4 photo
braking
reverse thrust
aircraft accel/decel
aircraft turning off
fire bell
a/c comms tasks
tower to a/c comms
R2 door
R1 door
a
b
c
d
e
harsh
moderated
accelerating
decelerating
VHF
VHF
VHF
intercomm
verbal exchange with purser
door cracked
open
chute out
engine rupture
aircraft stopped

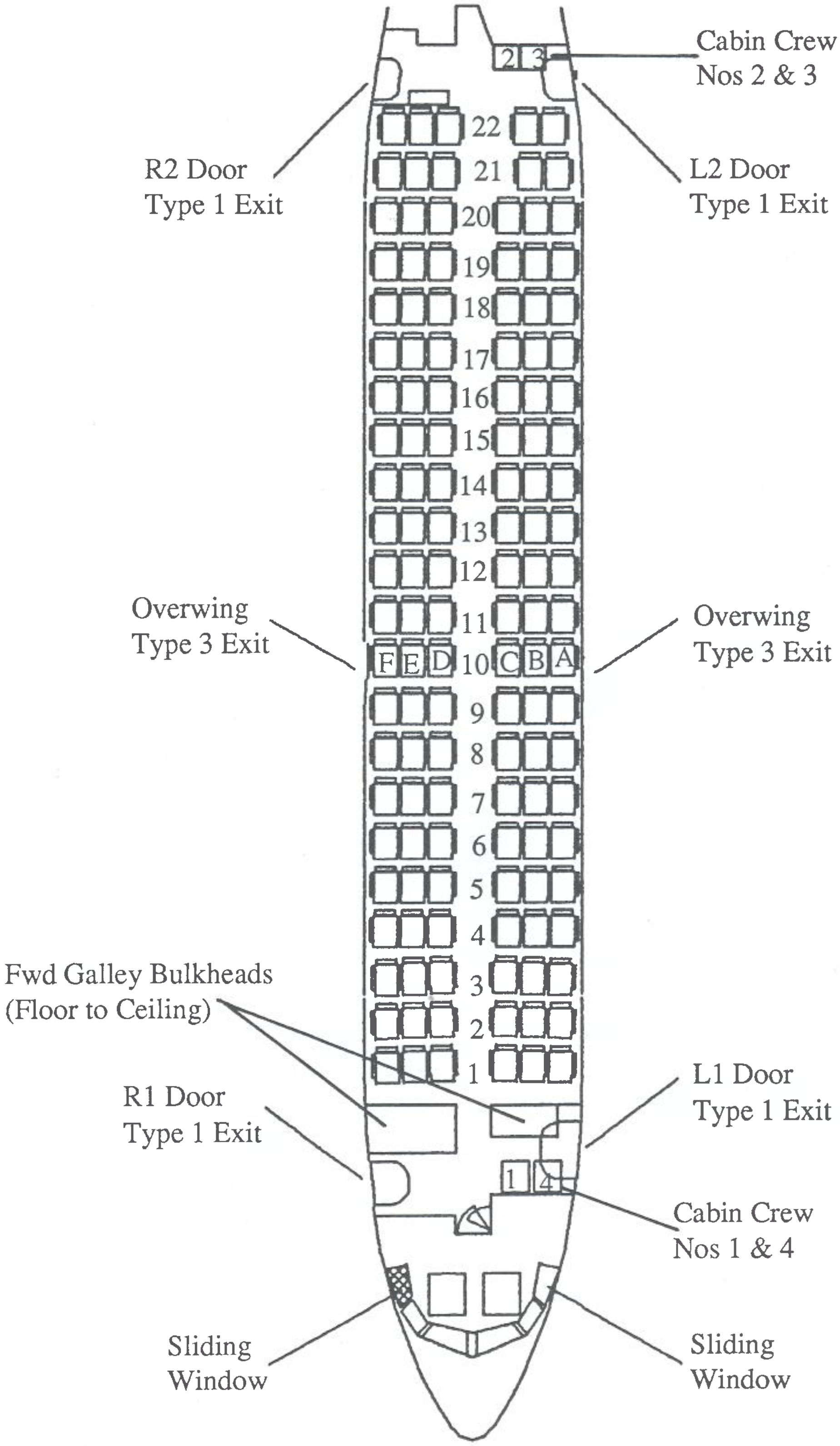
G-BGJL: INITIAL RESCUE AND EXIT OPENING



N53 21·21 W002 16·41

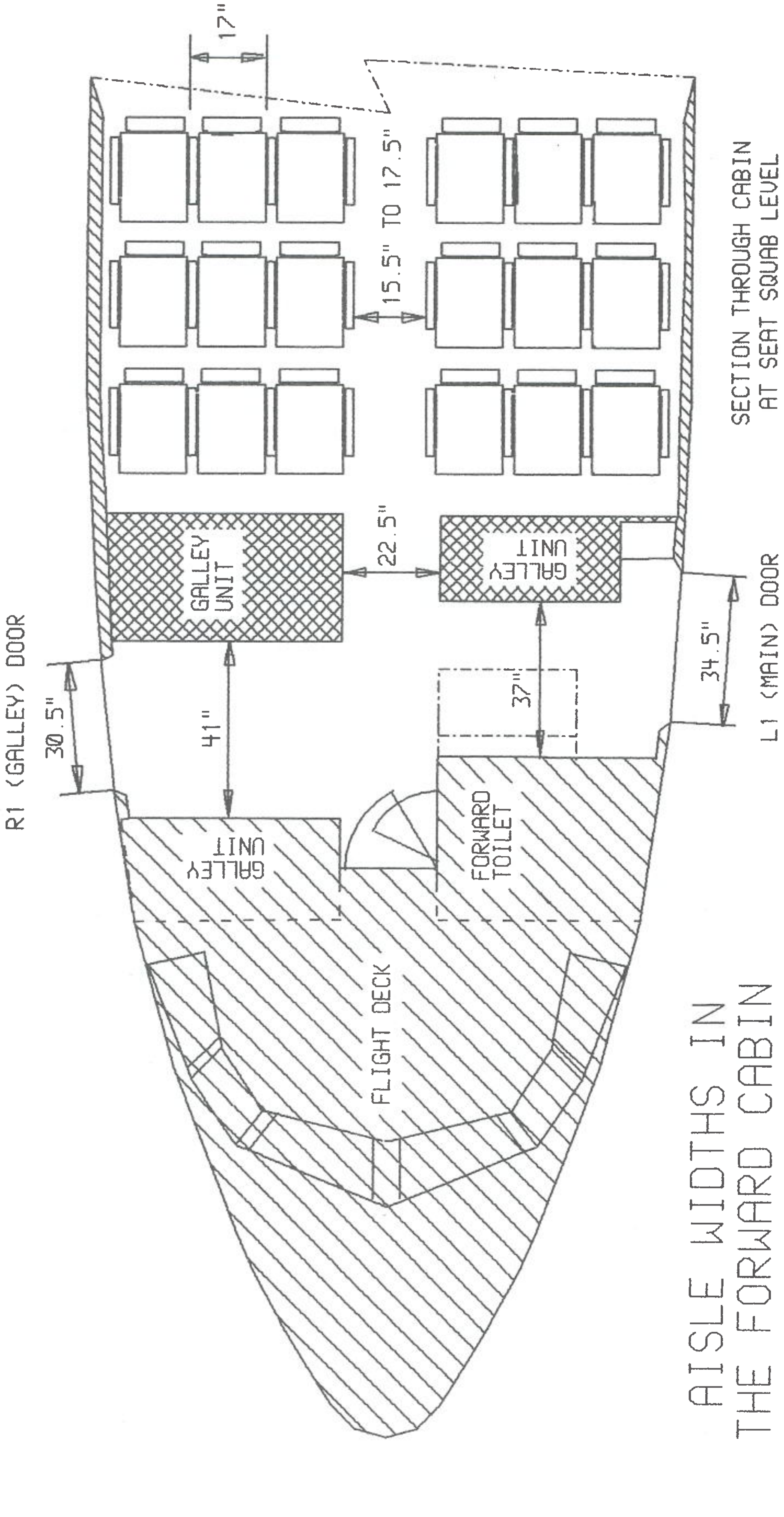


Appendix 3 fig.a

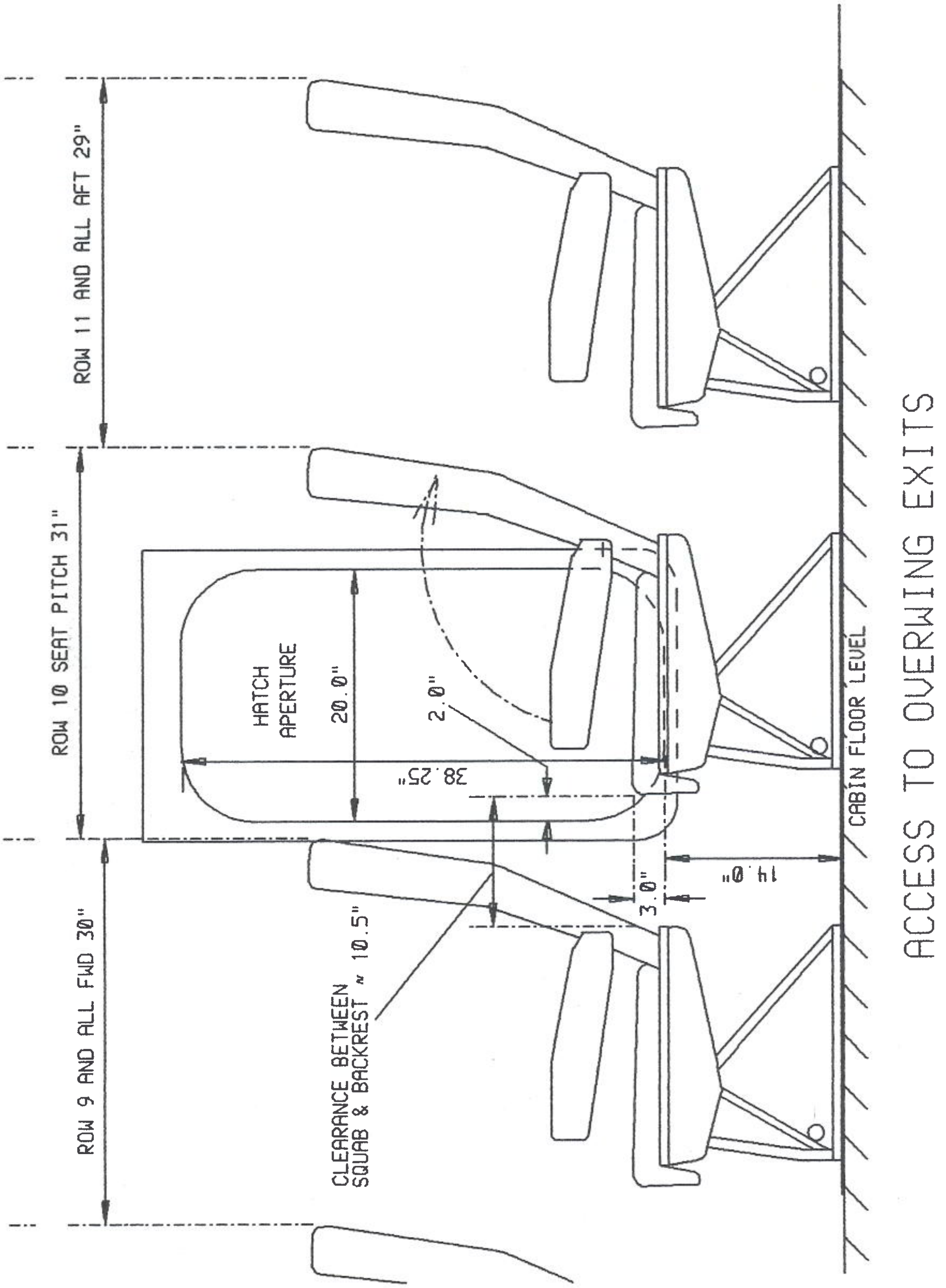


Door, Exit and Seat Identification and Cabin Crew Seat Location

Appendix 3 fig.b

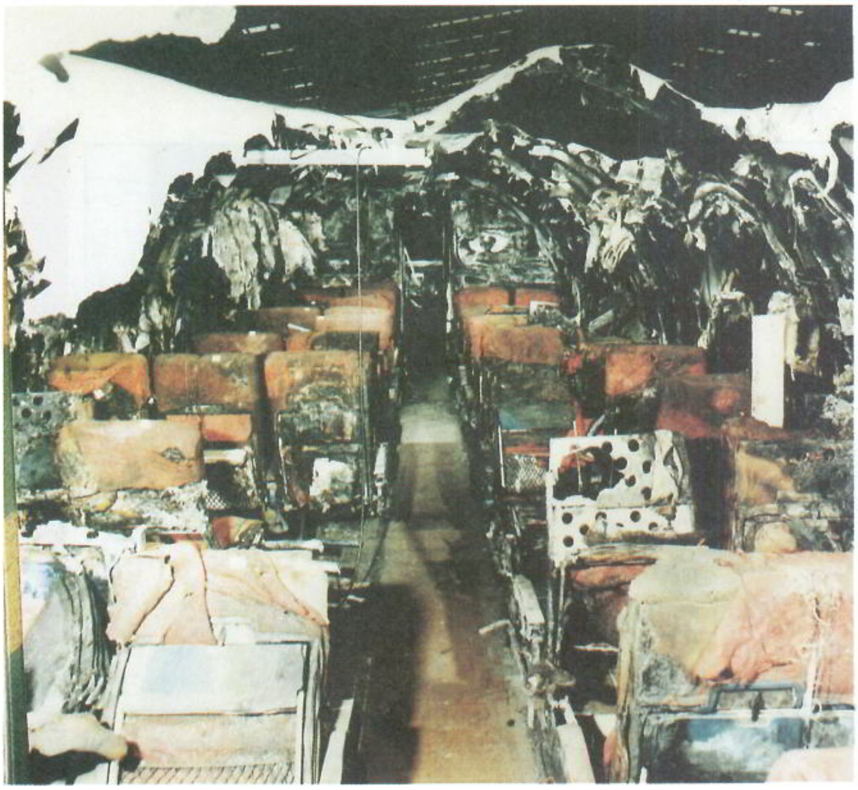


Appendix 3 fig.c



Appendix 3 fig. d

Extract From Passenger Safety Briefing Card



View Looking Forwards

View Looking Aft

Appendix 4a

Appendix 4b

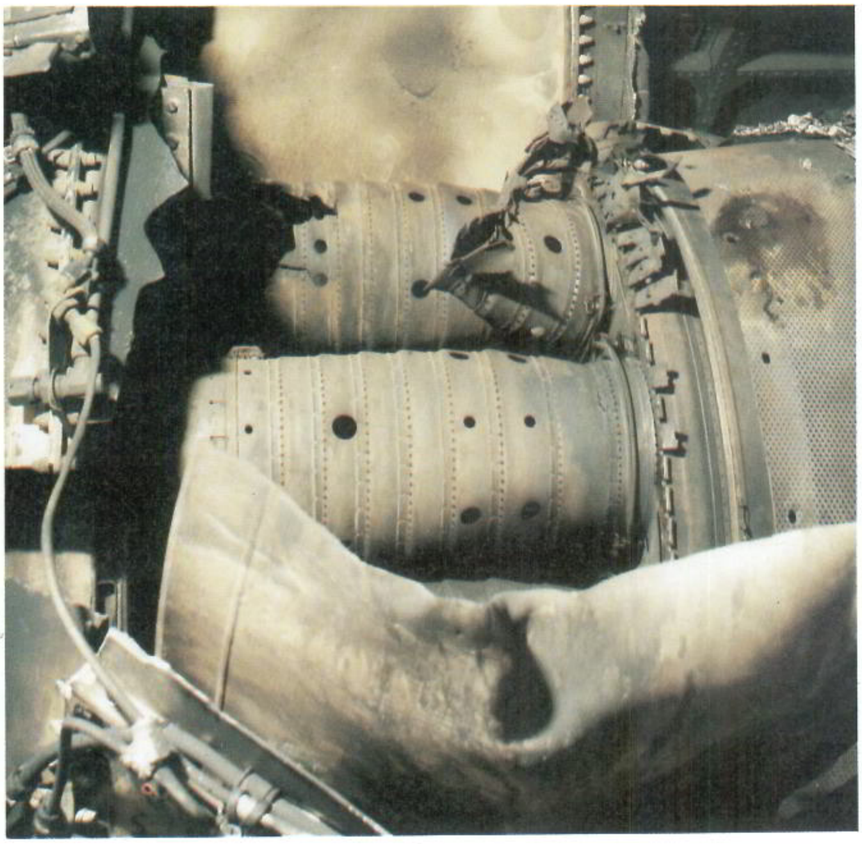
Appendix 4c

Appendix 4d

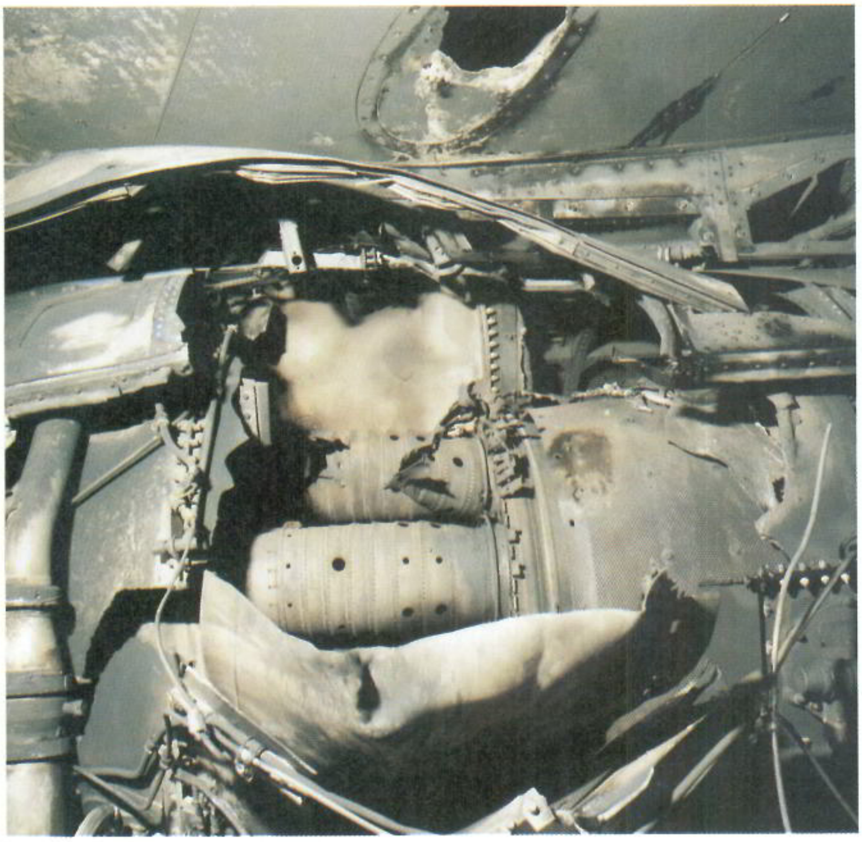
Appendix 4e

Appendix 4f

Appendix 5 a



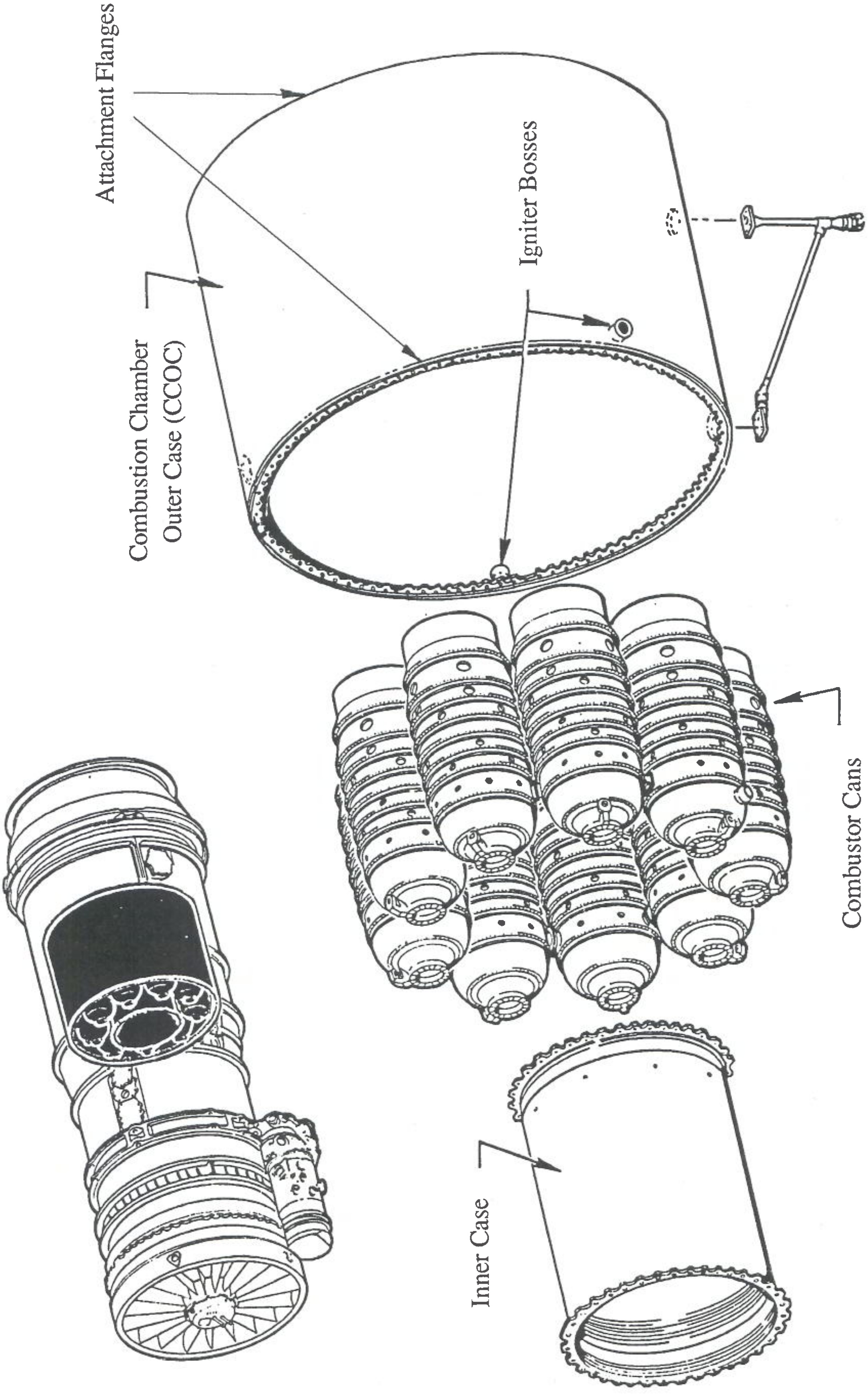
Remains of combustor can No 9 viewed through the CCOC rupture

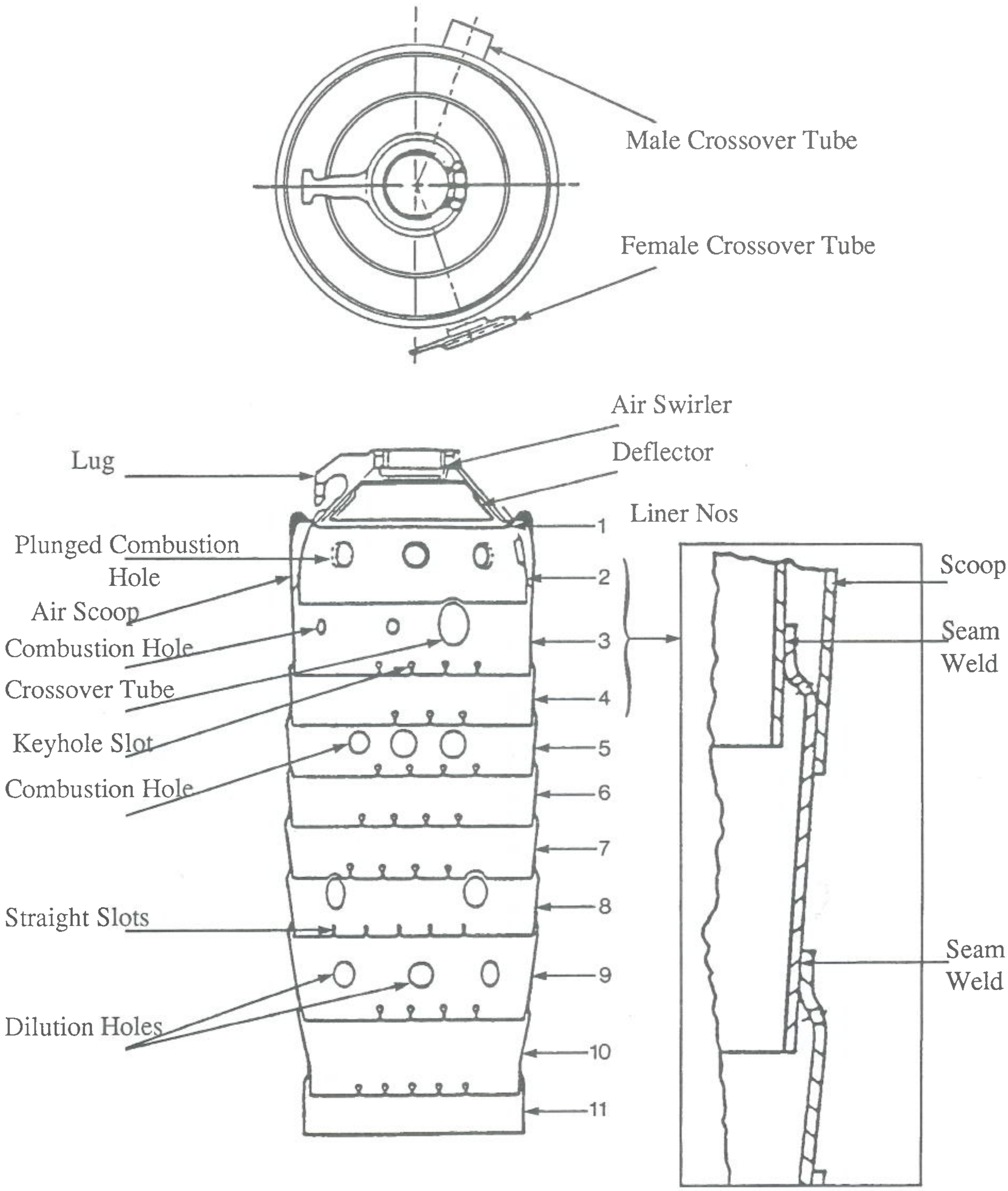


Engine rupture and holed fuel tank access panel

Appendix 5 fig b

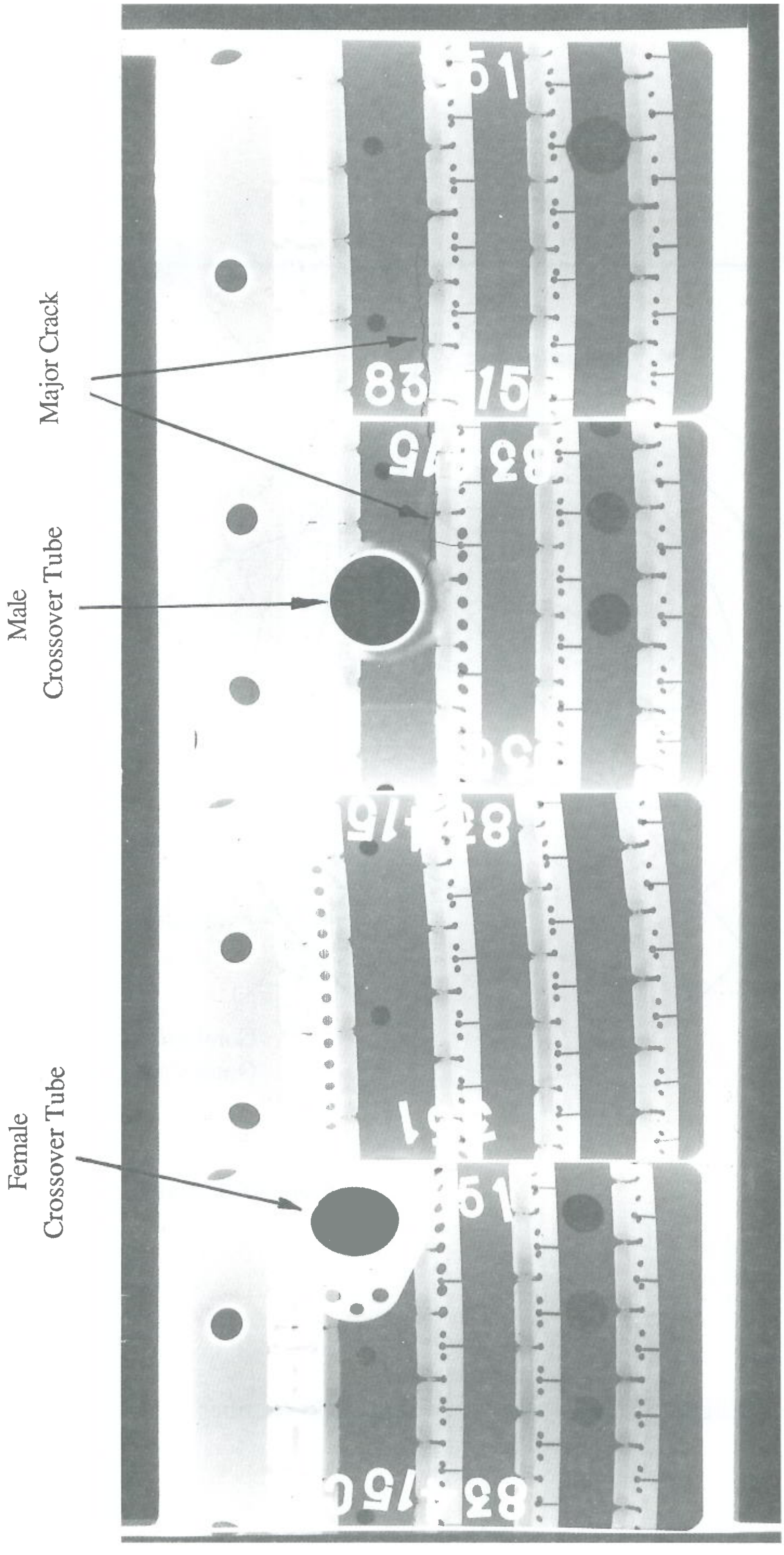
Combustion System





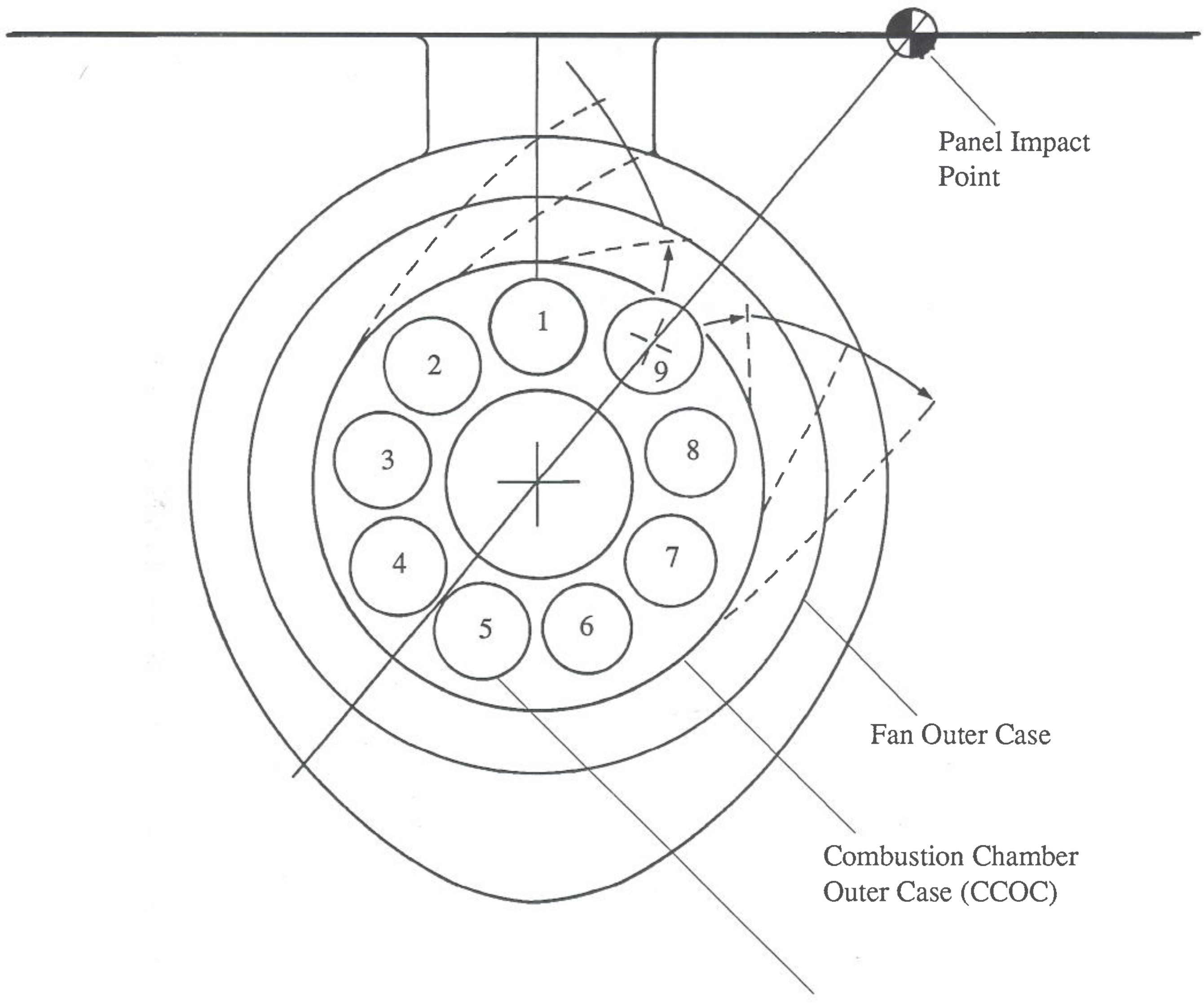
Combustor Can

Appendix 5 fig.d



Positive Prints of X-Radiographs Taken Around the Circumference of Can No 9 After 7,582 Flying Hours

Appendix 5 fig e



Engine Section Through Combustion Chamber
Looking Aft

Appendix 5 fig f

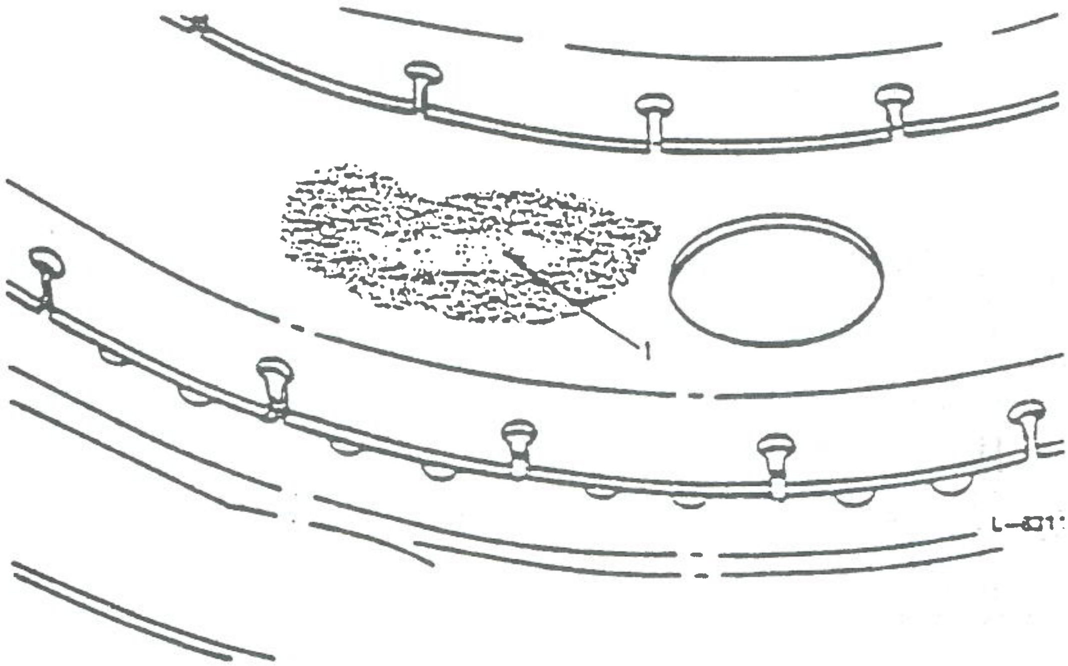
The Recovered Remains of Combustion Can No 9 from the Left Engine

Appendix 5 fig g

Schematic Summary of the Fractographic Features of the Circumferential Cracking in the 3rd Liner of Can No 9

Appendix 5 fig.h

COMBUSTION CHAMBERS - INSPECTION-01

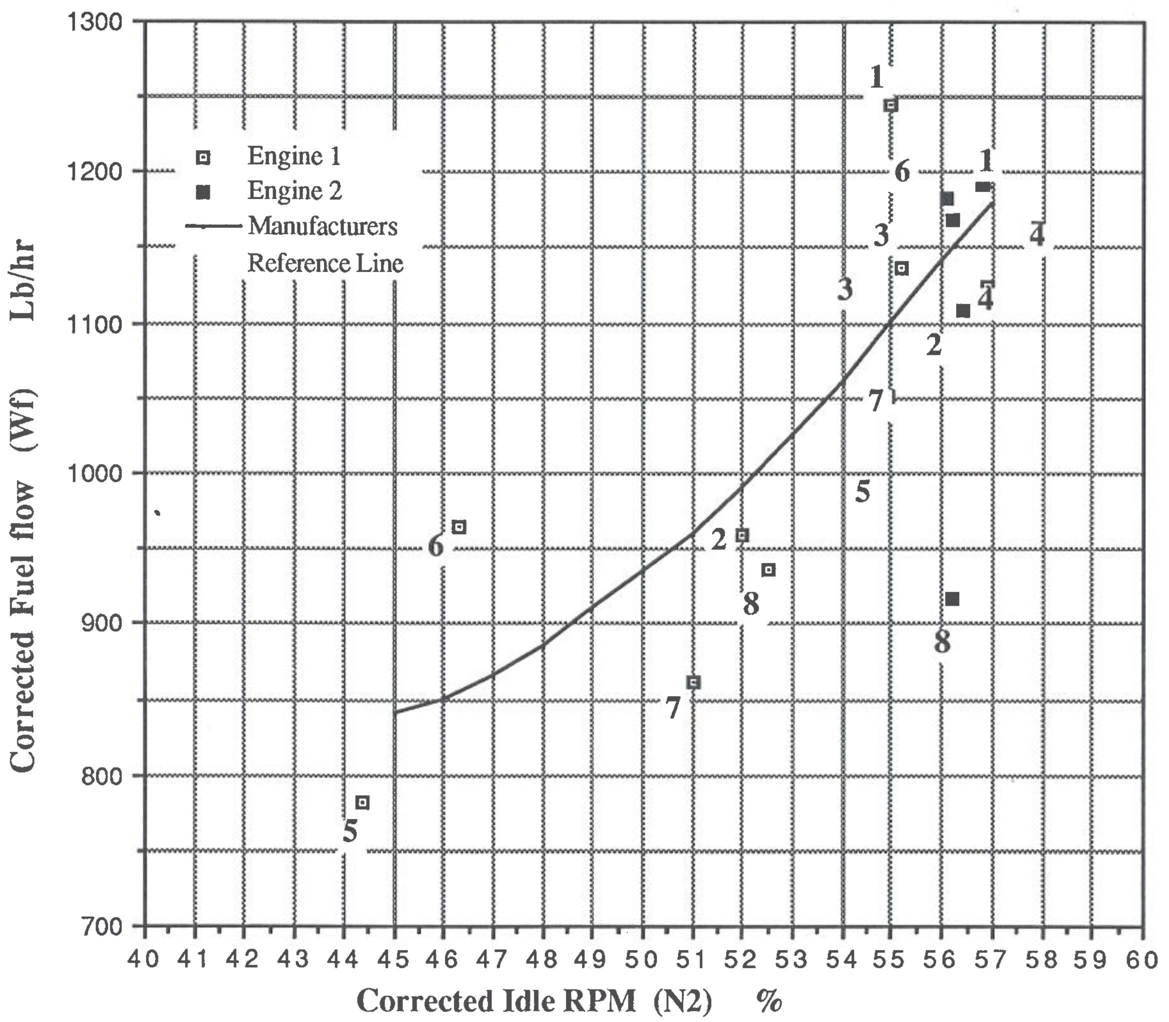


1. Oxidation And Distortion

Severe Local Oxidation And
Distortion (Unacceptable)
Figure 807
(Subtask 72-41-14-22-046)

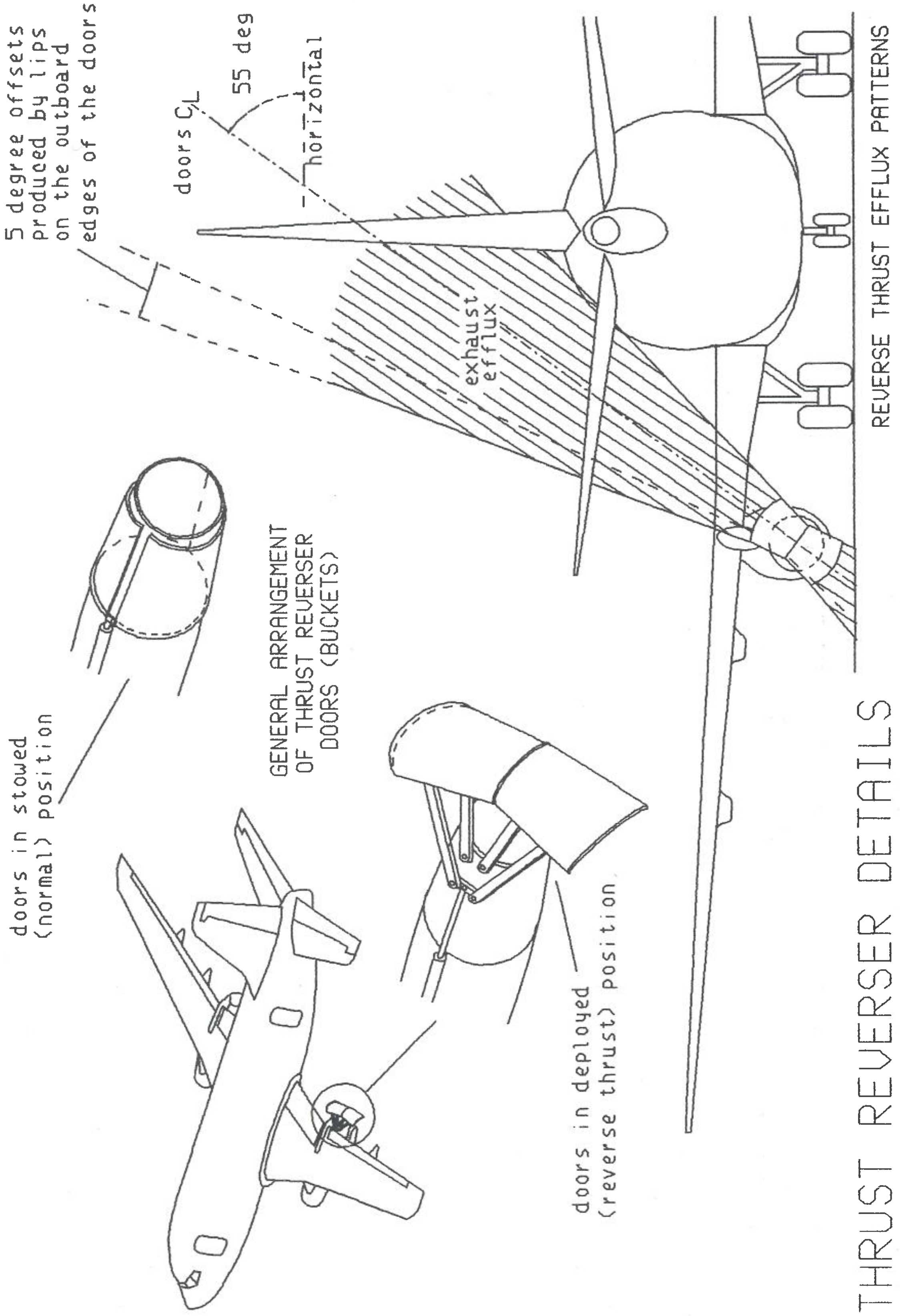
Plot of Corrected Fuel flow (Wf) VS. Corrected Idle RPM (N2)

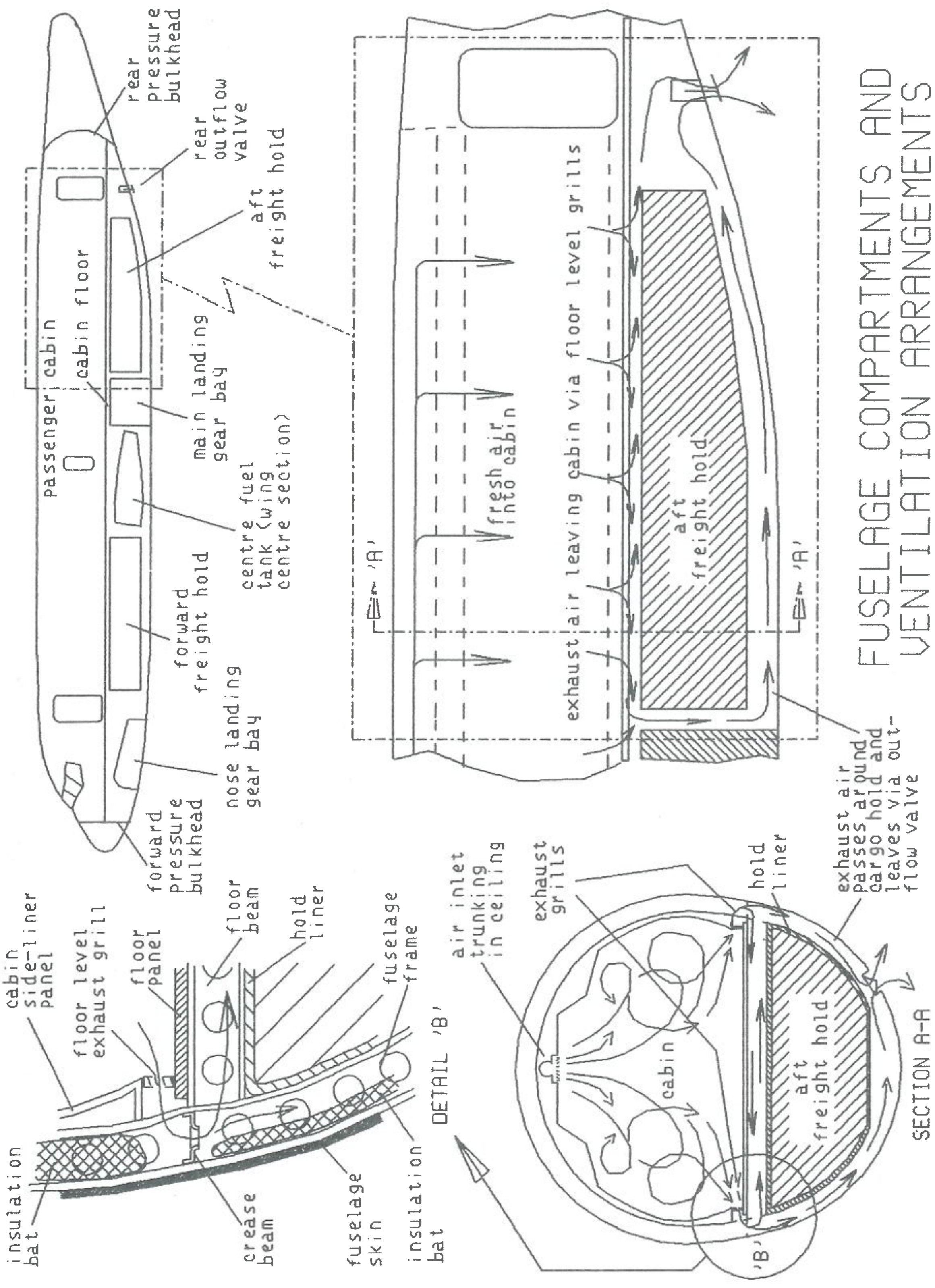
For Sectors flown between 21/8/85 and 22/8/85. Derived from Q.A.R. Data



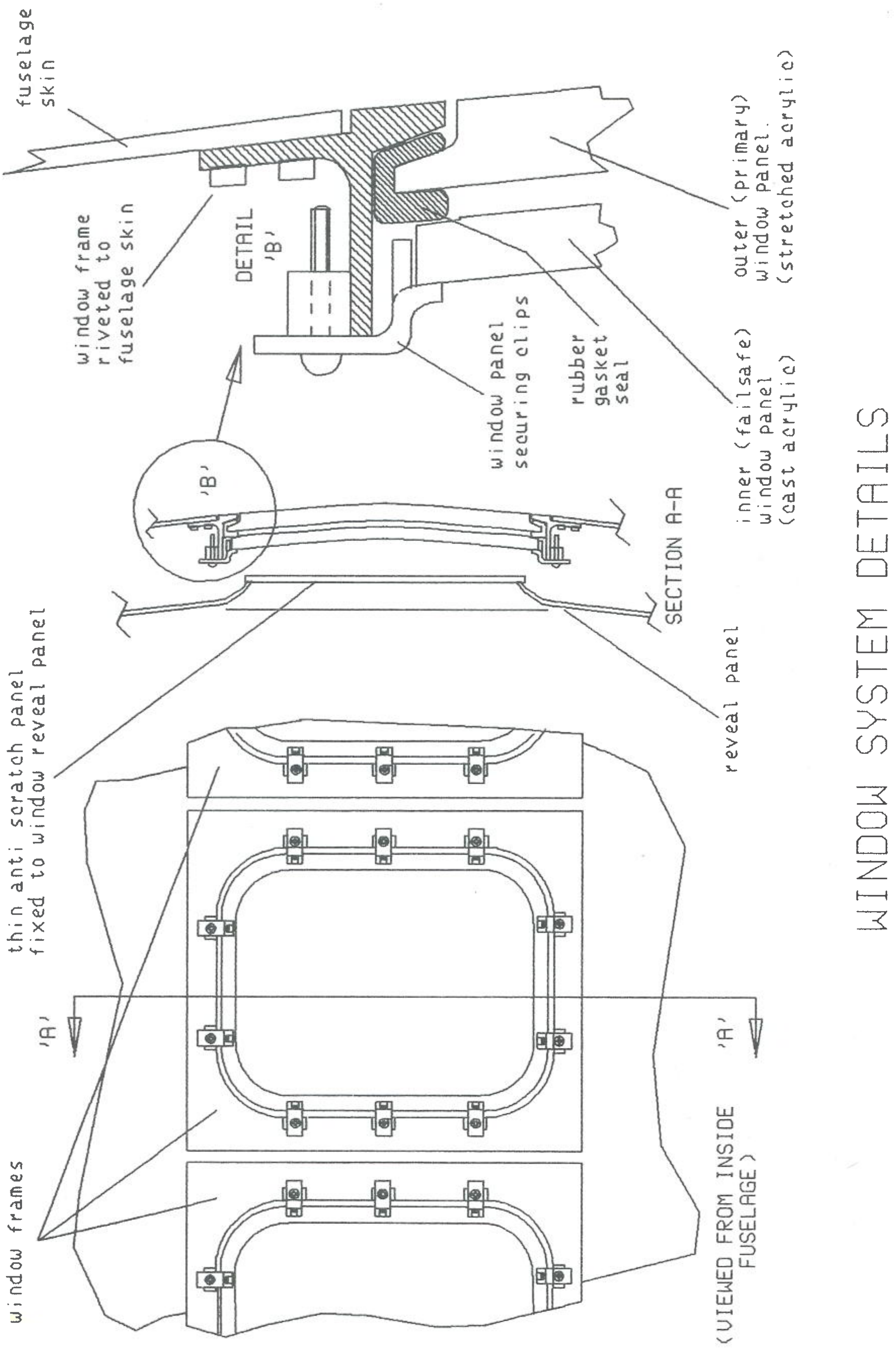
	Date	Sector
1	22/8/85	Manchester - Corfu
2	22/8/85	Athens - Manchester
3	21/8/85	Manchester - Athens
4	21/8/85	Ground Run
5	21/8/85	Barcelona - Manchester
6	21/8/85	Manchester - Barcelona
7	21/8/85	Palma - Manchester
8	21/8/85	Manchester - Palma

Appendix 5 fig i


THRUST REVERSER DETAILS
REVERSE THRUST EFFLUX PATTERNS
5 degree offsets produced by lips on the outboard edges of the doors
doors C_L
55 deg
horizontal
exhaust efflux
GENERAL ARRANGEMENT OF THRUST REVERSER DOORS (BUCKETS)
doors in stowed (normal) position
doors in deployed (reverse thrust) position


FUSELAGE COMPARTMENTS AND
VENTILATION ARRANGEMENTS
rear pressure bulkhead
rear outflow valve
aft freight hold
passenger cabin
cabin floor
main landing gear bay
centre fuel tank (wing centre section)
forward freight hold
nose landing gear bay
forward pressure bulkhead
fresh air into cabin
exhaust air leaving cabin via floor level grills
'A'
'A'
aft freight hold
exhaust air passes around cargo hold and leaves via out-flow valve
air inlet trunking in ceiling
exhaust grills
hold liner
cabin
aft freight hold
'B'
SECTION A-A
cabin side-liner panel
floor level exhaust grill
floor panel
floor beam
hold liner
fuselage frame
DETAIL 'B'
insulation bat
crease beam
fuselage skin
insulation bat

Appendix 6 fig.c



Emergency Evacuation Certification Requirements

FAR part 25.803

a) Each crew and passenger area must have emergency means to allow rapid evacuation in crash landings, with the landing gear extended and retracted, considering the possibility of the airplane being on fire.

b) Passenger ventral and tail cone, crew access, and service doors may be considered as emergency exits if they meet the applicable requirements of this section and 25.805 through 25.813.

c) Except as provided in paragraph (d) of this section, on airplanes having a seating capacity of more than 44 passengers, it must be shown by actual demonstration that the maximum seating capacity, including the number of crew-members required by the operating rules, for which certification is requested can be evacuated from the airplane to the ground within 90 seconds. Evacuees using stands or ramps allowed by subparagraph (8) of this paragraph are considered to be on the ground when they are on the stand or ramp, provided that the acceptance rate of the stand or ramp is no greater than the acceptance rate of the means available on the airplane for descent from the wing during an actual crash situation. The demonstration must be conducted under the following conditions:

(1) It must be conducted either during the dark of the night or during daylight with the dark of the night simulated, utilizing only the emergency lighting system and utilizing only the emergency exits and emergency evacuation equipment on one side of the fuselage, with the airplane in the normal ground attitude, with landing gear extended.

(2) All emergency equipment must be installed in accordance with specified limitations of the equipment.

(3) Each external door and exit, and each internal door and curtain must be in a configuration to simulate a normal take-off.

(4) Seat belts and shoulder harnesses (as required) must be fastened.

(5) A representative passenger load of persons in normal health must be used as follows:

(i) At least 30 percent must be female.

(ii) Approximately 5 percent must be over 60 years of age, with a proportionate number of females.

(iii) At least 5 percent but no more than 10 percent must be children under 12 years of age, prorated through that age group.

(6) Persons who have knowledge of the operation of the exits and emergency equipment may be used to represent an air carrier crew. Such representative crew-members must be in their seats assigned for take-off and landing and none may be seated next to an emergency exit unless that seat is his assigned seat for take off. They must remain in their assigned seats until receiving the signal for the beginning of the demonstration.

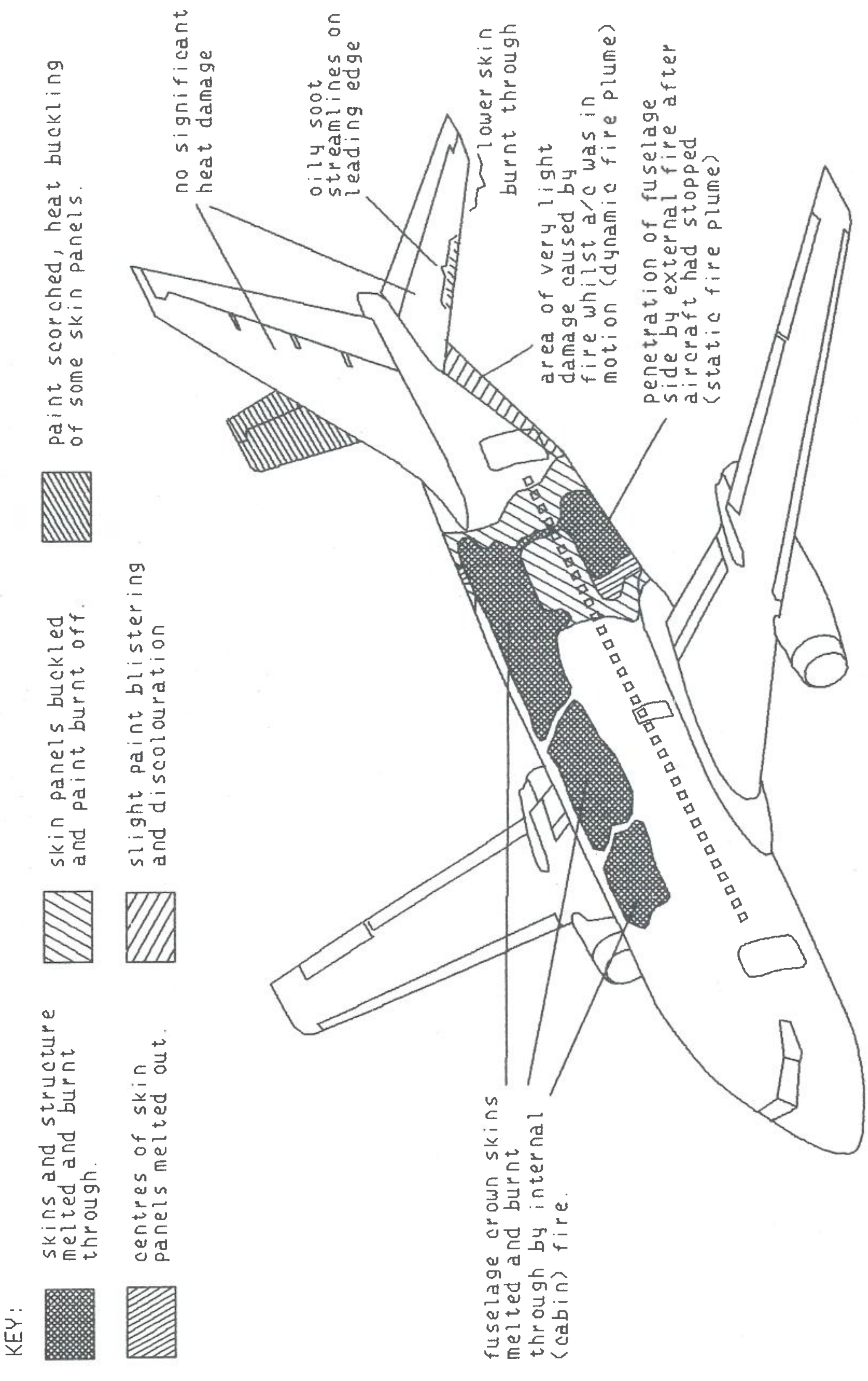
(7) There can be no practice or rehearsal of the demonstration for the passengers except that they may be briefed as to the location of all emergency exits before the demonstration. However, no indication may be given of the particular exits to be used in the demonstration.

(8) Stands or ramps may be used for descent from the wing to the ground.

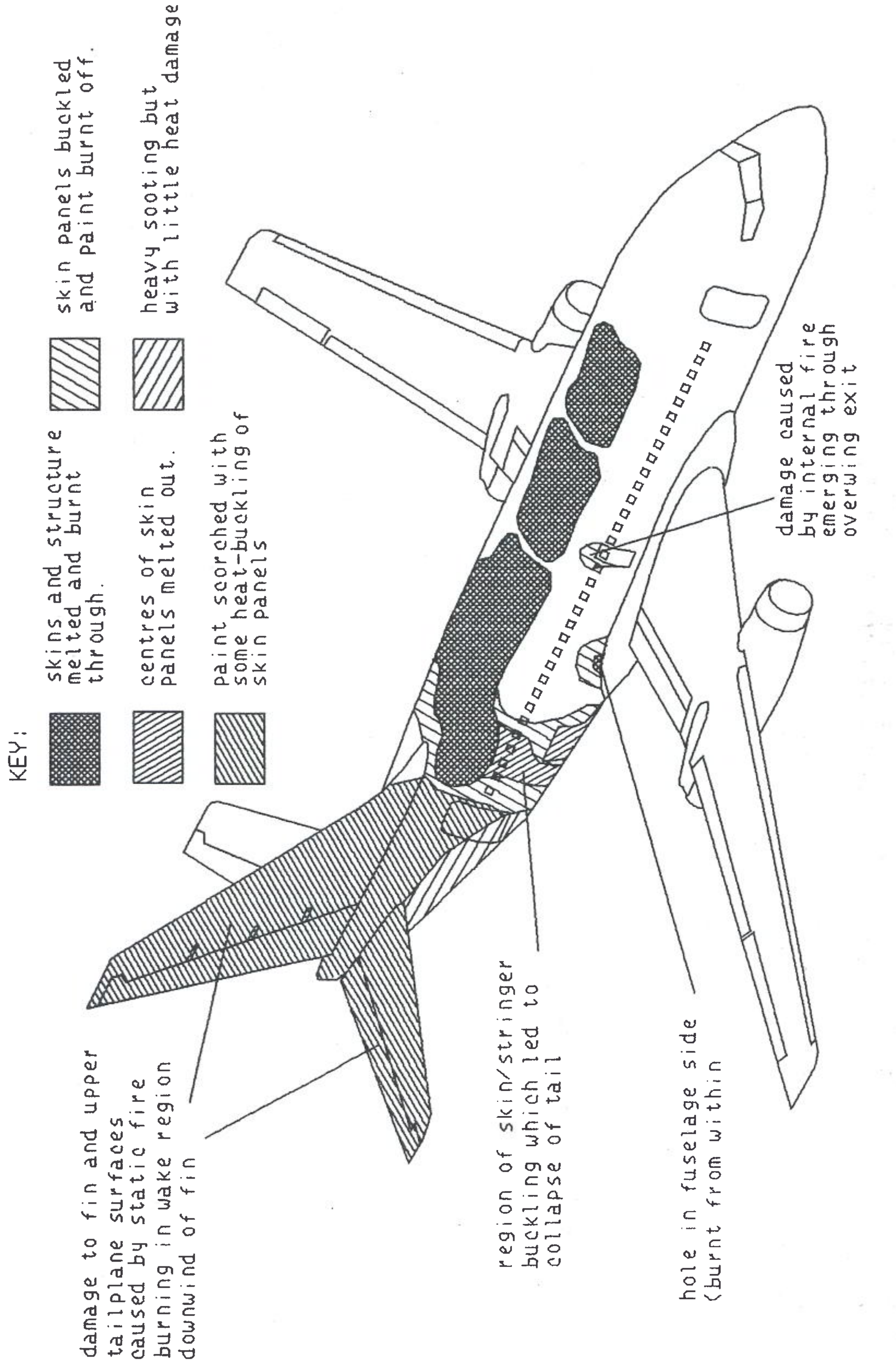
(9) All evacuees other than those using an overwing exit must leave the airplane by the means provided as part of the airplane's equipment.

d) The emergency evacuation demonstration need not be repeated after a change in the interior arrangement of the airplane or an increase of not more than 5 percent in passenger seating capacity over that previously approved by actual demonstration, or both, if it can be substantiated by analysis, taking due account of the differences, that all the passengers for which the airplane is certificated can evacuate within 90 seconds.

e) An escape route must be established from each overwing emergency exit, marked and (except for flap surfaces suitable as slides) covered with a slip resistant surface.

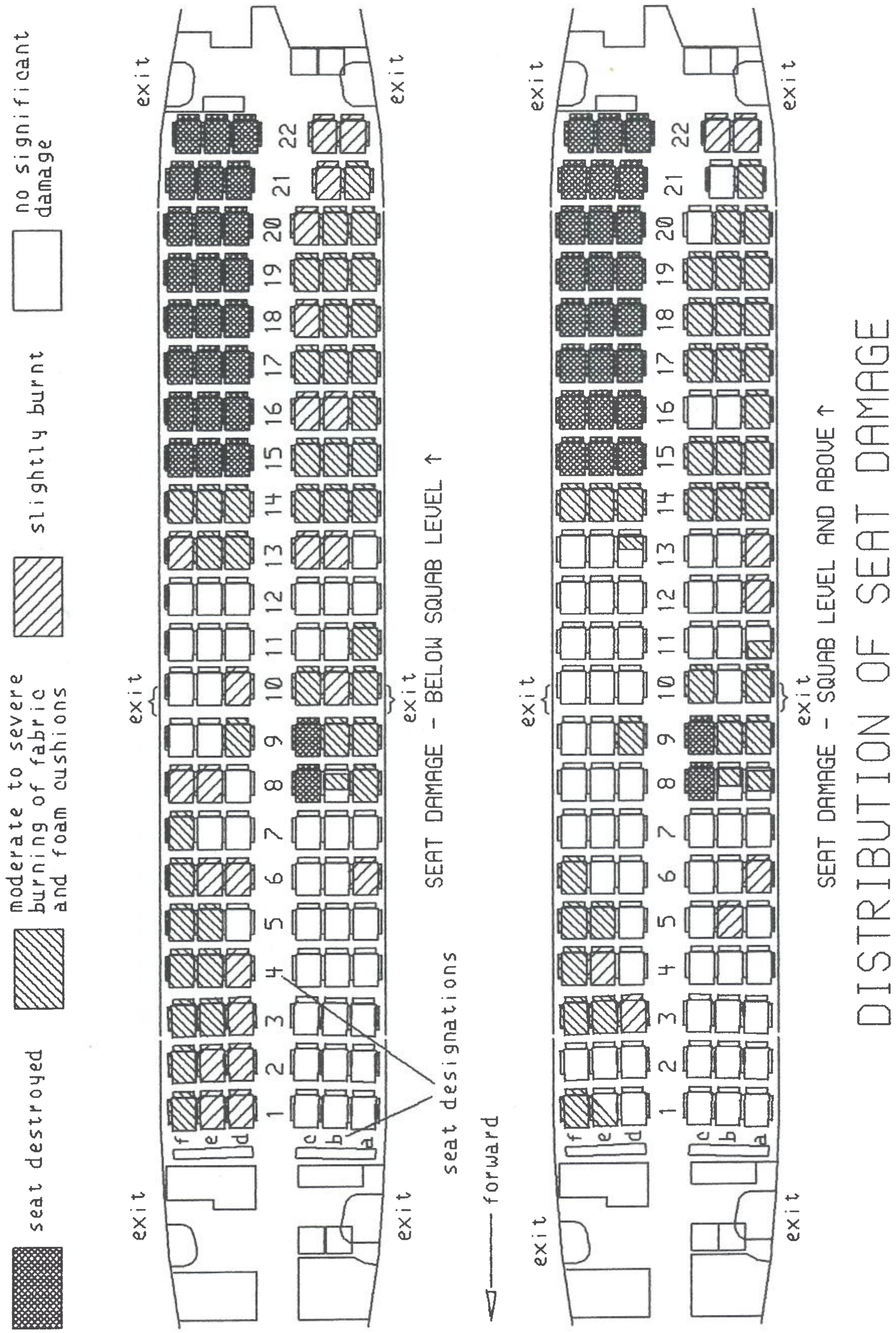


PRINCIPAL FIRE DAMAGE - FUSELAGE AND TAIL PORT SIDE

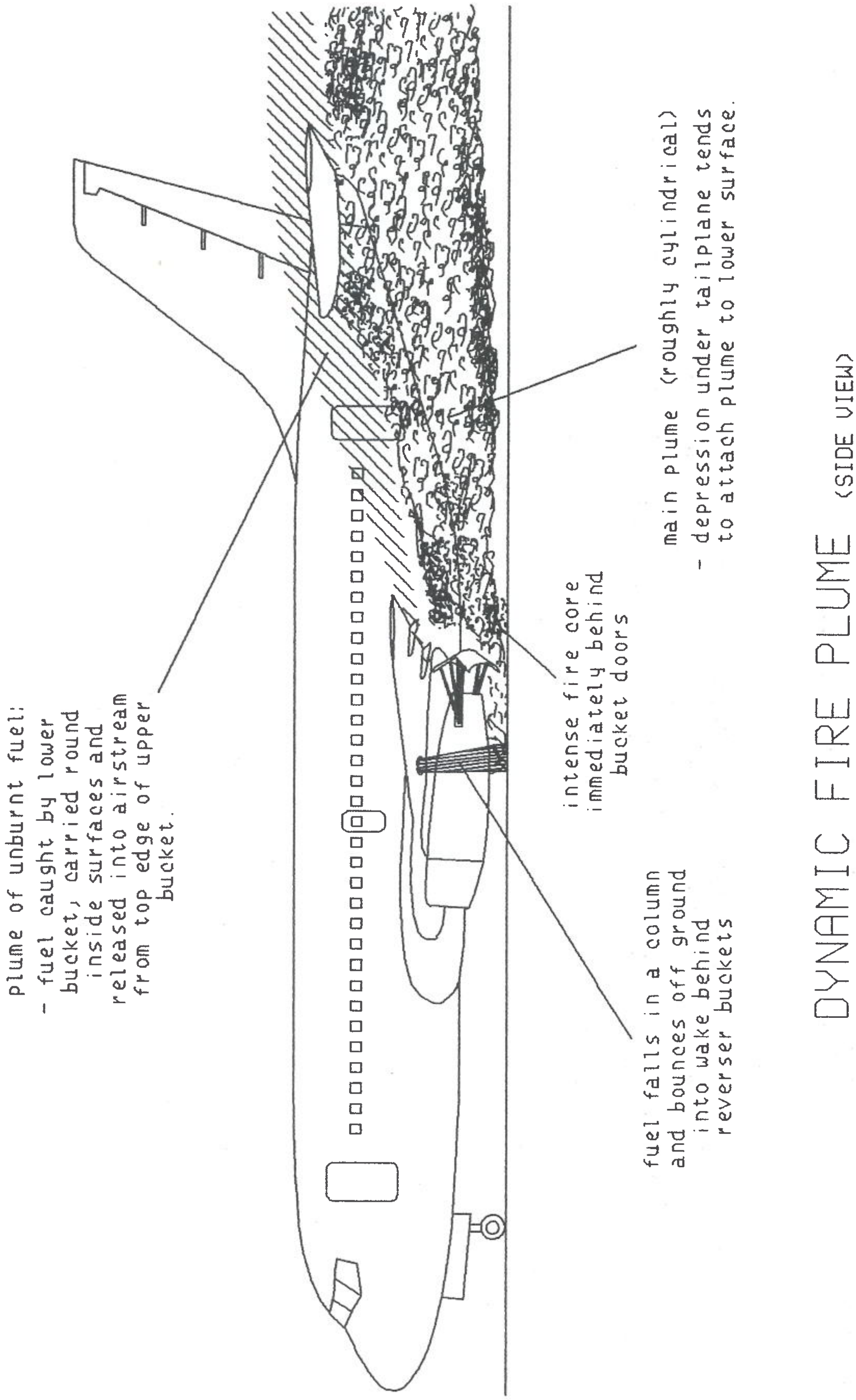


PRINCIPAL FIRE DAMAGE - FUSELAGE AND TAIL STARBOARD SIDE

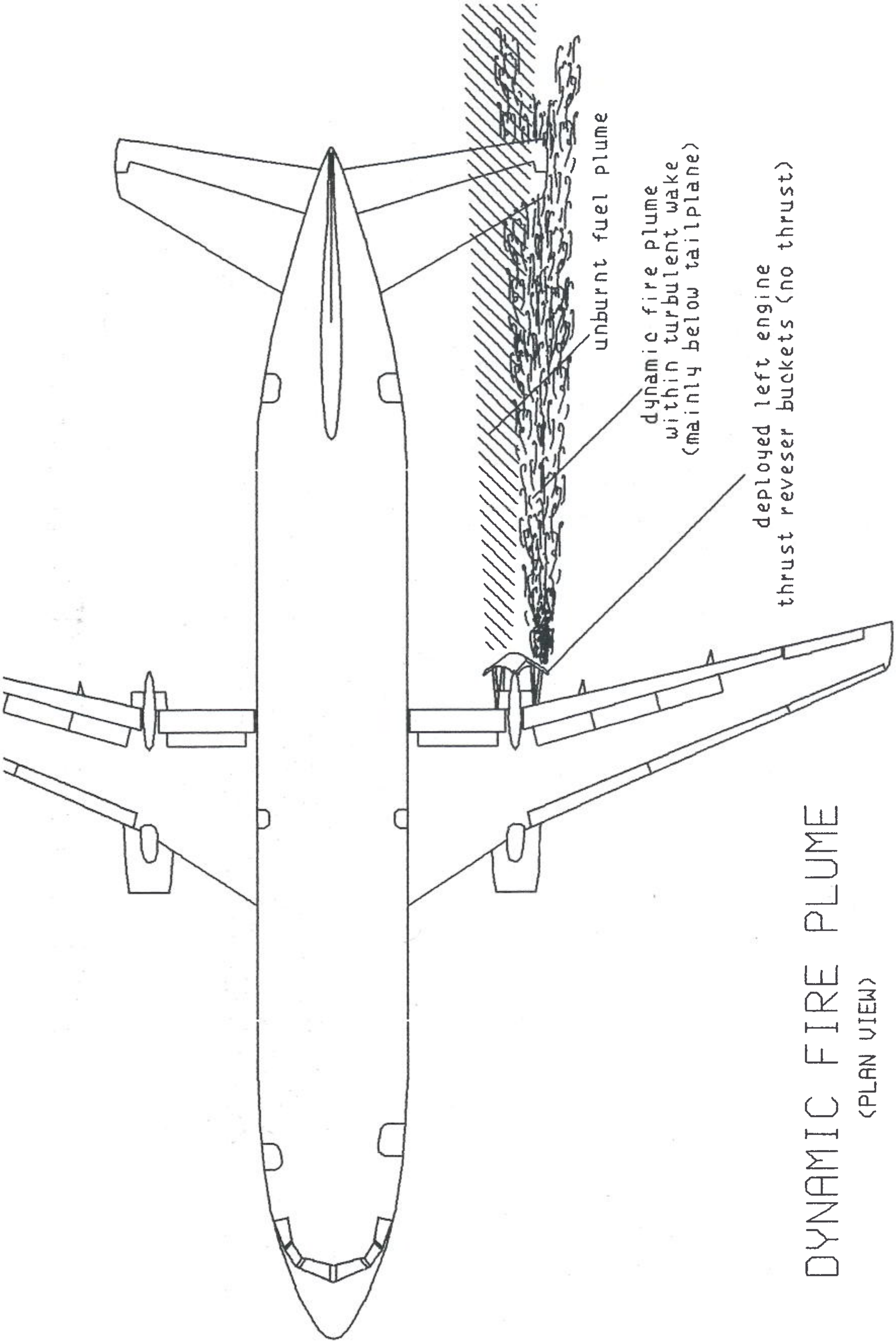
Appendix 8 fig c

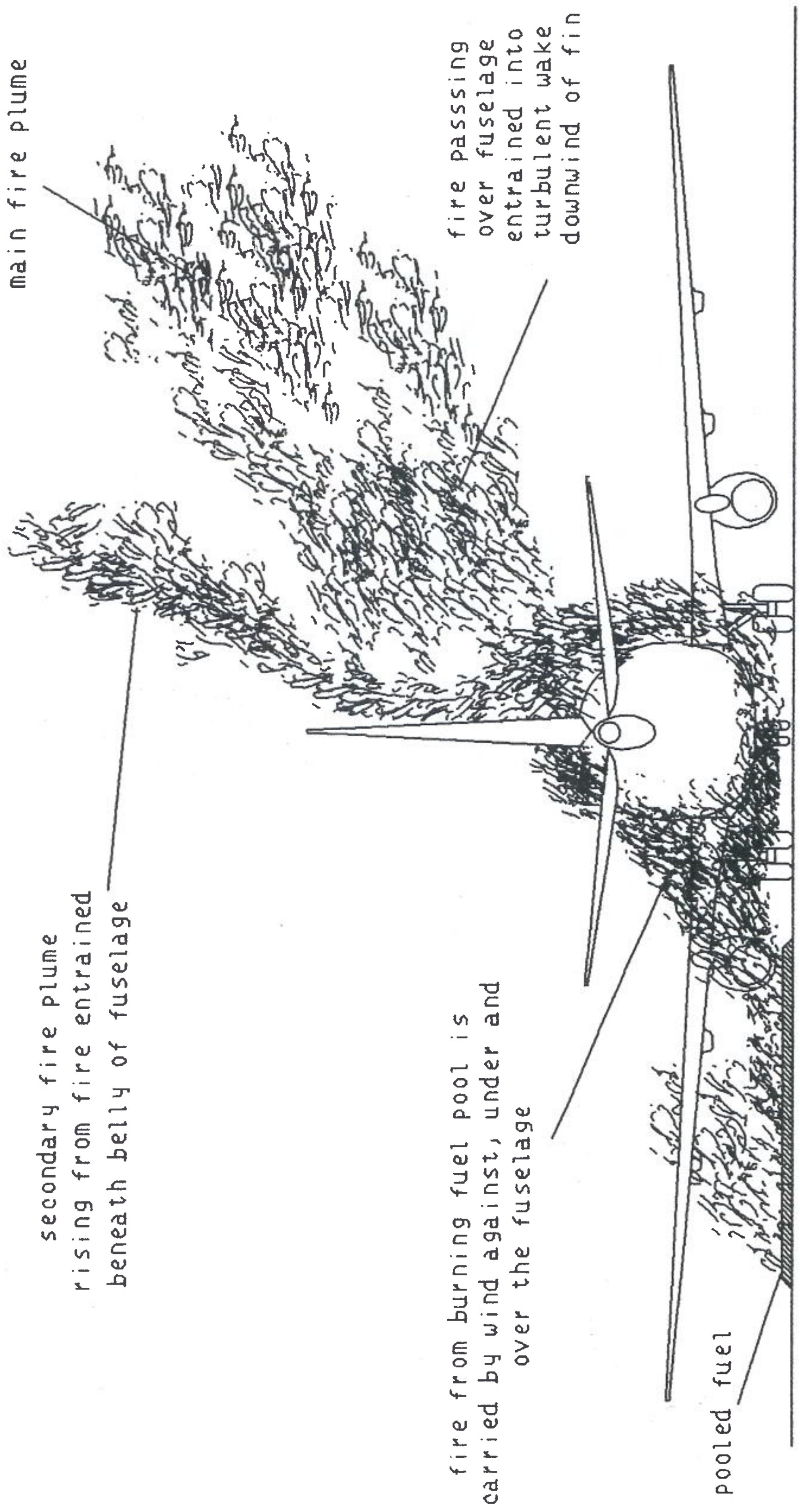


Appendix 7 fig.d



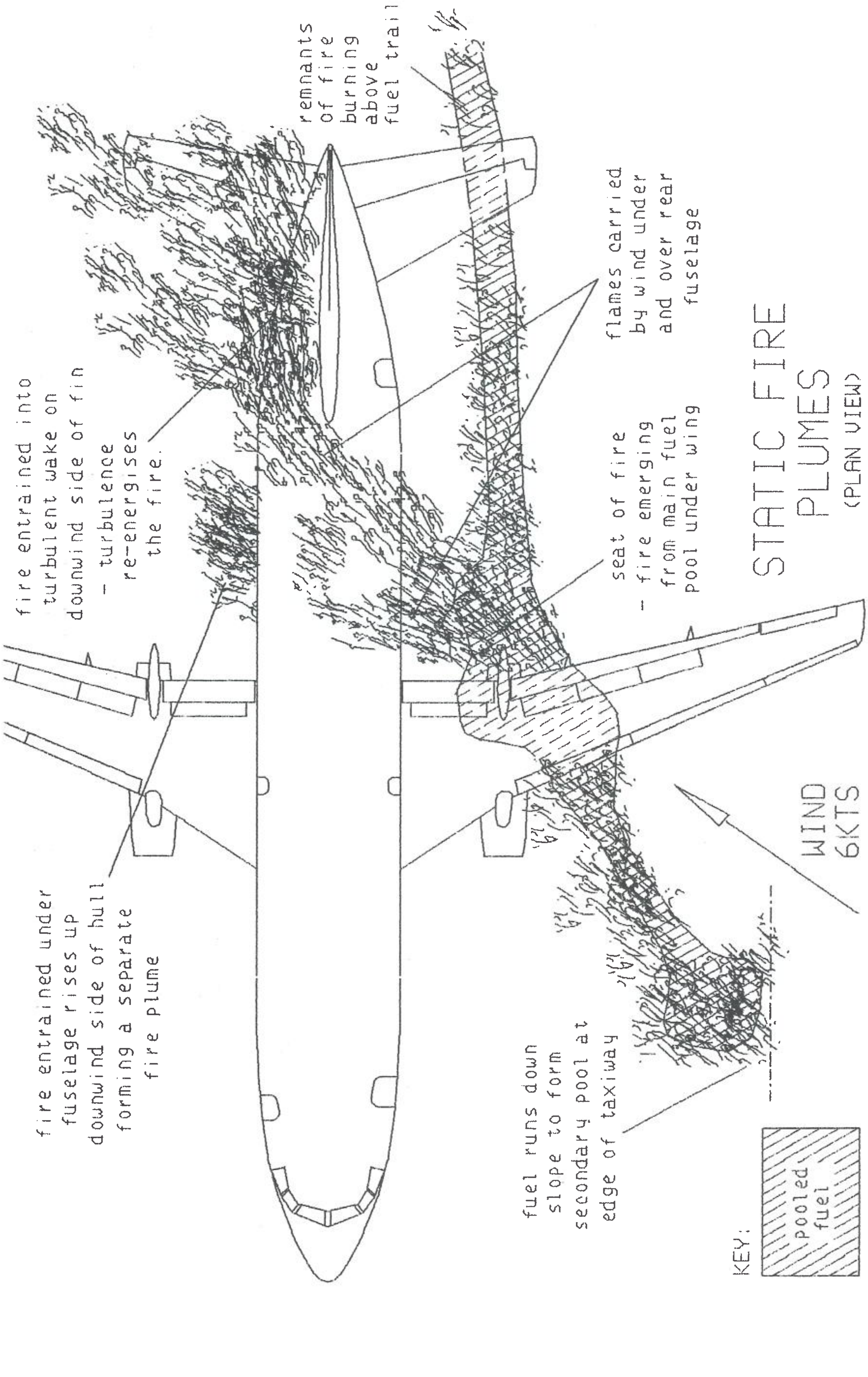
Appendix 8 fig e

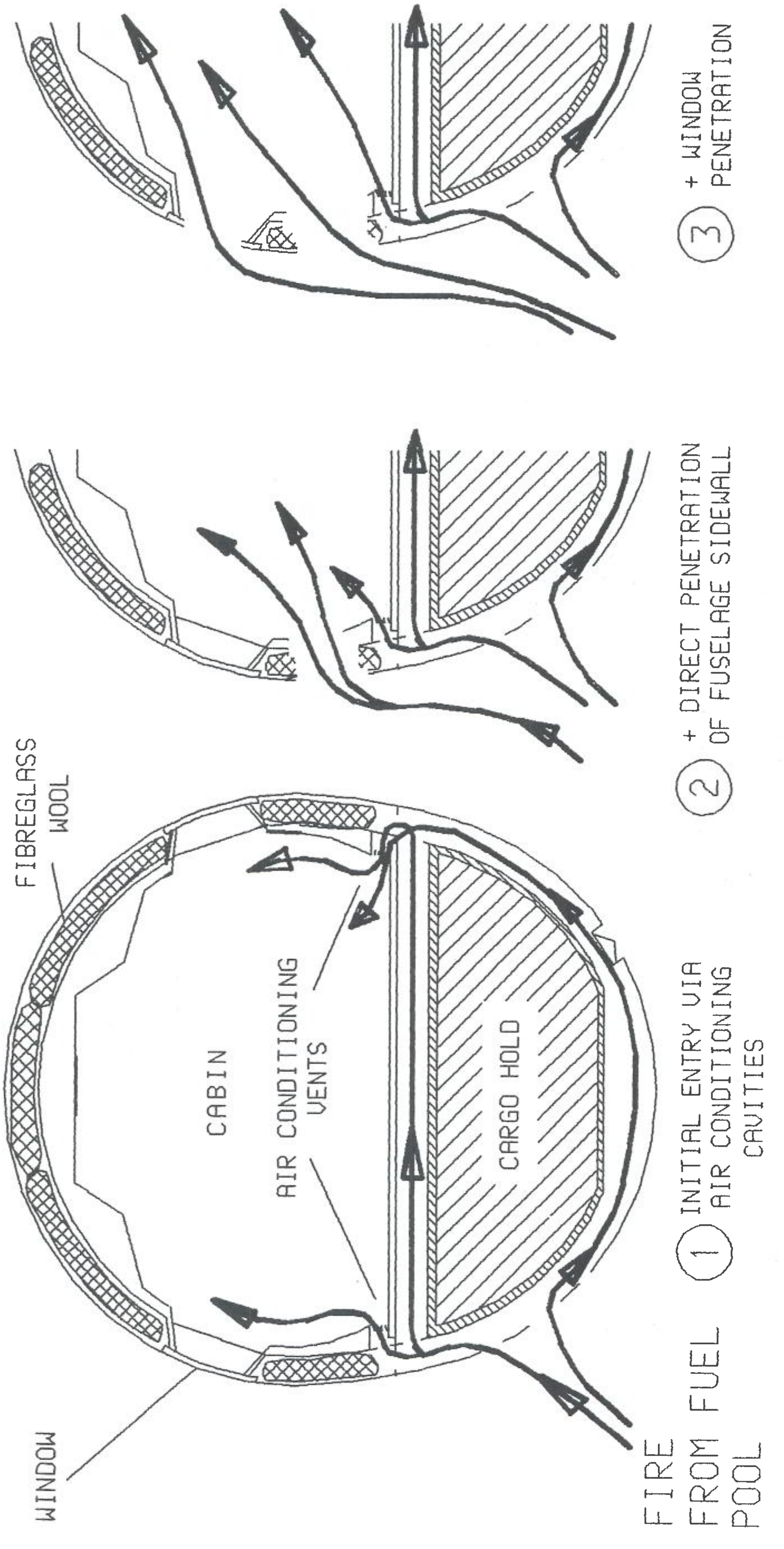




STATIC FIRE PLUMES (VIEWED FROM REAR)

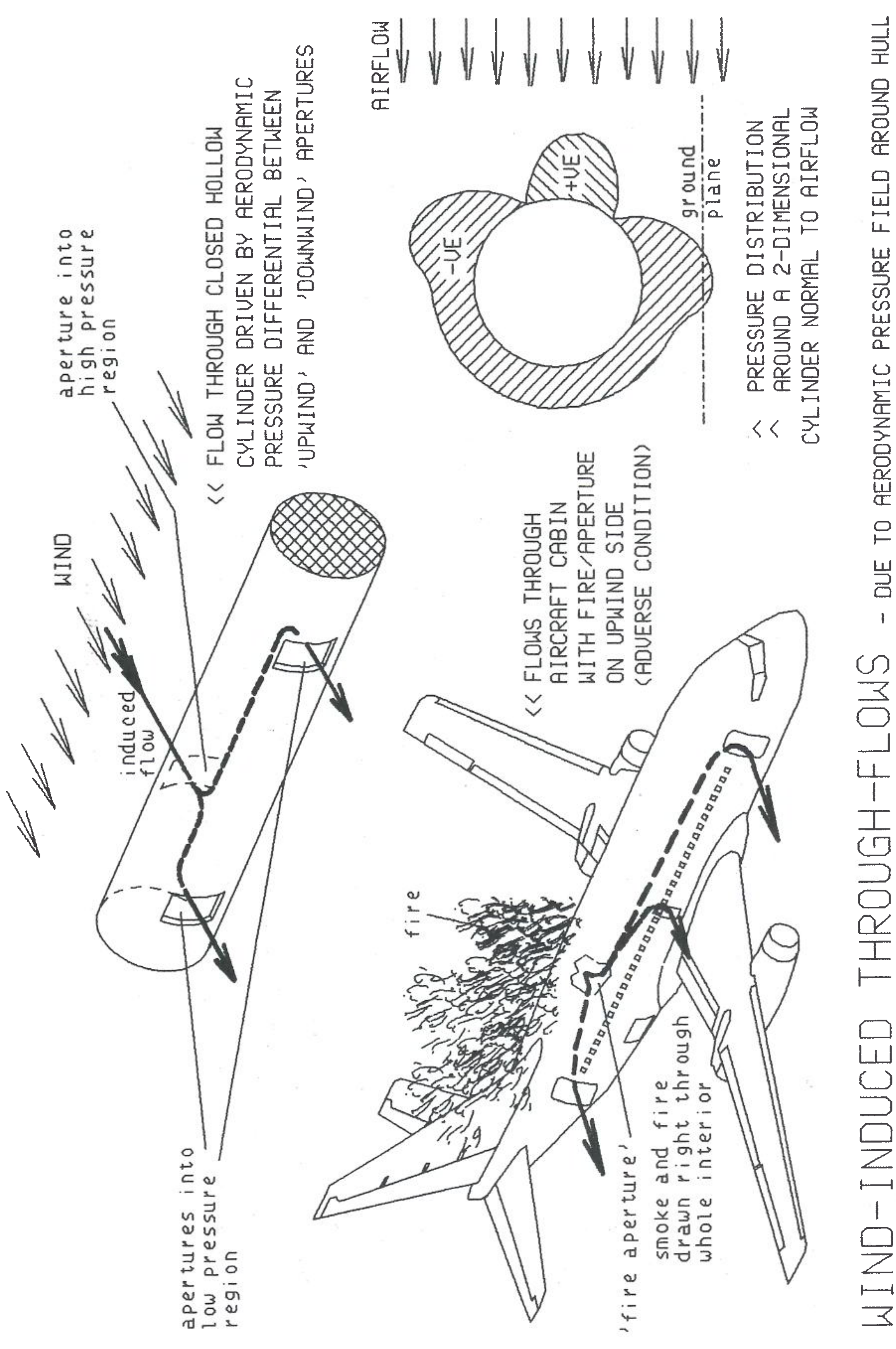
Appendix 8 fig g

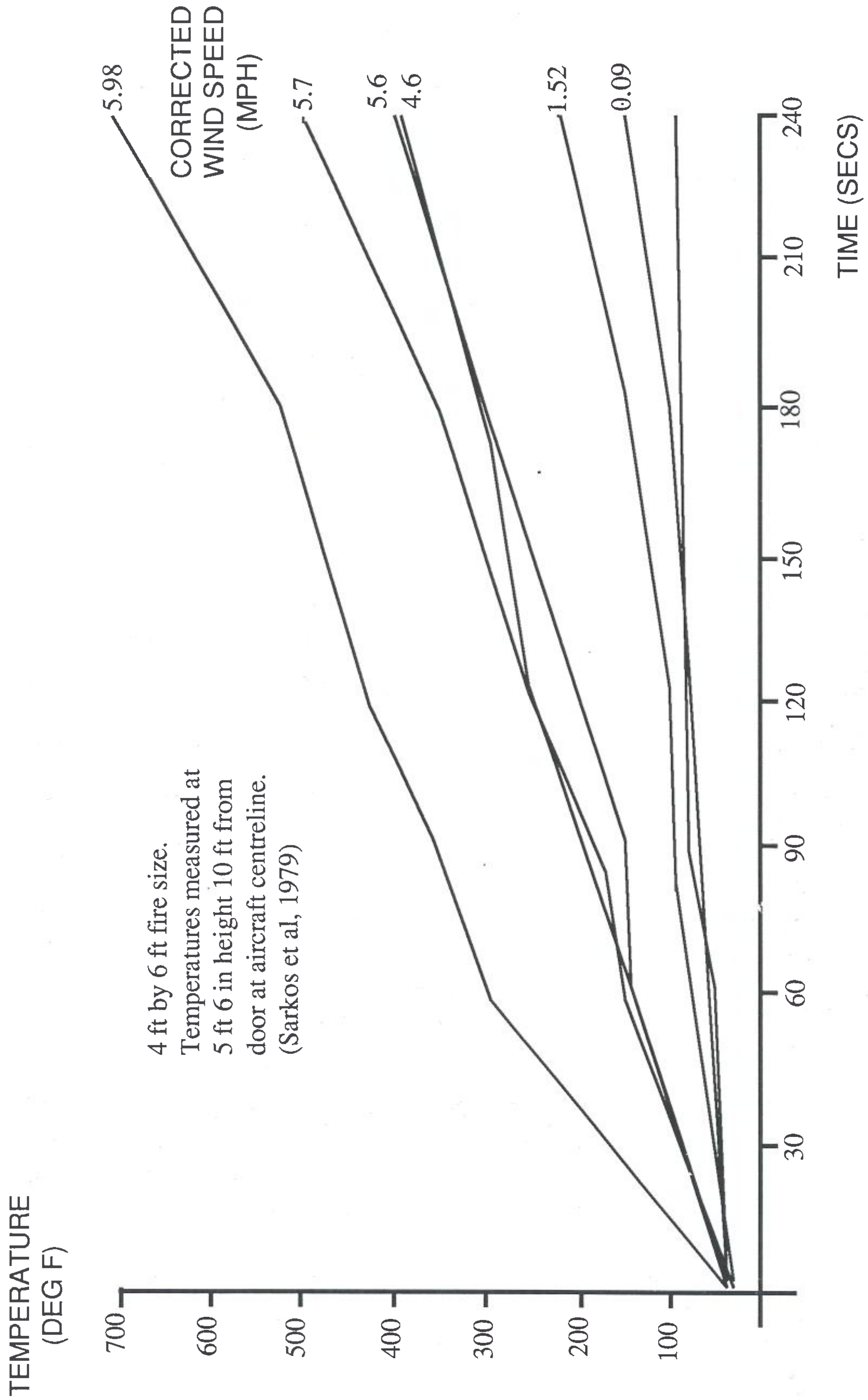




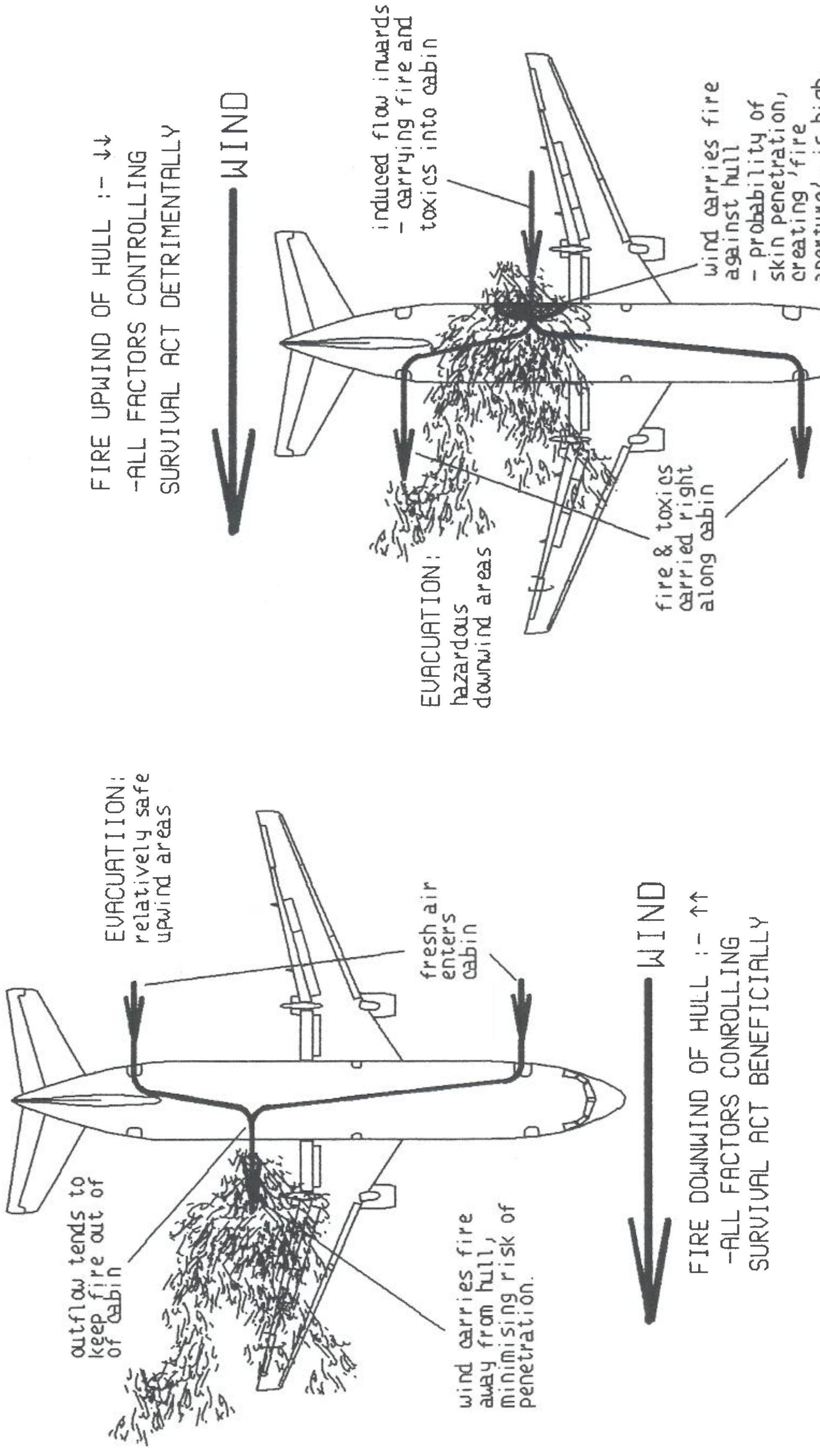
SEQUENCE OF FIRE PENETRATION

Appendix 8 fig.i



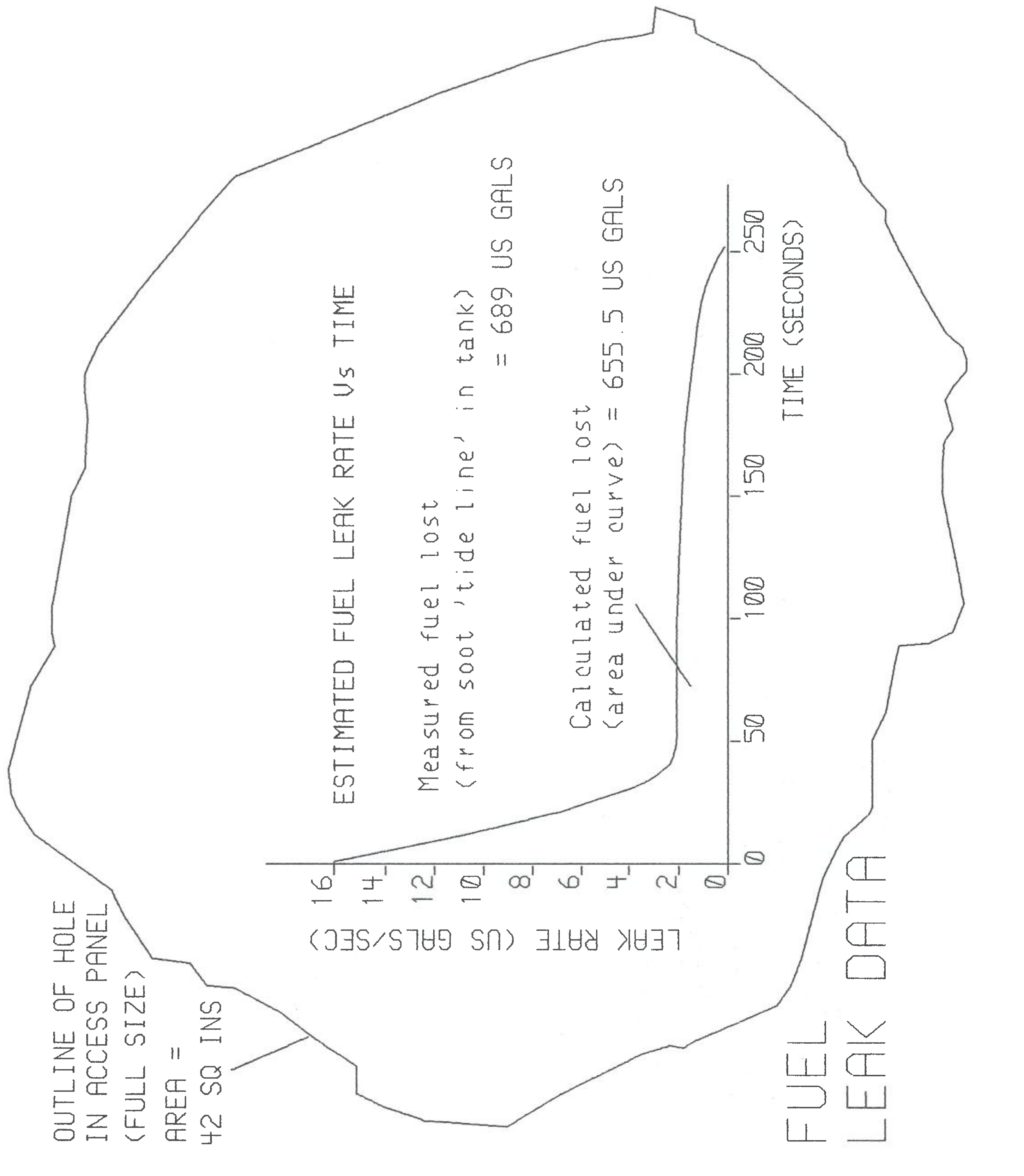


Effect of Wind on Cabin Temperatures



FIRE SCENARIOS

- ILLUSTRATING THE CRUCIAL INFLUENCE OF WIND DIRECTION ON SURVIVAL

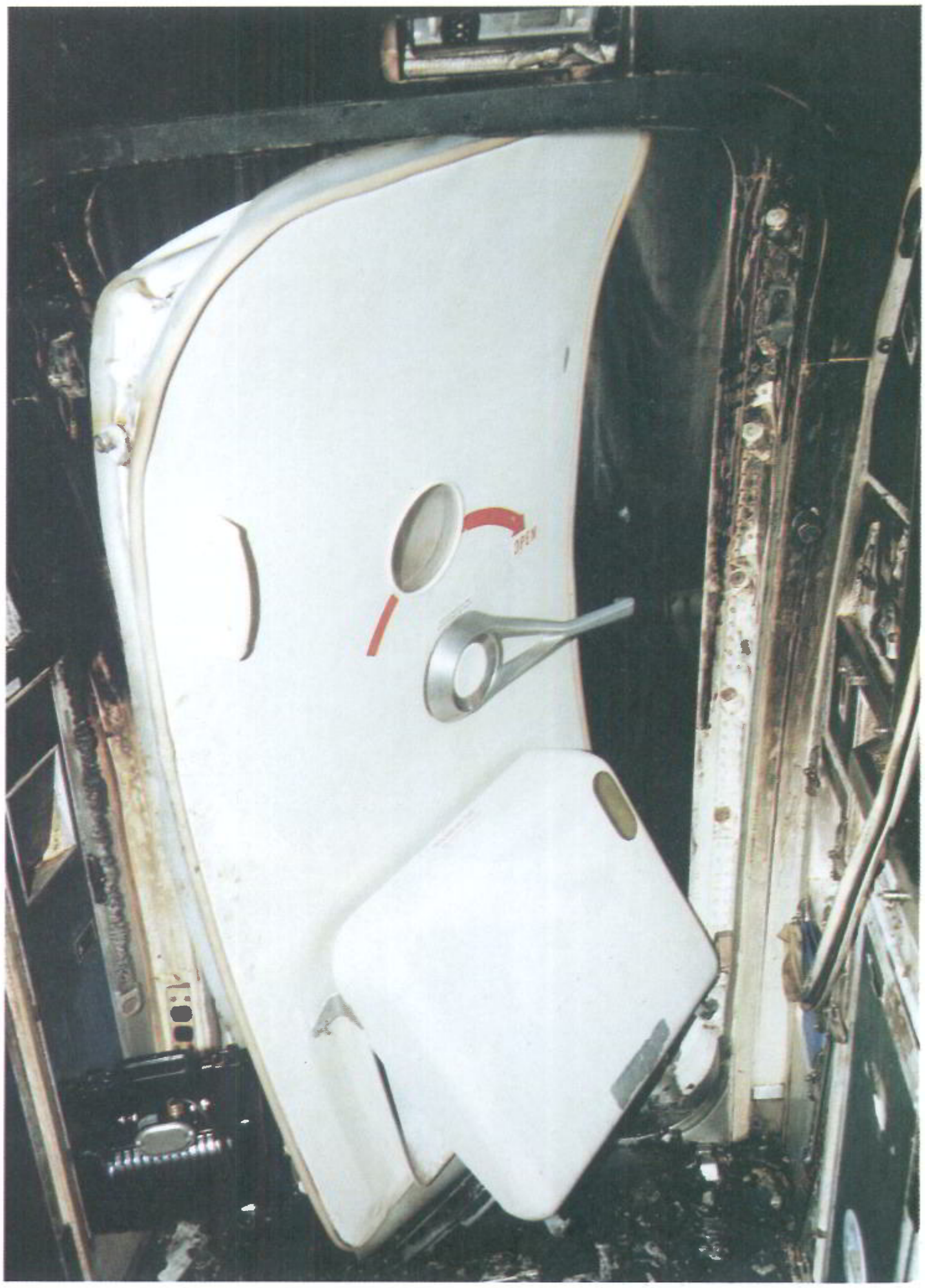

ESTIMATED FUEL LEAK RATE Vs TIME
Measured fuel lost
(from soot 'tide line' in tank)
= 689 US GALS
Calculated fuel lost
(area under curve) = 655.5 US GALS
LEAK RATE (US GALS/SEC)
TIME (SECONDS)
0
2
4
6
8
10
12
14
16
0
50
100
150
200
250
OUTLINE OF HOLE
IN ACCESS PANEL
(FULL SIZE)
AREA =
42 SQ INS
FUEL
LEAK DATA

Appendix 10 Photos. a-b

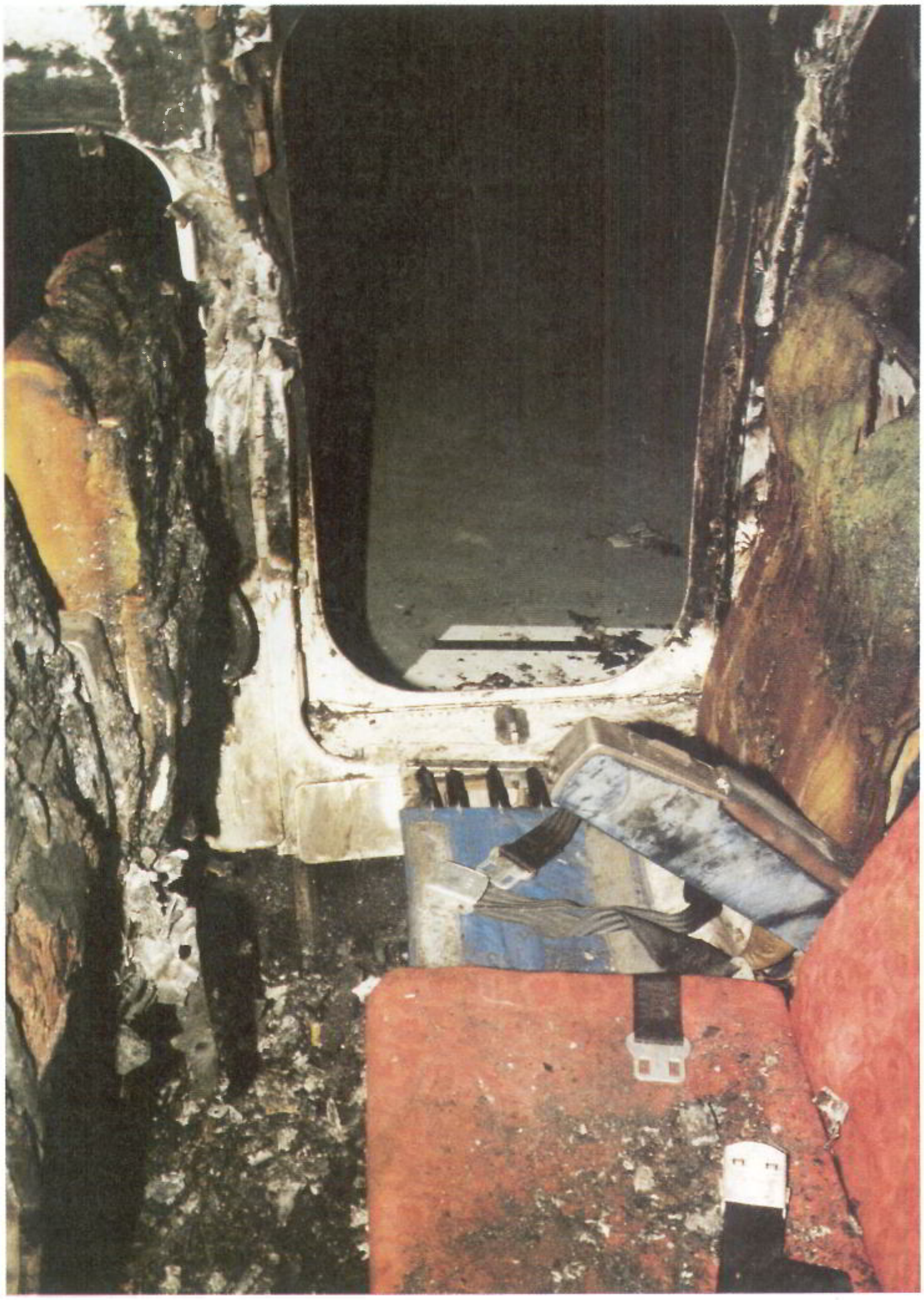
Right Forward (R1) Door Jam

a - Witness Mark on Slide Box Lid

b - Door Position With Witness Marks Aligned-External



c-Door Position Witness Mark Aligned - Internal



Area Adjacent to the Right Overwing Exit

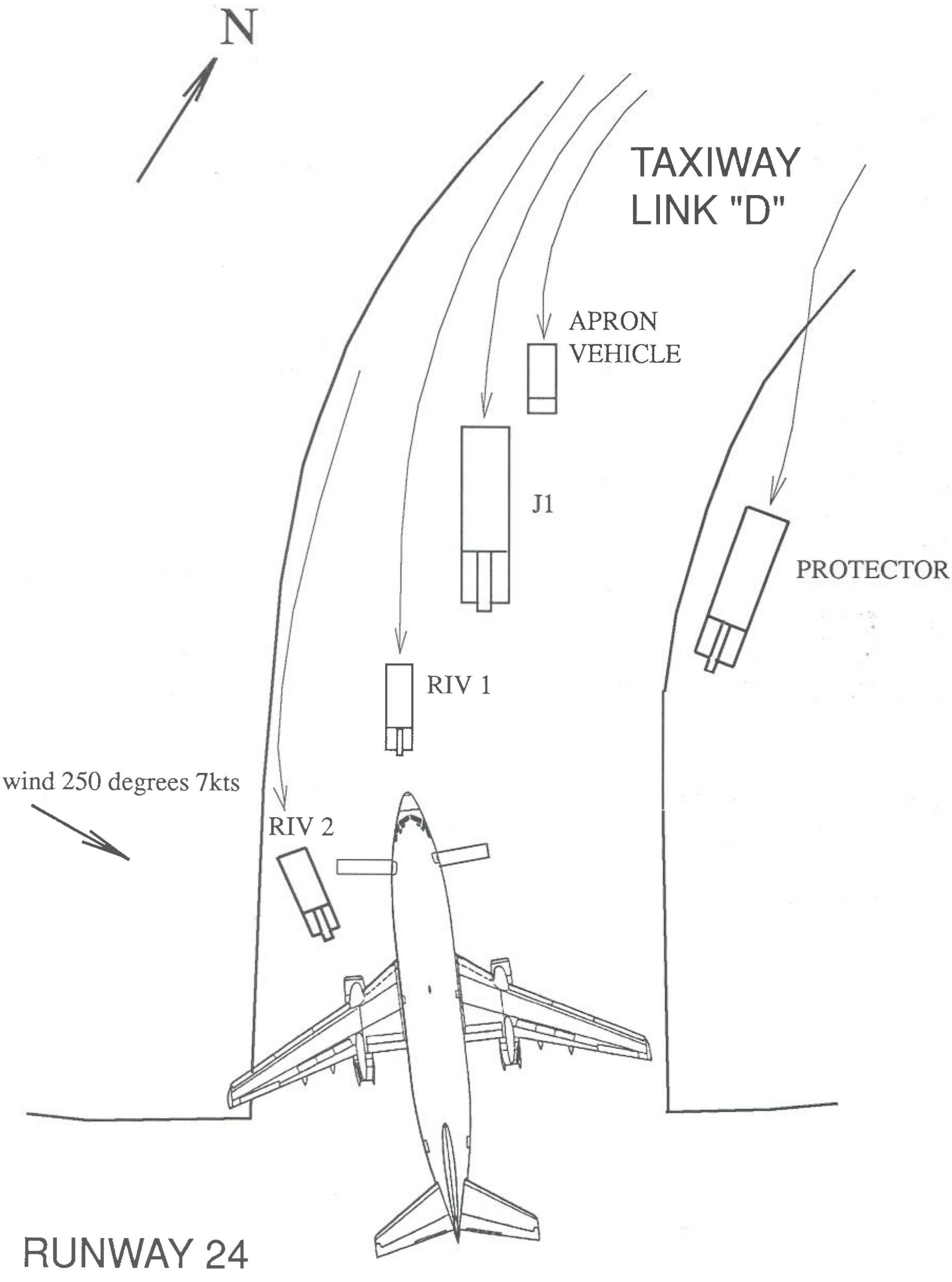
Appendix 12

Seat Number	Age	Sex	Carbon Monoxide Saturation % 100ml	Cyanide Micrograms/ grams/L	Benzene Milli-grams/L	Toluene Milli-grams/L	Pathology No
7C	16 yrs	F	61	315	0.47	0.04	40F
+8B	31yrs	M	-	-	-	-	-
8C	49 yrs	F	38	233	0.39	0.08	24F
8E	31 yrs	F	51	400	0.78	0.19	41F
8F	58 yrs	F	35	55	0.29	0.04	44F
9F	35 yrs	F	54	260	0.18	0.06	28F
10A	59 yrs	M	30	195	0.35	0.04	51M
10B	36 yrs	F	62	240	0.37	0.07	39F
12B	38 yrs	F	38	500	0.29	0.05	52F
12C	15 yrs	F	79	840	1.08	0.19	47F
12E	44 yrs	F	42	450	0.16	0.03	25F
12F	40 yrs	M	25	560	0.09	0.02	42M
13E	9 yrs	F	61	310	0.89	0.12	53F
14C	52 yrs	M	52	680	1.73	0.38	48M
14D	50 yrs	F	39	190	0.24	0.06	35F
14D	41 yrs	F	50	335	0.50	0.07	38F
15E	42 yrs	M	25	450	0.05	ND*	31M
15F	42 yrs	F	54	370	0.45	0.07	43F
16A	24 yrs	F	32	88	0.56	0.09	16F
16B	40 yrs	M	41	170	0.34	0.07	18M
16C	46 yrs	M	22	120	0.22	0.04	34M
16E	48 yrs	M	22	480	0.22	0.04	21M
16F	47 yrs	F	44	520	0.74	0.12	20F
17A/B	47 yrs	F	20	73	0.02	ND*	37F
17A/B	68 yrs	F	68	500	1.59	0.24	50F
17C/D		M	28	125	0.46	0.06	36M
17C/D	46 yrs	M	40	65	0.33	0.06	54M
17E	46 yrs	M	31	540	0.58	0.09	17M
17F	45 yrs	F	40	250	0.81	0.21	32F
18A	19 yrs	F	41	190	0.68	0.11	45F
18B	19 yrs	F	54	240	0.44	0.07	30F
18D	25 yrs	M	35	200	0.56	0.14	27M
19A	19 yrs	M	42	300	1.30	0.24	12M
19C	56 yrs	M	44	350	0.20	ND*	26M
19D	49 yrs	F	65	430	0.57	0.16	49F

Seat Number	Age	Sex	Carbon Monoxide Saturation %	Cyanide Micrograms/ 100ml	Benzene Milli- grams/L	Toluene Milli- grams/L	Path No.
19E	21 yrs	M	43	550	0.33	0.05	29M
19F	21 yrs	F	53	185	0.70	0.07	33F
20A	19 yrs	F	45	250	0.42	0.09	13F
20C	47 yrs	M	23	183	0.13	ND*	22M
20D	29 yrs	F	46	200	0.53	0.08	23F
20E	39 yrs	M	24	53	0.31	0.05	10M
20F	44 yrs	F	36	300	0.30	0.07	11F
21A	57 yrs	M	8	74	0.02	ND*	3M
21B	57 yrs	F	15	179	0.02	ND*	5F
21D	11 yrs	M	45	250	1.17	0.18	19M
21E	34 yrs	M	22	115	0.08	0.01	46M
21F	29 yrs	F	40	91	0.55	0.09	6F
21F(lap)	2 yrs	F	49	290	0.32	0.07	7F
22A	20 yrs	F	45	190	0.32	0.08	2F
22C	19 yrs	M	17	168	0.10	ND*	15M
22D	18 yrs	F	41	70	0.66	0.10	9F
22E	45 yrs	M	23	150	0.16	0.04	14M
22F	50 yrs	F	25	145	0.57	0.14	8F
Hostess	27 yrs	F	38	158	0.39	0.04	1F
Hostess	23 yrs	F	34	203	0.25	0.05	4F

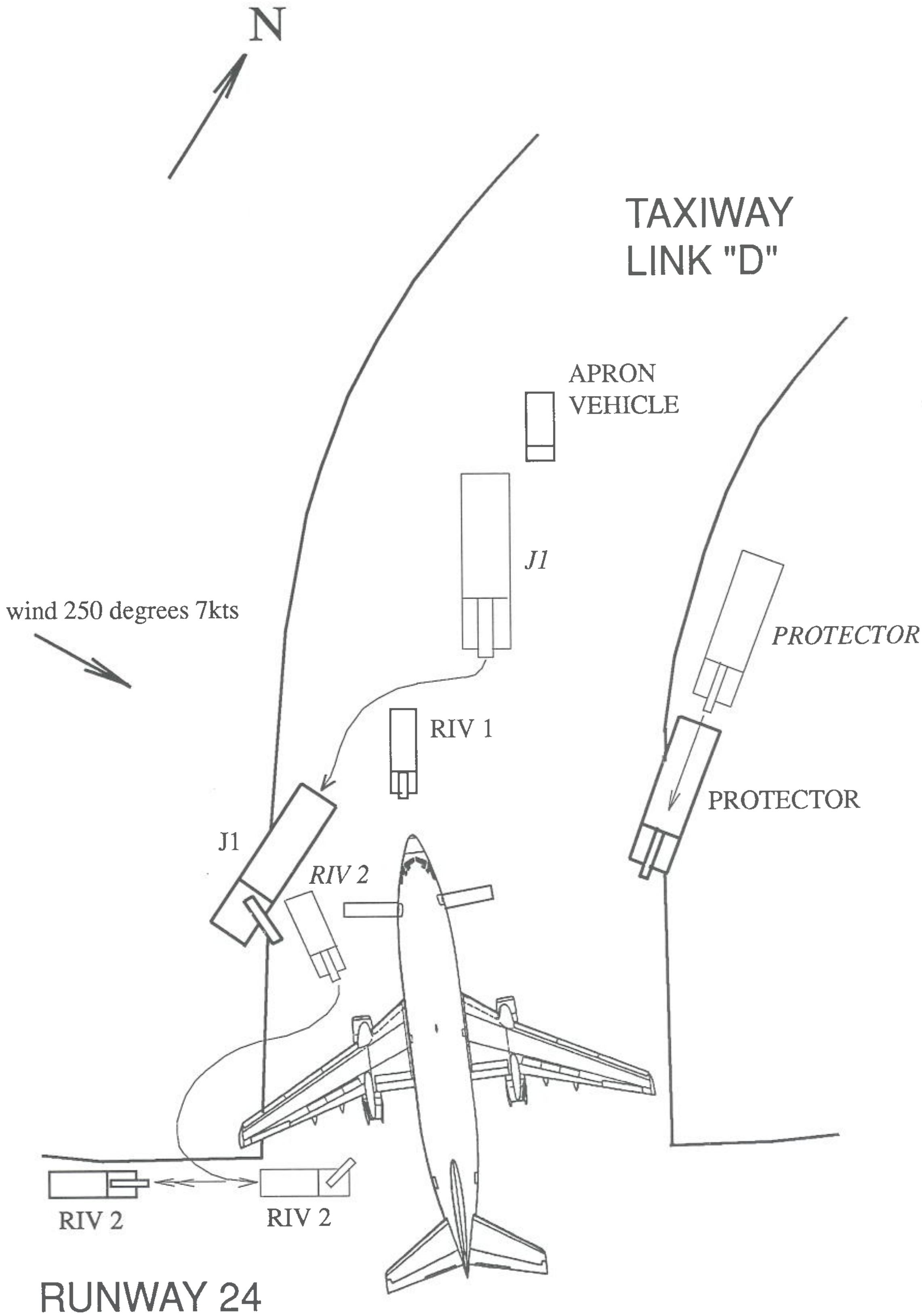
+ Died 6 days after accident; no toxicological results available representative of immediate post- accident absorbtion levels.

* ND - non detected.



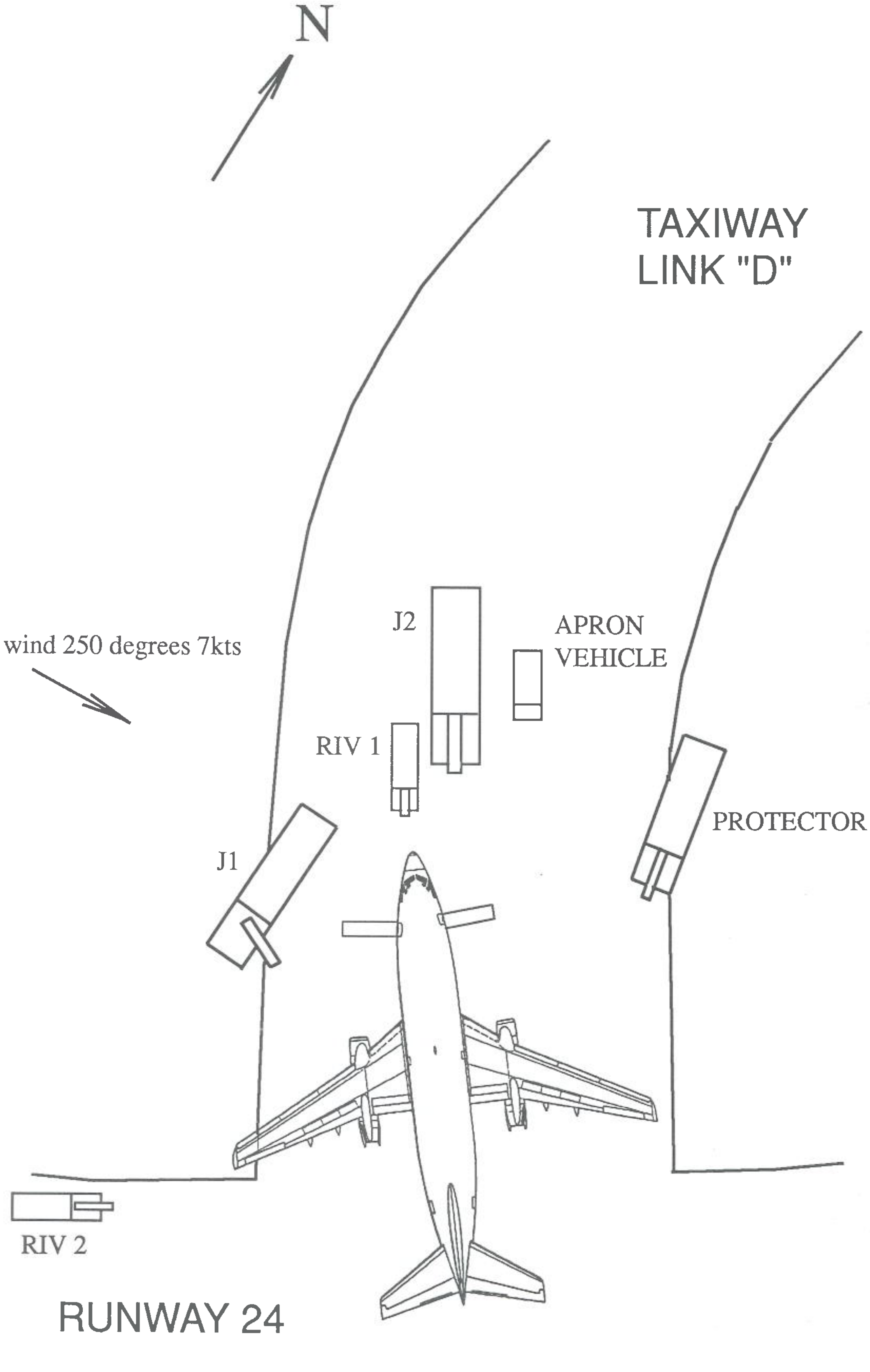
Fire Vehicle Initial Positioning

Appendix 13 fig. b



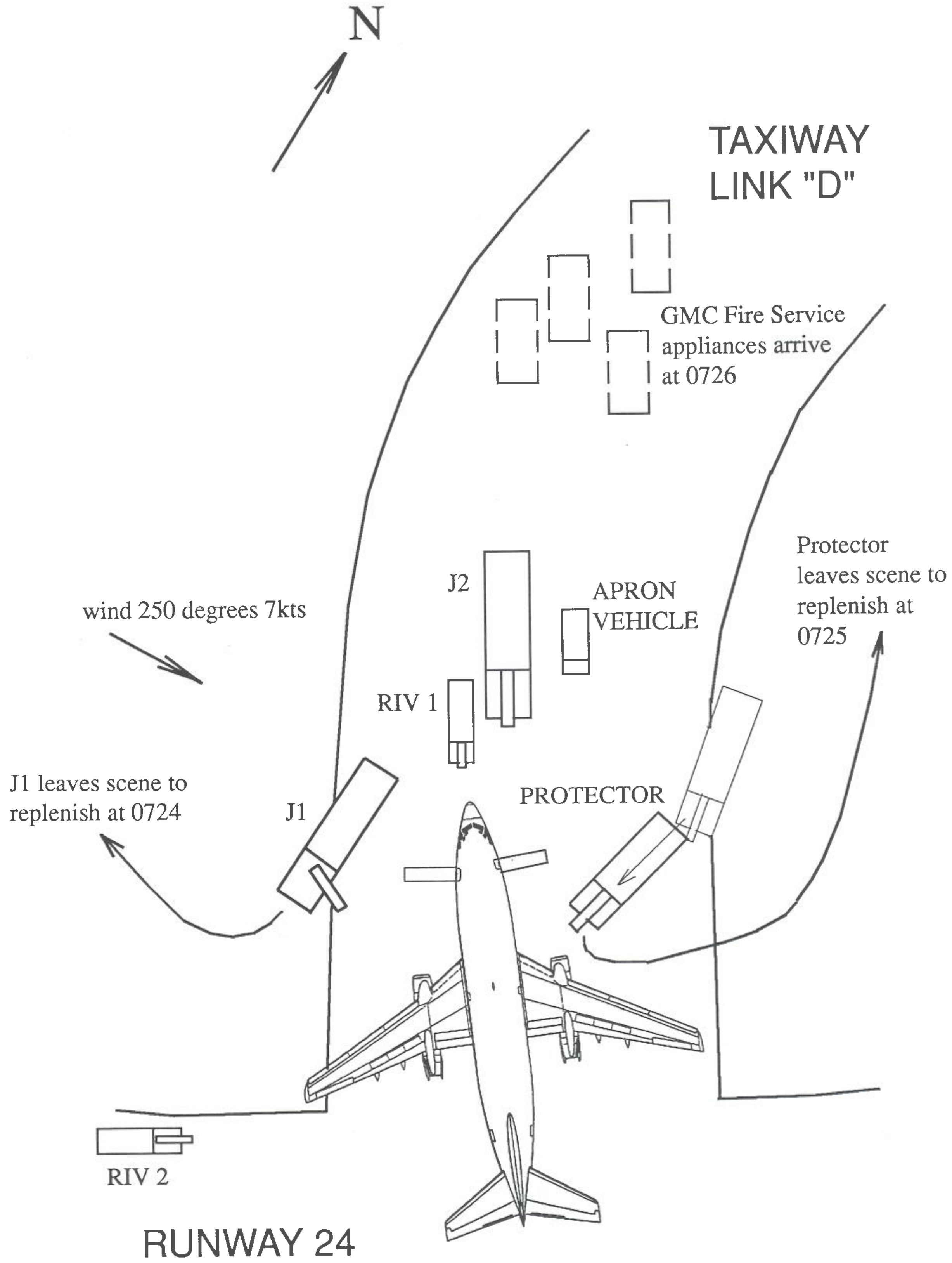
Fire Appliance Repositioning Following Initial Attendance

Appendix 13 fig. c

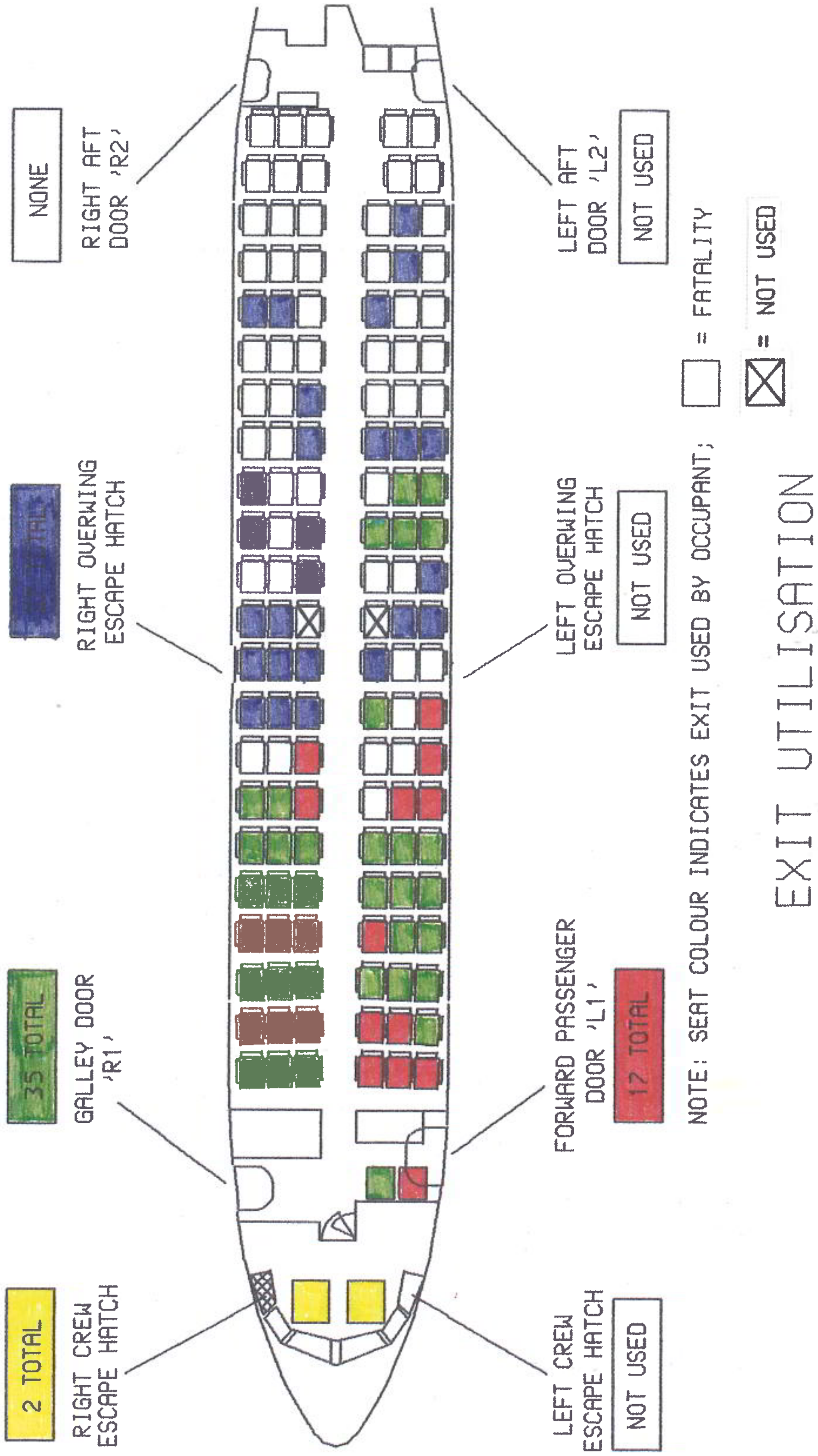


Fire Appliance Positioning After 3 to 5 Minutes

Appendix 13 fig. d



Fire Appliances After 5 to 6 Minutes


2 TOTAL
RIGHT CREW ESCAPE HATCH
35 TOTAL
GALLEY DOOR 'R1'
RIGHT OVERWING ESCAPE HATCH
NONE
RIGHT AFT DOOR 'R2'
LEFT CREW ESCAPE HATCH
NOT USED
FORWARD PASSENGER DOOR 'L1'
12 TOTAL
LEFT OVERWING ESCAPE HATCH
NOT USED
LEFT AFT DOOR 'L2'
NOT USED
NOTE: SEAT COLOUR INDICATES EXIT USED BY OCCUPANT;
= FATALITY
= NOT USED
EXIT UTILISATION

Material Combustion emissions

Material	Source	Sample Weight (Grams)	CO (ppm)	HCN (ppm)	HCL (ppm)	Other (ppm)
			Emissions (Concentration)			
Polyurethane Foam	Seat Cushion	4.2g F *	320	25	150	
		NF*	160	2	25	
Polyvinylchloride (PVC)	Panels	9.5g F	650	5	2000	
		NF	750	2	1100	
Polymethylmetha-crylate (PMMA)	Windows	32.9g F	2200	0	100	
		NF	400	0	3	
Modacrylic (100%)	Curtains	1.8g F	210	46	150	
		NF	90	37	100	
Wool	{Carpet {Curtains etc	9.4g F	190	15	0	
		NF	90	20	0	
PVC + Acrylonitrile-Butadiene Styrene (ABS) 94:6	Seat-track cover-strips	11.4g F	550	4	1300	
		NF	60	1	1100	
ABS(40:40:20) + plasticised PVC	PSU (Pass Service Unit)	6.8g F	700	25	50	
		NF	50	8	20	
Tetrafluoro-Ethylene/Vinyl-idene Fluoride	Seals (elastomer)	20.1g F	480	2	0	80HF-
		NF	20	0	0	90HF
Glassfabric (97%) with organic finish	Headliner	0.9g F	60	0	0	
		NF	10	0	0	
Glassfabric (60%) with Polyvinylidene fluoride coating	Headliner or Baggage-Liner	1.5g F	45	0	0	26HF
		NF	45	0	0	10HF

NOTE:

*F	=	FLAMING COMBUSTION
*NF	=	NON-FLAMING COMBUSTION (I.E. "SMOULDERING")
CO	=	CARBON MONOXIDE GAS
HCN	=	HYDROGEN CYANIDE GAS
HCL	=	HYDROGEN CHLORIDE GAS
HF	=	HYDROGEN FLUORIDE GAS
ppm	=	PARTS PER MILLION CONCENTRATION, BY VOLUME

B737 - INTERIOR MATERIALS

1 Ceiling

Forward and aft entrance area Oxygen panel doors	-	Vinyl aluminium laminate polyurethane painted
Flat lowered ceiling flat panels End caps Oxygen panel covers	-	Semi-rigid vinyl polyurethane painted
Curved panels	-	Compression moulded fibreglass polyurethane painted
Seals	-	Polyvinyl chloride extrusion polyurethane painted
Air Nozzles	-	Melamine plastic extrusion polyurethane painted

2 Carry-All Compartments

Compartment structures	-	Glass fabric reinforced nomex honeycomb sandwich panels - epoxy resin. Tedlar covered vinyl laminate
Trim strips	-	Tedlar covered polycarbonate
Trim retainer	-	Polyvinyl chloride extrusion polyurethane painted
Bullnose End caps	-	Tedlar covered semi-rigid vinyl

3 Passenger Service Unit

Base panel Oxygen door Spacer panel	-	Tedlar covered vinyl aluminium laminate
Switches	-	Polycarbonate
Gasper	-	Moulded nylon

4 Sidewall Panels

Panel	-	Tedlar covered vinyl aluminium laminate
Trim strips	-	Tedlar covered polycarbonate/moulded nylon

Inner reveal. Inner pane	-	Polycarbonate
Air Grille	-	Aluminium - polyurethane painted
Window shade	-	Vinyl fibreglass laminate
Dado/Air Grille	-	Polycarbonate

5 Floor

Panels	-	Fibrelam - Nomex core - main cabin Carbon fibre - vestibule area Birch ply - galley (1 off)
Carpet	-	100% wool (jute backing)

6 Bulkheads

Structure	-	Fibrelam - Nomex core Tedlar vinyl laminate finish

7 Galleys

Structure	-	Fibrelam - Nomex core Tedlar vinyl laminate finish (outside) Painted (inside)

8 Toilets

Structure	-	Fibrelam - Nomex core Tedlar vinyl laminate finish
Trim strips	-	Aluminium
Ceiling	-	Honeycomb - polyurethane painted
Fittings	-	Moulded fibreglass/moulded thermoplastic ABS painted or Tedlar vinyl laminate finish.
Cabinets	-	Melamine laminate/moulded fibreglass - paint finish
Floor pan	-	Moulded thermplastic ABS (Boltron/Royalite)

9 Attendants Seats

Cushions	-	Vinyl fabric covered foam
Frame	-	Moulded thermoplastic ABS (Bolton/Royalite)

10 Passenger Seats

Cushions	-	Polyurethane foam
Covers	-	100% Wool

Response of Humans to Various Concentrations of Gases
Concentration: parts per million
(Flammability Handbook for Plastics by K. J. Hilado
Technomic Publishing Co. Inc. Westport, Conn. 06881)

Carbon Monoxide (CO)	Symptoms
25	TLV* for conditions of heavy labour, high temperatures and decreased air pressure.
50	TLV and MAK+ value.
100	No poisoning symptoms even for long periods of time, allowable for several hours.
200	Headache after 2 to 3 hours, collapse after 4 to 5 hours.
300	Headache after 1.5 hours, distinct poisoning after 2 to 3 hours, collapse after 3 hours.
400	Distinct poisoning, frontal headache and nausea after 1 to 2 hours, collapse after 2 hours, death after 3 to 4 hours.
500	Hallucinations felt after 30 to 120 minutes
800	Collapse after 1 hour, death after 2 hours
1000	Difficulty in ambulation, death after 2 hours
1500	Death after 1 hour
2000	Death after 45 minutes
3000	Death after 30 minutes
8000 or above	Immediate death by suffocation
12800	Unconsciousness after 2 to 3 breaths, death in 1 to 3 mins

Hydrogen cyanide (HCN)

0.2 to 5.1	Threshold of odor
10	TLV and MAK value
18 to 36	Slight symptoms, headache, after several hours
45 to 54	Tolerated for ½ to 1 hour without difficulty
100	Fatal after 1 hour
110 to 135	Fatal after ½ to 1 hour, dangerous to life
135	Fatal after 30 minutes
181	Fatal after 10 minutes
280	Immediately fatal

Nitrogen dioxide (NO_2)

5	TLV and MAK value, threshold of perception by odor
10 to 20	Mildly irritant to eyes, nose, and upper respiratory tract
25 to 38	No adverse effects in workers exposed over several years
50	Distinct irritation
80	Tightness of chest after 3 to 5 minutes
90	Pulmonary oedema after 30 minutes
100 to 200	Very dangerous within 30 to 60 minutes
250	Death after a few minutes

Hydrogen fluoride (HF)

3	TLV and MAK value
3 to 5	Redness of skin, irritation of nose and eyes after one week exposure
32	Irritation of eyes and nose
60	Itching of skin, irritation of respiratory tract from exposure of 1 minute
120	Conjunctival and respiratory irritation just tolerable for 1 minute
50 to 100	Dangerous to life after a few minutes

Hydrogen chloride (HC1)

1 to 5	Limit of detection by order
5	TLV and MAK value
5 to 10	Mild irritation of mucous membranes
35	Irritation of throat on short exposure
50 to 100	Barely tolerable
1000	Danger of lung oedema after merely short exposure

Sulphur dioxide (SO_2)

3 to 5	Odour threshold
5	TLV and MAK value
8 to 12	Slight irritation of eyes and throat, resistance of air tracts
20	Coughing and eye irritation
30	Immediate strong irritation, remains very unpleasant
100 to 250	Dangerous to life
600 to 800	Death in a few minutes

Ammonia (NH_3)

1 to 50	Detectable odour
25	TLV value
50	MAK value
57 to 72	Respiration not significantly changed
96	Slight irritation of nose, throat, and eyes
100	Working possible, adaptation
200	Irritation of the mucous membranes
500 to 1000	Strong irritation of upper respiratory tract
2000	Fatal

Acrolein

0.1	TLV and MAK value
0.805	Lachrymation, irritation of mucous membranes
1.0	Immediately detectable, irritation
5.5	Intense irritation
10 and over	Lethal in a short time
24	Unbearable

Benzene

25	TLV value
500	Slight irritation
1500 to 4000	Dangerous to life after several hours
8000	Fatal after 30 to 60 minutes
20,000	Fatal after 5 minutes

Toluene

100	TLV value
200	MAK value
190 to 380	No complaints
500 to 1000	Headache, nausea, momentary loss of memory, anorexia, irritation of eyes
1000 to 1500	Palpitation, extreme weakness, loss of co-ordination, impairment of reaction time
2000 to 2500	Dizziness, nausea, narcosis after 3 hours
10,000	Immediately fatal

Styrene

60	Threshold of odour, no irritation
100	TLV and MAK value, strong odour, tolerable
200 to 400	Intolerable odour
216	Unpleasant subjective symptoms
376	Definite signs of neurological impairment
600	Irritation of eyes
800	Immediate irritation of eyes and throat, somnolence, weakness
Over 800	Nausea, vomiting, and total weakness

Formaldehyde

0.05 to 1.0	Threshold of odour
0.08 to 1.6	Slight irritation of eyes and nose
0.25 to 1.6	Threshold of irritation of eyes
0.5	Threshold of irritation of throat
1.0	MAK value
2.0	TLV value
10	Conjunctivitis, rhinitis, and pharyngitis within a few minutes
10 to 15	Dyspnoea, cough, pneumonia, bronchitis
over 50	Necrosis of mucous membranes, spasm of larynx, oedema of lungs

Acetaldehyde

0.07 to 0.21	Threshold of odor
25 to 50	Transient slight irritation of eyes after 15 minutes
100	TLV value
134	Slight irritation of respiratory tract after 30 minutes
200	MAK value, irritation of nose and throat

Acrylonitrile	
20	TLV and MAK value
Carbon Dioxide (CO_2)	
250 to 350	Normal concentration in air
900 to 5000	No effect
5000	TLV and MAK value
18000	Ventilation increased by 50 per cent
25000	Ventilation increased by 100 per cent
30000	Weakly narcotic, decreasing acuity of hearing, increase in pulse and blood pressure
40000	Ventilation increased by 300 per cent, headache, weakness
50000	Symptoms of poisoning after 30 minutes, headache, dizziness, sweating
80000	Dizziness, stupor, unconsciousness
90000	Distinct dyspnoea, loss of blood pressure, congestion, death within 4 hours
100000	Headaches and dizziness
120000	Immediate unconsciousness, death in minutes
200000	Narcosis, immediate unconsciousness, death by suffocation
Oxygen (O_2)	
21%	Normal concentration in air
17	Respiration volume increased, muscular co-ordination diminished, more effort required for attention and clear thinking
12 to 15	Shortness of breath, headache, dizziness, quickened pulse, quick fatigue upon exertion, loss of muscular co-ordination for skilled movements
10 to 14	Faulty judgement
10 to 12	Nausea and vomiting, exertion impossible, paralysis of motion
6 to 8	Collapse and unconsciousness, but rapid treatment can prevent death
6 or below	Death in 6 to 8 minutes
2 to 3	Death in 45 seconds

SHORT-TERM EXPOSURE LIMITS FOR SMOKE CONSTITUENTS

Constituent	Parts per Million	mg/m^3	Remarks	Reference
Benzene (C_6H_6)	3,000	9,570	3,000 to 4,700 ppm can be inhaled for 1 hour without serious consequences	1
Carbon dioxide (CO_2)	50,000 (*ie* 5%)	90,000	U.S.Navy permits 1 hour emergency exposure to this level. 50,000 ppm provides signs of intoxication on 30 minutes exposure.	2 5

Carbon monoxide (CO)	1,500	1,717	NRC emergency exposure limit for 10 minutes	3
Hydrobromic acid (HBr)	30	99	By analogy to HC1 and CL_2(Chlorine)	
Hydrochloric acid (HC1)	30	45	NRC emergency exposure limit for 10 minutes	3
Hydrocyanic acid (HCN)	60	66	50 to 60 ppm for 1 hour has no serious consequences. 45 to 54 ppm for 30 to 60 minutes without immediate or late effects	1 4
Hydrofluoric acid (HF)	20	16	NRC emergency exposure limit for 10 minutes	3
Nitrogen dioxide (NO_2)	30	56	NRC emergency exposure limit for 10 minutes	3
Phosgene ($COCL_2$)	3.0	12	3.1 ppm is least amount causing immediate throat irritation; 4.0 causes immediate irritation of the eyes; 4.8 causes coughing; 25 ppm is dangerous for even short exposures	1
Sulphur dioxide (SO_2)	30	79	NRC emergency exposure limit for 10 minutes	3

References: 1. Henderson, Y., and Haggard, H. W., Noxious Gases and the Principles of Respiration Influencing Their Action. Reinhold Publishing Co, New York, 1943

2. Submarine Atmosphere Habitability Data Book. NAVSHIPS 250-649-1, September 1962, Navy Dept.

3. Smyth, H.F., Jr., "Military and Space Short-Term inhalation Standards," Arch. Environ, Health 12:488-90, 1966

4. Patty, F.A. (Editor), Industrial Hygiene and Toxicology, Second Revised Edition, Vol. 2, 1963, Interscience Publishers, New York

5. A.C.G.I.H. Committee on Threshold Limit Values "Documentation of Threshold Limit Values, Rev. Edition, 1966 American Conference of Governmental Industrial Hygienists, Cincinatti, Ohio.

*TLV is the threshold limiting value, the maximum acceptance concentration for continuous exposure for an 8 hour exposure, daily, in working environment.

+MAK - Maximale Arbeitsplatz Konzentrationen - maximum workplace concentration (West German TLV)

Flashover

Flashover is a term used to describe a sudden fire-transfer mechanism, from a local fire involving only the interior materials close to the source of the fire, to a more widespread fire in which the remaining interior space is directly affected by, or is actively involved in, the fire processes. Although it is a term used frequently by the various agencies involved with fire research and firefighting, the precise meaning attached to its use by these agencies varies, and the term must therefore be used, and interpreted, with some care.

All usage however, concerns the fire development within an enclosed space having some ventilation at low levels, but restricted ventilation of the upper levels. The overall mechanism of the flashover process is as follows:-

i) The combustion of interior materials at or close to the source of the fire releases hot combustion products, comprising both gas and carbon particulate, which rise and, because they are confined by the ceiling, flow along the ceiling creating a layer of hot, radiant material which extends throughout the interior.

ii) The heat from this radiant hot gas/soot layer starts to "cook" the furnishing materials in the remaining interior space, which decompose, releasing gaseous pyrolisis products.

iii) As the "cooking" process continues, the accumulation of pyrolisis products increases and the temperature of the furnishing materials increases.

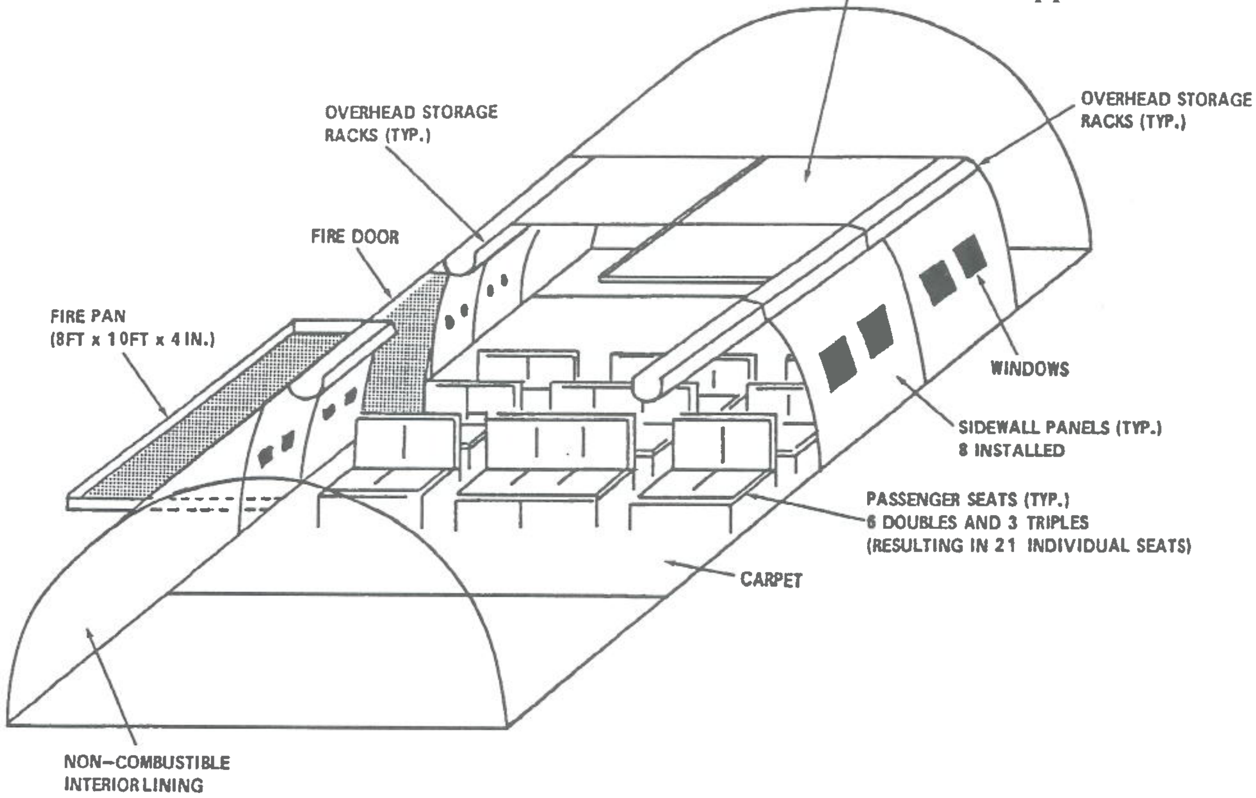
iv) Ultimately a point is reached, provided the oxygen supply is sufficient, when either the pyrolisis products or the furnishing materials (or both) ignite sponaneously, producing a rapid change from local to total fire involvement.

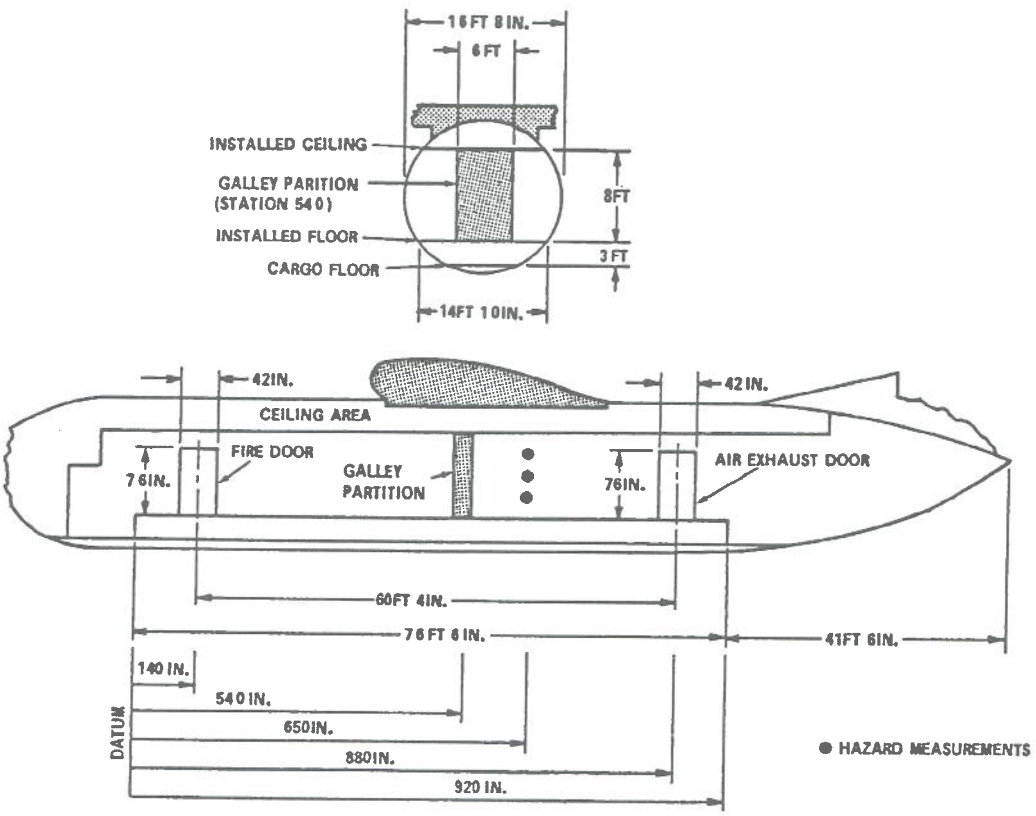
v) This rapid change from local to more general fire involvement is the condition known as flashover, and it is accompanied by dramatic changes in the internal environment. In general terms, these changes will be a steep fall-off in the oxygen level, a very rapid rise in the levels of all toxic combustion products, a sudden reduction in visibility and a steep temperature rise. The precise characteristics of these changes, their severity and duration, will depend upon whether the furnishing materials ignite throughout the interior, or whether the process involves principally the ignition of gaseous pyrolosis products with limited involvement of the furnishing materials.

Conventional use of the term springs from research into building fires, in which the interior spaces are invariably of approximately cubic proportions, and in which the ratio of combustible material volume to the free volume of the interior space is relatively small. In such circumstances, the flashover process will invariably develop fully to include the complete combustion of all materials contained within the room.

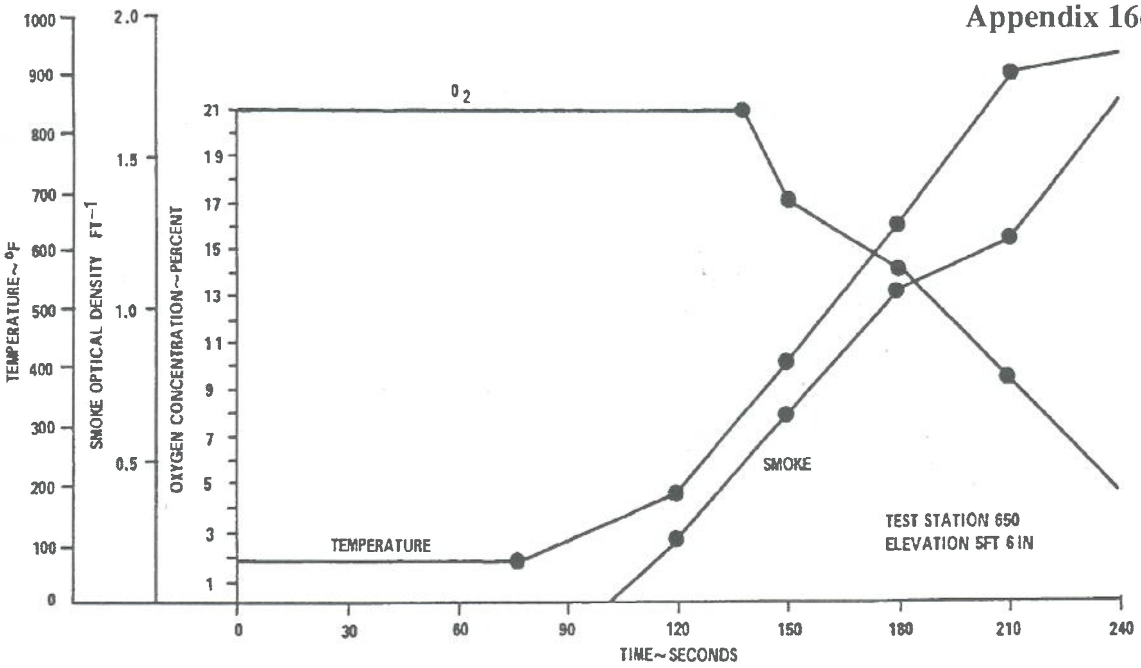
When the term is used in the context of aircraft fires, involving an interior space of quite different proportions - a long tube in which the combustible material volume forms a much higher proportion of the total volume, and in which there is much greater scope for widely differing ventilation patterns, much greater care is needed in interpreting its meaning because of the tendency for a more limited form of flashover to occur.

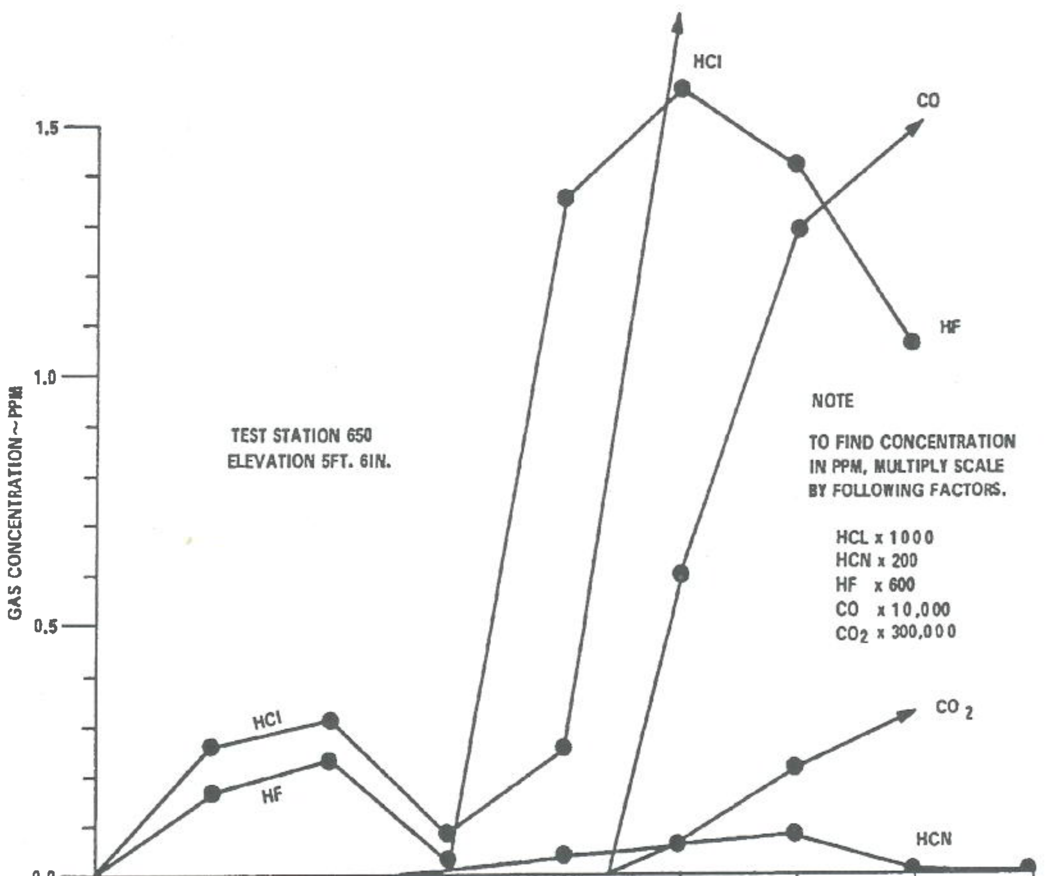
Appendix 16b



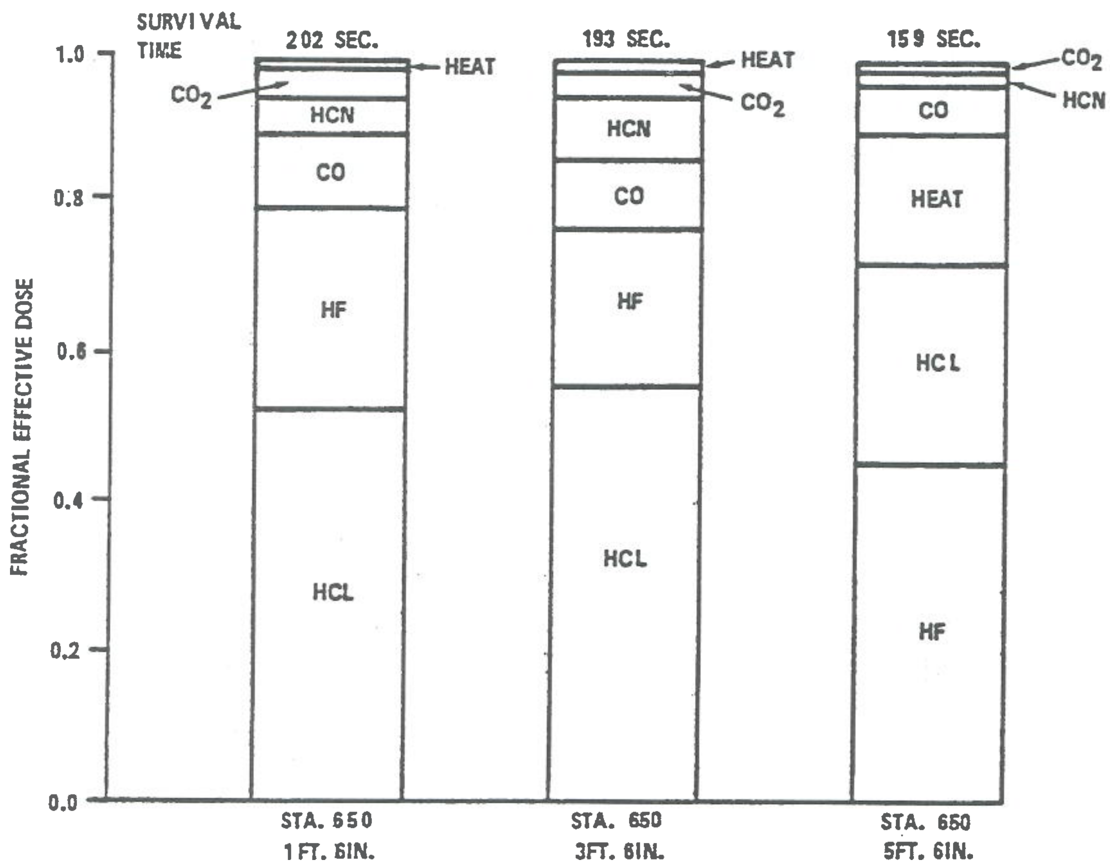


FAA Technical Centre, Atlantic City, C133 Test Article

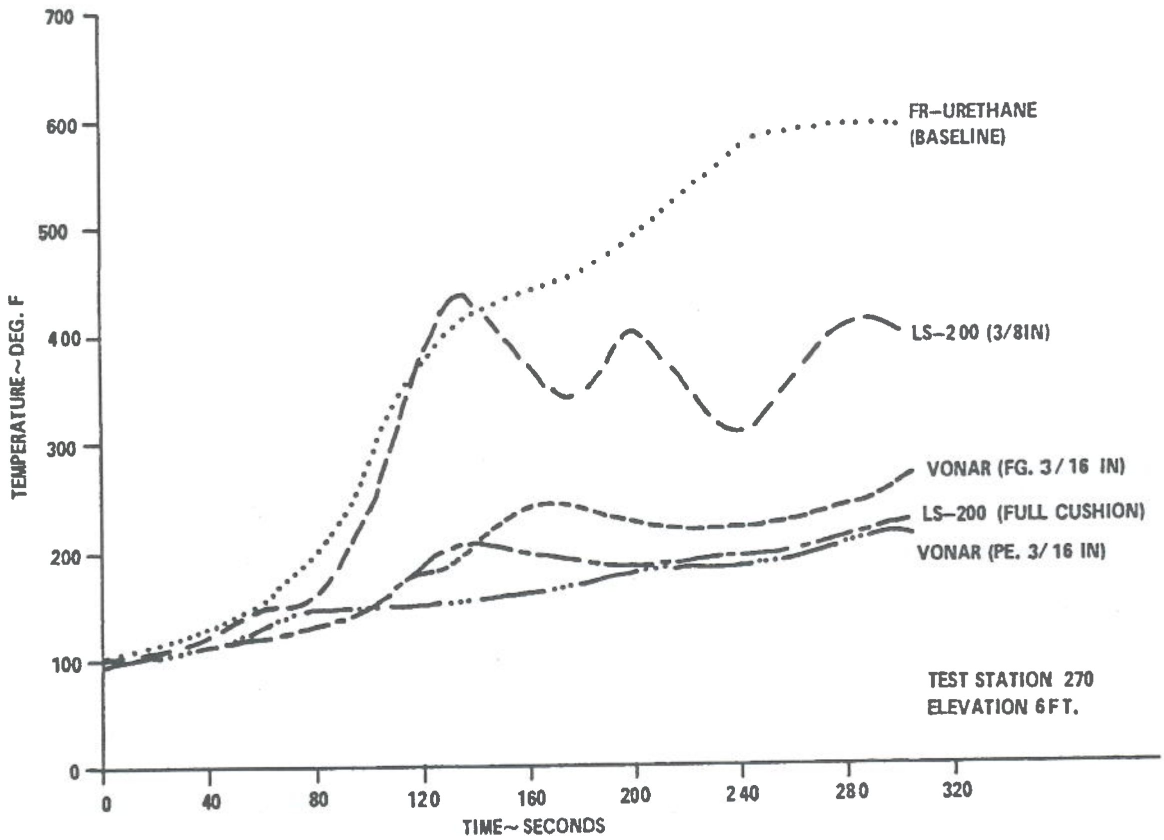




C133 Tests, Sample Results: Temperature, Smoke, Residual Oxygen, and Some Toxics Monitored up to and Through Flashover



Effect of Elevation on Survivability in the Aft Cabin



Effects of Fire Blocking Layer on Double Seat Cushioning on Metal Frame

Concept Description	Estimated Installation Cost Per Aircraft: Narrow Body	Estimated Installation Cost Per Aircraft: Wide Body	Annual Operational Cost/Aircraft Narrow Body	Annual Operational Cost/Aircraft Wide Body	Deaths Prevented (Index)	Cost Per Death Prevented (US$)
Smoke Masks/Hoods	2,970	7,965	614	1,618	16.55	140,326
Zoned Water Spray	57,600	86,300	8,860	13,900	15.45	1,154,720
Improved Interior Finish and Seating	131,000	262,000	3,478	17,760	7.0	3,384,511
Evacuation Markers	1,500	3,000	200	400	1.64	754,704
Improved Slides, Ramps, etc.	1,600	3,200	2,640	5,280	8.09	440,179
Fire Retardant Fuselage Envelope	87,333	174,666	2,324	4,652	9.91	1,476,593

Examples from FAA Report[10] Cost Benefit Analysis

Breathable-Gas Smokehood Test Protocols

1. Tests Carried out at the R.A.F. Institute of Aviation Medicine

Since all the breathable gas hoods had been developed prior to the promulgation of the CAA preliminary draft specification on the 18 July 1986, the IAM decided to test all units to some 90% of their rated (by respective manufacturers) endurance, in order to give a margin of safety during testing. Thus a hood with a claimed endurance of 20 minutes, was set a target of 18 minutes. The associated work profile was taken from the CA A draft specification requirement for "Type 1" Passenger Smokehoods - ie Hoods designed to give 15 minutes (sedentary) protection, for the in-flight smoke situation, followed by five minutes (active) protection to cover the subsequent ground evacuation. The "Type 1" preliminary draft specification was as follows:

"20 minutes at pressure altitudes between the equivalent of sea-level and 10,000 feet with a minimum workload associated with a mean respiratory rate of 30 litres/minute BTPD (body temperature and pressure, dry). Within the 20 minute period of protection, the equipment shall also afford the necessary protection and high respiratory demands associated with a 5 minute period at an average workload of 80 watts in which, at any time, any one of the following transient conditions is assumed to occur:

	180 watts for a period of 30 seconds
(or)	150 watts for a period of 1 minute
(or)	100 watts for a period of 2 minutes"

NOTE: The above provisional workload profiles had been suggested by the CAA, without the benefit of adequate evacuation test data.

The IAM work profile adopted from the above thus initiated with a period "at rest" followed by the final 5 minutes of the target endurance being carried out with the first 3 minutes at 70 watts and the last 2 minutes at 100 watts workload. The work simulation was carried out using a cycle ergometer, with male subjects.

During each test, oxygen and carbon dioxide concentrations adjacent the mouth were continuously analysed by mass spectrometry (approximately 20 litres/minute sampling rate). In addition air temperature close to the face was recorded using a thermister and hood internal pressure monitored using a celesco transducer (or inside the ori-nasal mask, as applicable).

2. Tests Carried out at the Scientific Division, British Coal

These tests were conducted using an 'Auer' lung simulator for accurate comparison. Since the IAM assessment had not included high energy expenditure immediately after donning (*ie* the ground fire evacuation scenario), it was decided to test the three types of smokehood at 30 litres/minute (ie approximately equivalent to 100 watts for a bodyweight of 70 kg) to establish their endurance under such conditions.

In addition, since the Cabin Crew Smokehood was designed to the French specification (5 minutes at 60 watts, 5 minutes at 80 watts, 5 minutes 60 watts) to give 15 minutes protection for cabin crew, it was also decided to test all three types over an endurance of 15 minutes.

This second protocol required an initial 10 minutes at 10 litres/minute (sedentary), followed by 3 minutes at 20 litres/minute (approximately 70 watts) followed by 2 minutes at 30 litres/minute. This protocol ensured that the last five minutes of the endurance would be at an average workload of 82 watts, compared to the required 80 watts (average) for the last five minutes as stipulated by the CAA Type 1 Draft specification.

The third protocol was to the CAA Draft "Type 1" requirement of 20 minutes protection.

From the results for the ground-evacuation protocol, it was observed that the first Passenger Smokehood achieved some 12 minutes before the concentration of carbon dioxide exceeded 5% (the AAIB limit) compared with some 5 minutes for the other. The Cabin Crew Smokehood exceeded 7.45% carbon dioxide within the first minute.

The 15 minute protocol was fully achieved by the first Passenger Smokehood with only a very low concentration of carbon dioxide of 2.15% (well below the 5% limit), compared to a maximum of 12 minutes for the other, before the 5% limit was exceeded. However, the Cabin Crew Smokehood exceeded 5% carbon dioxide after only the 6th minute.

3. Leakage Tests Carried out at C.D.E. Porton Down:

Four of the breathable gas hoods which had been tested at the IAM, including the cabin crew hood, were submitted for leakage testing by the Physical

Protection Division of the Chemical Defence Establishment at Porton Down. These designs included three types utilising an elasticated neck ("septal") seal and one passenger hood which used both a neck seal and an ori-nasal mask.

Male test subjects donned the hoods (and initiated the gas-cylinder) before entering a clear plastic enclosure (of 2 cubic metres volume) placed over a treadmill. A background blank reading was taken and then an aerosol of sub-micron sodium chloride particles was introduced into the enclosure. The test subject remained sedentary (standing) for 10 minutes and then walked for 1½ minutes (70 watts/minute). The test was then completed after a further ½ minute sedentary to complete sampling.

Two adaptors were used in each hood, one with a 1 litre/minute off-take to a Moores Flame Photometer to measure sodium content, and a second adaptor for air replacement.

Appendix 18b

The Auer Lung

An Auer artificial lung is a machine which simulates human breathing by providing a sinusoidal flow, the volume and breathing rate of which can be adjusted within the range of 10-90 L/minute. It incorporates 2 auxiliary "lungs" which function in phase with the main lung, allowing removal of a proportion of the "inhaled" gas (equivalent to the volume of oxygen absorbed by a human lung) and introduction of a corresponding volume of carbon dioxide into the "exhalate".

The inhaled gas is passed through a cooler to maintain the temperature of the gas entering the lung(s) at a constant value.

The exhaled gas is passed through a heater and humidifier to maintain it at 37°C, and fully saturated with water vapour (Body Temperature and Pressure, Saturated).

BREATHABLE GAS SMOKEHOOD PERFORMANCE RESULTS FROM TESTS AT BRITISH COAL SCIENTIFIC DIVISION:

TEST CONDITIONS 1

Minute Volume (litres):	30
Breathing Frequency (cycles per min):	20
Exhaled CO_2 conctn. (%):	4.5
Exhaled Air Condition:	Fully saturated at 37°C

PASSENGER SMOKEHOOD TYPE: 1 (Compressed oxygen source)

Time	Inhaled CO_2	Inhaled 0_2	Inhalation Temperature	Breathing Resistances (mbar)	
(minutes)	(%)	(%)	(°C)	Inhalation	Exhalation
1	1.55	31.5	26.5	-1.3	+5.2
2	2.05	41.8	37.5	-7.4	+5.4
3	2.25	45.1	40.5	-5.5	+5.6
4	2.25	48.5	43.5	-3.3	+5.7
5	2.45	53.6	43.0	-3.3	+5.7
6	2.65	58.4	43.5	-2.2	+5.8
7	3.00	63.3	44.5	-3.2	+5.9
8	3.30	65.0	44.5	-4.2	+5.9
9	3.65	66.4	45.0	-6.8	+5.9
10	4.00	65.0	45.0	-8.8	+5.8
11	4.65	61.0	45.0	-10.0	+5.7
12	5.65	56.1	44.5	-10.0	+5.6
13	7.70	50.8	44.0	-9.5	+5.5
14	10.60	46.3	43.0	-9.5	+5.3

PASSENGER SMOKEHOOD TYPE 2 (Compressed Oxygen Source)

Time	Inhaled CO_2	Inhaled 0_2	Inhalation Temperature	Breathing Resistances (mbar)	
(minutes)	(%)	(%)	(°C)	Inhalation	Exhalation
1	3.40	29.0	41.0	NIL	+0.1
2	4.05	43.2	46.0	NIL	+0.2
3	4.50	51.5	47.0	NIL	+0.2
4	4.90	56.0	48.0	NIL	+0.2
5	5.40	58.6	49.0	NIL	+0.1
6	6.05	60.1	50.0	NIL	+0.1
7	6.85	61.0	48.5	NIL	NIL
8	7.55	61.3	48.0	NIL	NIL
8.75	8.00	61.5	47.5	NIL	NIL

CABIN CREW SMOKEHOOD: (Compressed oxygen source)

TEST CONDITIONS 1

Time (minutes)	Inhaled CO_2 (%)	Inhaled 0_2 (%)	Inhalation Temperature (°C)	Breathing Resistance (mbar) Inhalation	Exhalation
1	7.45	32.9	22.0	-0.3	+1.7
2	12.70	44.9	22.5	-0.3	+1.7
3	14.15	53.0	23.0	-0.4	+1.8
4	14.65	57.5	24.0	-0.4	+1.7
5	>15.0	60.2	24.0	-0.4	+1.6

The test was terminated after 5 minutes when the inhaled carbon dioxide concentration was in excess of 15%.

TEST CONDITIONS 2	(A) Sedentary conditions	(B) 70 Watt workload	(C) 100 Watt workload
Minute Volume (litres):	10	20	30
Breathing Frequency (cycles per min.):	10	15	20
Exhaled CO_2 conctn. (%):	3.5	4.0	4.5
Exhaled Air Condition:	Fully saturated at 37°C		

PASSENGER SMOKEHOOD TYPE 1:

	Time (minutes)	Inhaled CO_2 (%)	Inhaled 0_2 (%)	Inhalation Temperature (°C)	Breathing Resistances (mbar) Inhalation	Exhalation
A	1	0.50	23.3	26.5	-0.1	+3.0
	2	1.35	24.9	28.0	NIL	+3.6
	3	1.40	51.3	29.0	-O.1	+3.2
	4	1.40	62.2	29.5	-0.2	+2.7
	5	1.40	70.4	30.5	-0.3	+2.2
	6	1.40	75.6	32.5	-0.3	+1.8
	7	1.40	78.8	34.0	-0.4	+1.6
	8	1.40	80.5	35.5	-0.5	+1.5
	9	1.40	81.2	36.5	-0.8	+1.4
	10	1.40	81.3	37.0	-0.9	+1.3
B	11	1.45	80.9	36.0	-0.8	+2.8
	12	1.55	80.1	38.0	-1.0	+2.8
	13	1.60	78.8	40.0	-1.0	+2.8
C	14	1.95	75.7	43.0	-14.5	+4.6
	15	2.15	69.2	45.0	-14.5	+4.6

TEST CONDITIONS 2

PASSENGER SMOKEHOOD TYPE 2

	Time	Inhaled CO_2	Inhaled O_2	Inhalation Temperature	Breathing Resistance (mbar)	
	(minutes)	(%)	(%)	(°C)	Inhalation	Exhalation
A	1	1.00	26.1	36.0	Nil	+0.1
	2	1.40	41.8	37.0	Nil	+0.1
	3	1.60	49.2	39.0	Nil	+0.1
	4	1.65	54.4	39.0	Nil	+0.1
	5	1.65	58.0	40.5	Nil	+0.1
	6	1.80	60.2	40.5	Nil	+0.1
	7	1.85	61.8	41.0	Nil	+0.1
	8	1.90	62.5	41.0	Nil	+0.1
	9	1.95	62.6	41.0	Nil	+0.1
	10	2.00	62.7	41.0	Nil	+0.1
B	11	3.25	62.5	42.0	Nil	+0.1
	12	4.05	61.3	43.5	Nil	+0.1
	13	4.45	60.4	43.5	Nil	+0.1
C	14	5.90	59.6	44.0	-0.1	+0.1
	15	6.90	57.8	45.0	-0.1	+0.1

TEST CONDITIONS 2

CABIN CREW SMOKEHOOD

	Time	Inhaled CO_2	Inhaled O_2	Inhalation Temperature	Breathing Resistances (mbar)	
	(minutes)	(%)	(%)	(°C)	Inhalation	Exhalation
A	1	0.90	25.8	22.0	-0.1	+0.8
	2	2.85	43.2	21.5	-0.1	+0.9
	3	3.95	56.2	21.0	-0.1	+0.9
	4	4.60	64.5	21.5	-0.1	+0.9
	5	4.90	68.9	21.5	-0.1	+0.9
	6	5.15	71.6	21.5	-0.1	+0.8
	7	5.40	72.9	22.0	-0.1	+0.8
	8	5.60	73.5	22.0	-0.2	+0.7
	9	5.80	73.1	22.0	-0.2	+0.7
	10	6.05	72.2	22.0	-0.2	+0.7
B	11	7.50	69.6	23.5	-0.5	+0.8
	12	9.60	66.5	24.0	-0.5	+0.8
	13	10.30	64.4	24.5	-0.5	+0.8

Note The test was terminated after 13 minutes when the inhaled carbon dioxide concentration was in excess of 10%.

TEST CONDITIONS 3

	(A) Sedentary conditions	(B) 70 Watt workload	(C) 100 Watt workload
Minute Volume (litres):	10	20	30
Breathing Frequency (cycles per min.):	10	15	20
Exhaled CO_2 conctn. (%):	3.5	4.0	4.5

Exhaled Air Condition: Fully saturated at 37°C

PASSENGER SMOKEHOOD TYPE 1 (Modified with increased oxygen capacity)

	Time (minutes)	Inhaled CO_2 (%)	Inhaled O_2 (%)	Inhalation Temperature (°C)	Breathing Resistances (mbar) Inhalation	Breathing Resistances (mbar) Exhalation
A	1	1.2	28.5	33.5	-0.6	+1.6
	2	1.15	33.5	33.5	-0.6	+1.6
	3	1.15	37.5	34.0	-0.6	+1.6
	4	1.15	39.5	34.5	-0.6	+1.7
	5	1.15	41.0	35.0	-0.6	+1.7
	6	1.15	41.0	36.0	-0.6	+1.7
	7	1.10	40.5	36.5	-0.6	+1.7
	8	1.10	40.0	37.0	-0.6	+1.7
	9	1.10	39.0	37.0	-0.6	+1.8
	10	1.10	38.0	37.5	-0.6	+1.8
	11	1.10	37.0	38.0	-0.6	+1.8
	12	1.10	36.0	38.0	-0.6	+1.8
	13	1.10	35.0	38.5	-0.6	+1.8
	14	1.10	34.0	38.5	-0.6	+1.8
	15	1.10	33.0	39.0	-0.6	+1.8
B	16	1.45	32.0	39.5	-1.1	+3.6
	17	1.45	30.5	40.5	-1.2	+3.6
	18	1.50	30.0	41.5	-1.2	+3.6
C	19	1.45	29.0	42.0	-2.1	+5.8
*	20	1.50	28.0	43.0	-2.2	+5.9
	21	1.55	27.0	43.5	-2.2	+5.9
	22	1.65	26.5	44.0	-2.2	+5.9
	23	1.80	26.0	44.5	-2.2	+5.9
	24	1.95	25.5	44.5	-2.2	+5.9
	25	2.30	25.0	44.5	-2.2	+5.9
	26	2.90	24.5	44.0	-2.2	+5.9
	27	3.80	24.0	44.0	-2.1	+5.8
	28	4.90	23.5	43.5	-2.1	+5.8
	29	6.10	23.0	43.0	-2.2	+5.7

* CAA Draft Specification Endurance Requirement (20 mins)

NOTE: This hood performed for a further 8 minutes at high workload (100 watts) before inhaled CO_2 concentration exceeded 5% limit.

TEST CONDITIONS 3 (but with sedentary period extended from 15 minutes to 25 minutes)

PASSENGER SMOKEHOOD TYPE 1 (Modified with increased oxygen capacity as previously)

	Time (minutes)	Inhaled CO_2 (%)	Inhaled O_2 (%)	Inhalation Temperature (°C)	Breathing Resistance (mbar) Inhalation	Exhalation
A	1	0.9	40.0	31.0	-0.3	+1.4
	2	1.0	60.0	31.0	-0.3	+1.5
	3	1.0	69.0	31.0	-0.3	+1.7
	4	1.0	73.5	31.5	-0.3	+1.6
	5	1.0	77.0	32.0	-0.4	+1.6
	6	1.0	78.5	32.5	-0.4	+1.5
	7	1.0	80.0	33.0	-0.4	+1.4
	8	1.0	81.5	33.5	-0.4	+1.4
	9	1.0	82.5	33.5	-0.4	+1.5
	10	1.0	83.0	34.0	-0.5	+1.5
	11	1.0	83.5	34.5	-0.5	+1.4
	12	1.0	83.5	34.5	-0.5	+1.4
	13	1.05	83.5	35.0	-0.5	+1.4
	14	1.05	83.5	35.0	-0.5	+1.4
	15	1.05	83.0	35.0	-0.5	+1.4
	16	1.05	81.5	35.5	-0.5	+1.4
	17	1.05	80.0	35.5	-0.5	+1.4
	18	1.10	79.0	36.0	-0.5	+1.4
	19	1.10	77.5	36.0	-0.5	+1.4
	20	1.10	76.5	36.0	-0.5	+1.4
	21	1.10	75.5	36.0	-0.6	+1.4
	22	1.10	73.5	36.0	-0.6	+1.3
	23	1.10	72.0	36.0	-0.6	+1.3
	24	1.10	70.0	36.0	-0.6	+1.4
	25	1.15	68.0	36.0	-0.6	+1.3
B	26	1.75	69.5	35.5	-0.8	+4.7
	27	1.90	63.0	36.0	-0.8	+4.7
	28	2.15	60.0	36.5	-0.9	+4.8
C	29	2.70	57.0	38.0	-1.5	+7.6
	30	3.45	53.0	39.0	-1.6	+7.6
*	31	4.70	49.5	40.0	-1.6	+7.5
	32	7.00	45.5	40.5	1.6	+7.4

* 31 min. endurance achieved before inhaled CO_2 exceeded 5%, - well in excess of CAA draft specification requirement of 20 minutes.

TEST CONDITIONS 3

PASSENGER SMOKEHOOD TYPE 2

	Time	Inhaled CO_2	Inhaled O_2	Inhalation Temperature	Breathing Resistances (mbar)	
	(minutes)	(%)	(%)	(°C)	Inhalation	Exhalation
A	1	0.65	24.4	33.0	Nil	+0.1
	2	1.10	38.7	25.5	Nil	+0.1
	3	1.25	48.0	38.0	Nil	+0.1
	4	1.30	53.5	29.0	Nil	+0.1
	5	1.40	57.3	39.0	Nil	Nil
	6	1.45	59.3	39.5	Nil	Nil
	7	1.70	60.6	40.0	Nil	Nil
	8	1.90	61.4	40.5	Nil	Nil
	9	2.05	61.6	41.0	Nil	Nil
	10	2.15	61.4	42.0	Nil	Nil
	11	2.35	60.9	42.0	Nil	Nil
	12	2.50	60.1	42.5	Nil	Nil
	13	2.45	59.2	42.5	Nil	Nil
	14	2.45	58.0	43.0	-0.1	Nil
	15	2.60	56.9	43.5	-0.1	Nil
B	16	4.10	55.3	44.0	-0.1	Nil
	17	5.15	52.6	44.5	-0.1	Nil
	18	5.55	50.5	44.5	-0.1	Nil
C	19	6.85	48.1	45.0	-0.1	Nil
	20	7.75	45.8	46.0	-0.1	Nil

FILTER PERFORMANCE RESULTS - EXAMPLES FROM THE TWO BEST TYPES TESTED AT RAPRA AND BRITISH COAL SCIENTIFIC DIVISION

TEST REF 1

FILTER TYPE 1 (Standard)
FIRE TYPE: HIGH TEMPERATURE

Parameter	Challenge Atmosphere (5 minute average)	Filtered Air	AAIB Limits (for 5 min endurance)
CO	12,100 ppm(1.2%)	nil ppm	400 mls max cumulative
HCN	642 ppm	1.9 ppm	20 ppm max
HCL	541 ppm	7.8 ppm	10 ppm max
NO_x	114 ppm	-	10 ppm max
SO_2	99.ppm	11 ppm	10 ppm max
NH_3	329 ppm	6 ppm	75 ppm max
Acrolein	43 ppm	<0.8 ppm	1 ppm max
CO_2	5.35%	5.9%	5%
O_2	14.7%	14.1%	(see appendix14b)
Temperature	91°C	75°C	90°C(dry)
Particulate	2.2 mg/l	nil	
Breathing Resistance		12.9 mbar Inhale 1.5 mbar Exhale	20 mbar Inhale

TEST REF 53

FILTER TYPE: 1 (Modified)
FIRE TYPE: HIGH TEMPERATURE

Parameter	Challenge Atmosphere (5 min average)	Filtered Air	AAIB Limits (for 5 min endurance)
CO	14,650 ppm (1.47%)	nil ppm	400 mls max cumulative
HCN	342 ppm	<0.1 ppm	20 ppm max
HCL	1352 ppm	8 ppm	10 ppm max
NO_x	190 ppm	4 ppm	10 ppm max
SO_2	204 ppm	15 ppm	10 ppm max
NH_3	496 ppm	9 ppm	75ppm max
Acrolein	37 ppm	<1.0 ppm	1 ppm max
CO_2	4.75%	6.0%	5%
O_2	13.45%	14.7%	(see Appendix 14b)
Temperature	107°C	65.5°C	90°C (Dry)
Particulate	8.9 mg/l	0	
Breathing Resistance		18.5 mbar Inhale 1.5 mbar Exhale	20 mbar Inhale

TEST REF 20

FILTER TYPE: 1 (Standard)
FIRE TYPE: MEDIUM TEMPERATURE

Parameter	Challenge Atmosphere (5 min average)	Filtered Air	AAIB Limits (for 5 min endurance)
CO	10,000 ppm (1%)	90 ppm	400 mls max cumulative
HCN	457 ppm	1.5 ppm	20 ppm max
HCL	275 ppm	17 ppm	10 ppm max
NO_x	161 ppm	-	10 ppm max
SO_2	152 ppm	<5 ppm	10 ppm max
NH_3	447 ppm	6 ppm	75 ppm max
Acrolein	19 ppm	<0.01 ppm	1 ppm max
CO_2	4.%	3.8%	5%
O_2	15.7%	16.6%	(see Appendix 14b)
Temperature	63°C	65°C	90°C (Dry)
Particulate	2.4 mg/l	0	
Breathing Resistance		16.5 mbar Inhale 1.4 mbar Exhale	20 mbar Inhale

FILTER TYPE: 1 (Standard)
FIRE TYPES: HIGH TEMPERATURE

Parameter	Challenge Atmosphere	Filtered Air	AAIB Limits (for 5 min endurance)
Benzene	310 ppm (maximum conctn found)	31 ppm (max)	*
Toluene	260 ppm "	26 ppm (max)	100 ppm max
Styrene	230 ppm "	2 ppm (max)	100 ppm max
Acetaldehyde	43 ppm "	43 ppm (max)	100 ppm max
Acrylonitrile	55 ppm "	5 ppm (max)	20 ppm max

<u>SINGLE GAS-CHALLENGE TESTS AT BRITISH COAL, SCIENTIFIC DIVISION</u>

HF	413 ppm	1.2 ppm	10 ppm max

*The TLV for Benzene is 25 ppm, but it has been reported that concentrations of 3,000-4,700 ppm can be inhaled for 1 hour without serious consequences (Appendix 14b)

TEST REF 4

FILTER TYPE:2 (Standard)
FIRE TYPE: HIGH TEMPERATURE

Parameter	Challenge Atmosphere (5 min average)	Filtered Air	AAIB Limits (for 5 min endurance)
CO	15,950 ppm (1.6%)	nil ppm	400 mls max cumulative
HCN	380 ppm	3.5 ppm	20 ppm max
HCL	4,443 ppm	13.0 ppm	10 ppm max
NO_x	178 ppm	-	10 ppm max
SO_2	231 ppm	<7 ppm	10 ppm max
NH_3	878 ppm	5 ppm	75 ppm max
Acrolein	34 ppm	<0.1 ppm	1 ppm max
CO_2	5.4.%	5.4%	5%
O_2	13.75%	14.8%	(see Appendix 14b)
Temperature	83°C	174°C*	90°C (Dry)
Particulate	-	-	
Breathing Resistance		18.0 mbar Inhale 1.8 mbar Exhale	20 mbar Inhale

*NOTE: The first 2 tests with this standard type of filter showed similar excessive inhaled gas temperatures. Subsequent tests were carried out with a modified filter which utilised a built-in heat-exchanger behind the filter.

TEST REF 12

FILTER TYPE: 2 (Modified with Heat Exchanger)
FIRE TYPE: HIGH TEMPERATURE

Parameter	Challenge Atmosphere (5 min average)	Filtered Air	AAIB Limits (for 5 min endurance)
CO	12,400 ppm (1.24%)	nil ppm	400 mls max cumulative
HCN	360 ppm	0.7 ppm	20 ppm max
HCL	561 ppm	4.3 ppm	10 ppm max
NO_x	-	-	10 ppm max
SO_2	257 ppm	<5 ppm	10 ppm max
NH_3	877 ppm	76 ppm	75 ppm max
Acrolein	9 ppm	<0.01 ppm	1 ppm max
CO_2	5.2.%	5.7%	5%
O_2	14.5%	15.4%	(see Appendix 14b)
Temperature	99°C	49.5°C	90°C (Dry)
Particulate	-	-	
Breathing Resistance		11.5 mbar Inhale 2.0 mbar Exhale	20 mbar Inhale

FILTER TYPE: 2 (Modified with Heat Exchanger)
FIRE TYPES: HIGH TEMPERATURE

Parameter	Challenge Atmosphere	Filtered Air	AAIB Limits (for 5 min endurance)
Benzene	310 ppm (maximum conctn. found)	31 ppm (max)	*
Toluene	260 ppm "	26 ppm (max)	100 ppm max
Styrene	230 ppm "	23 ppm (max)	100 ppm max
Acetaldehyde	43 ppm.."	4 ppm (max)	100 ppm max
Acrylonitrile	55 ppm "	5 ppm (max)	20 ppm max

<u>SINGLE GAS-CHALLENGE TESTS AT BRITISH COAL, SCIENTIFIC DIVISION</u>

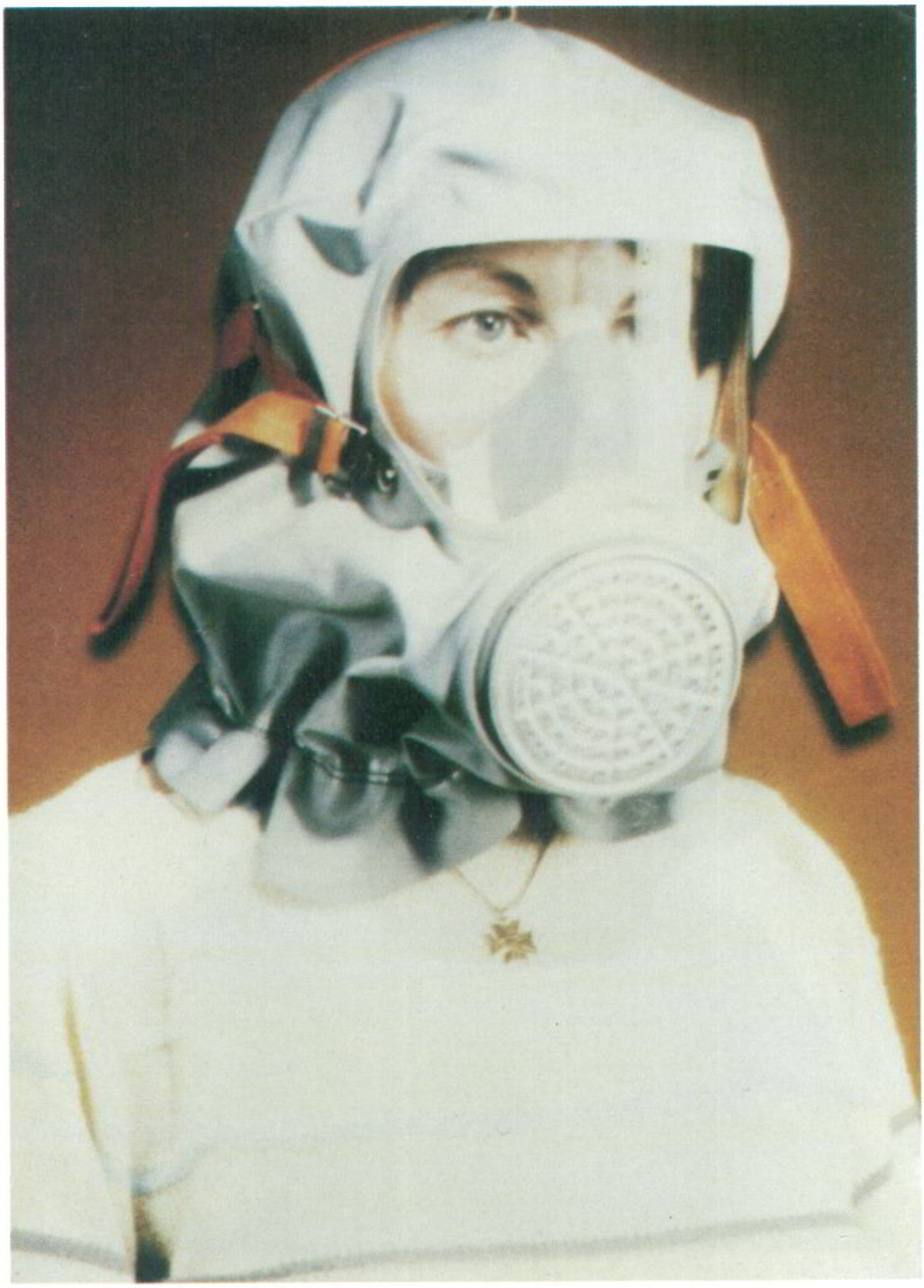
HF	356 ppm	8.3 ppm	10 ppm max

*The TLV for Benzene is 25 ppm, but it has been reported that concentrations of 3,000-4,700 ppm can be inhaled for 1 hour without serious consequences (Appendix 14b)

Passenger smokehood type 1(compressed oxygen source)

Passenger smokehood type 2 (compressed oxygen source)

Cabin crew smokehood (compressed oxygen source)



Passenger smokehood type 1 (filter)

Passenger smokehood type 2 (filter)

Temperature Stratification Effects in the Forward Galley

List of abbreviations used in this report

ADD	Acceptable Deferred Defect
AFFF	Aqueous Film Forming Foam
ANO	Air Navigation Order
ANPRM	Advanced Notice of Proposed Rule Making
APU	Auxiliary Power Unit
ATC	Air Traffic Control
ATIS	Automatic Terminal Information Service
BCF	Bromochlorodifluoromethane
BEOL	British Airways Engine Overhaul Ltd
CAA	Civil Aviation Authority
CAMI	Civil Aeromedical Institute
CCOC	Combustion Chamber Outer Case
CVR	Cockpit Voice Recorder
DO	Divisonal Officer
EPR	Engine Pressure Ratio
FAA	Federal Aviation Administration
FCU	Fuel Control Unit
FDR	Flight Data Recorder
GCMS	Gas Chromatography Mass Spectographic
GMC	Greater Manchester Council
HMI	Heavy Maintenance Inspection
IAS	Indicated Air Speed
IPTM	Institute of Pathology and Tropical Medicine
J1	"Jumbo" Foam Tender No 1
J2	"Jumbo" Foam Tender No 2
Kt	Knots
L1	Left Front Door
L2	Left Rear Door
LMI	Light Maintenance Inspection
LP	Low Pressure
MIAFS	Manchester International Airport Fire Service
N2	High Pressure Spool Speed
NPRM	Notice of Proposed Rule Making
NTSB	National Transportation Safety Board
OSU	Ohio State University
PA	Public Address
PPM	Parts Per Million
PVC	Polyvinyl Chloride
PWSR	Post Weld Stress Relief

QAR	Quick Access Recorder
RI	Right Front Door
R2	Right Rear Door
RAPRA	Rubber and Plastics Research Association
RFF	Rescue and Fire Fighting
RIV	Rapid Intervention Vehicle
RTF	Radio Telephony
RVP	Rendezvous Point
SCCM	Senior Cabin Crew Member
SEP	Safety Equipment and Procedures
SHT	Solution Heat Treatment
T4	Combustor Inlet Air Temperature
T7	Exhaust Gas Temperature
TSN	Time Since New
UHF	Ultra High Frequency
VHF	Very High Frequency

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