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Crash Injury Protection In Survivable Air Transport Accidents-U.S. Civil Aircraft Experience From 1970 To 1978

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This report was the result of a joint FAA Technical Center and FAA Civil Aeromedical Institute effort.

16. Abstract

This report reviews 27 survivable ground accidents and 3 in-flight accidents occurring from 1970 through 1978. Twenty-five of the ground accidents and all of the in-flight accidents involved reports of seat or restraint performance. Comparisons of injury and fatality rates are made with studies involving earlier model aircraft accidents.

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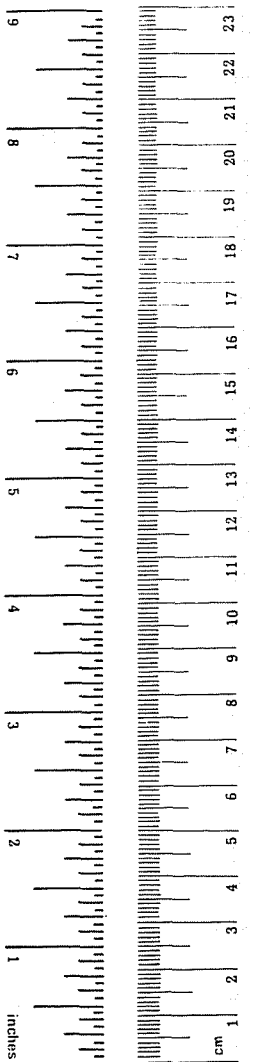
METRIC CONVERSION FACTORS

Approximate Conversions to Metric Measures

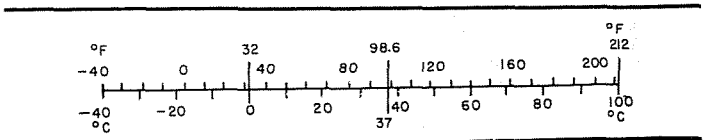
Symbol	When You Know	Multiply by	To Find	Symbol
	LENGTH			
in	inches	*2.5	centimeters	cm
ft	feet	30	centimeters	cm
yd	yards	0.9	meters	m
mi	miles	1.6	kilometers	km
	AREA			
in^2	square inches	6.5	square centimeters	cm^2
ft^2	square feet	0.09	square meters	m^2
yd^2	square yards	0.8	square meters	m^2
mi^2	square miles	2.6	square kilometers	km^2
	acres	0.4	hectares	ha
	MASS (weight)			
oz	ounces	28	grams	g
lb	pounds	0.45	kilograms	kg
	short tons (2000 lb)	0.9	tonnes	t
	VOLUME			
tsp	teaspoons	5	milliliters	ml
Tbsp	tablespoons	15	milliliters	ml
fl oz	fluid ounces	30	milliliters	ml
c	cups	0.24	liters	l
pt	pints	0.47	liters	l
qt	quarts	0.95	liters	l
gal	gallons	3.8	liters	l
ft^3	cubic feet	0.03	cubic meters	m^3
yd^3	cubic yards	0.76	cubic meters	m^3
	TEMPERATURE (exact)			
°F	Fahrenheit temperature	5/9 (after subtracting 32)	Celsius temperature	°C

*1 in = 2.54 (exactly). For other exact conversions and more detailed tables, see NBS Misc. Publ. 286, Units of Weights and Measures, Price $2.25, SD Catalog No. C13.10:286.



Approximate Conversions from Metric Measures

Symbol	When You Know	Multiply by	To Find	Symbol
	LENGTH			
mm	millimeters	0.04	inches	in
cm	centimeters	0.4	inches	in
m	meters	3.3	feet	ft
m	meters	1.1	yards	yd
km	kilometers	0.6	miles	mi
	AREA			
cm^2	square centimeters	0.16	square inches	in^2
m^2	square meters	1.2	square yards	yd^2
km^2	square kilometers	0.4	square miles	mi^2
ha	hectares (10,000 m^2)	2.5	acres	
	MASS (weight)			
g	grams	0.035	ounces	oz
kg	kilograms	2.2	pounds	lb
t	tonnes (1000 kg)	1.1	short tons	
	VOLUME			
ml	milliliters	0.03	fluid ounces	fl oz
l	liters	2.1	pints	pt
l	liters	1.06	quarts	qt
l	liters	0.26	gallons	gal
m^3	cubic meters	35	cubic feet	ft^3
m^3	cubic meters	1.3	cubic yards	yd^3
	TEMPERATURE (exact)			
°C	Celsius temperature	9/5 (then add 32)	Fahrenheit temperature	°F



CAVEAT

The work presented herein was the result of an extensive literature search performed during April 1979 through April 1980. The results of this effort provided the basis for a more indepth FAA/NASA funded evaluation of passenger seat/restraint systems and accident experience by the major air transport airframe manufacturers.

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EXECUTIVE SUMMARY

This report is the result of a joint FAA Technical Center and FAA Civil Areomedical Institute effort whose purpose was twofold: (1) to compile a data base on passenger seat/restraint system performance in survivable transport category accidents, and (2) to determine if correlation exists between occupant, seat/restraint system performance, airframe/floor deformation, and/or passenger injuries fatalities.

As a result of an extensive literature search of air carrier accident data, 1970 through 1978, 27 survivable ground accidents and 3 in-flight (turbulence) accidents were found in which seat/restraint system performance was identified and/or discussed.

Comparison of data indicated that floor or cabin deformation frequently is a cause of seat failure. Also flailing injuries due to either bending over the restraint or secondary impact with the aircraft interior, appear to be common.

The results of this effort provided the basis for a more indepth FAA/NASA funded evaluation of air carrier accident experience by the major airframe manufacturers.

INTRODUCTION

The effectiveness of transport aircraft seating and restraint systems in preventing injuries and death during an aircraft crash has been addressed by several authors (references 1 through 21). Perhaps the most comprehensive of these was that of Haley et al. (reference 19), which summarized a study of 61 survivable transport aircraft accidents which occurred during the years 1955 through 1964 and provides recommendations of dynamic design or test criteria for air transport seats. That study was, however, largely based upon crashes of smaller and slower aircraft. It is generally conceded that modern jet transport aircraft may create a different crash environment, perhaps resulting in fewer injuries because of the greater mass and crushable structure of the aircraft, or perhaps more injuries because of the greater landing and takeoff speeds, characteristic of these newer aircraft. The present study was undertaken to obtain similar data on more recent crashes, and to assess the continuing validity of the earlier recommendations.

PURPOSE.

The objectives of this effort were: (1) to compile a data base on passenger seat/restraint system performance in survivable transport category accidents and (2) to determine if correlation exists between occupant seat/restraint system performance, airframe/floor deformation, and/or passenger injuries/fatalities.

BACKGROUND.

The Civil Aeromedical Institute (CAMI) Airline Cabin Safety Data Bank (reference 22) was queried for those accidents or incidents which involved seat or restraint system factors for the years 1970 through 1978. This time span was selected to obtain as much recent data as possible; and older type aircraft are excluded from this effort. Crashes occurring after 1978 were not uniformly reported at the time this study was initiated. Twenty-seven ground accidents and three in-flight incidents were identified in this search. Two of the ground accidents were later considered to be essentially survivable only "by chance" and were discarded from the study. National Transportation Safety Board (NTSB) Aircraft Accident Reports, Human Factors Group Reports, Structural Factors Group Reports, Crashworthiness Investigation Reports, and CAMI crash injury files were obtained for these accidents whenever possible. These data were reviewed and summaries prepared. To enable more rational comparison with the Haley report, NTSB Accident Summaries were then reviewed to find additional accidents which met the criteria of that study, but did not involve seat or restraint system factors. The Haley criteria, in essence, selected moderate to severe multiengine transport aircraft crashes in which at least one serious injury occurred, and in which at least one survival could have resulted from adequate seating and restraint. (In addition, the present study is limited to accidents investigated under the jurisdiction of the United States, where more consistent methodology and reporting could be expected.) Two additional accidents which met those criteria were located and have been included in the data of this study.

Occasional discrepancies in the data were found when comparing the various source reports. In those cases, the data which appeared to most accurately reflect the actual occurrence were included in this study. The problems of obtaining representative data were compounded by the fact that no uniform mandatory requirement exists for collecting or reporting the details desirable for a study such as this.

Thus, the data available for review varies to the extent of the investigators interest, knowledge, group assignment in the investigation, and resources (time) which could be made available for the investigation. Inconsistencies and inadequacies were frequently found in the records; these same problems have undoubtedly been present in previous studies. Since resolution of these problems must rest with the judgment of the authors, care must be used in making more than rudimentary comparisons among the data.

DISCUSSION

Although the previously mentioned inadequacies preclude accurate statistical comparisons of data, it is essential that some comparison be made with prior studies to indicate the achievement of the goals of this study. To provide a chronology of the effectiveness of crash injury protection techniques, the data of the present study (table 1) are compared with the reported results of Paullin and Heyl (reference 4), and Haley et al. (reference 19), in table 2. Paullin and Heyl described noncatastrophic civil air transport aircraft accidents occurring from 1950 to 1959, according to the following categories (reference 4):

Category 1 - Aircraft whose seats are securely fastened to the floor, and were designed to withstand at least a crash load of 1,000 pounds applied at an angle of 45° upward and forward through the seat belt without failure of the seat or restraint. Aircraft involved were: DC-3, DC-4, DC-6, L-049 series, and L-18.

Category 2 - Aircraft which had seats/restraints designed to withstand at least 6 gravity (g) crash loads without failure of the seat or restraint. Aircraft involved were: B-377, CV-240, CV-340, DC-6A, DC-6B, DC-7, L-1049, M-202, and M-404.

Category 3 - Aircraft which had seats/restraints designed to withstand at least 9 g crash loads without failure of the seat or restraints. Aircraft involved were: B-707, L-1649, L-188, V-745, V-810, F-27, and C-46.

The listing in table 2, for the results of the Haley study (reference 19), includes only the civil transport accidents listed in that report.

It must be remembered that the data in table 2 reflect the results of both operational and mechanical factors of air transport crashes. Although the overall safety of air transport has undoubtedly increased over the years (reference 1), this has apparently been due to improvements in accident avoidance techniques. Indeed, the level of crash protection provided by the aircraft of categories 1 and 2 may have been compensated by operational conditions which resulted in the low injury rates shown. Paullin and Heyl caution against the acceptance of the data listed for the category 3 aircraft because of the few cases investigated at the time of their report. Nevertheless, the trend towards the greater injury rates reported by Haley is evident. These rates appear to have peaked during the period of the Haley study, and are presently somewhat lower.

The reasons for the lower injury rates indicated in the present study cannot be accurately determined. A portion of the reduction of fatal injuries is due to the reduction of fire fatalities from 17 percent to 13 percent, approximately one-fourth. The most likely cause for this reduction is a corresponding reduction

TABLE 1. SURVIVABLE IN-FLIGHT AND GROUND IMPACT AIR CARRIER ACCIDENTS INVOLVING PASSENGER SEAT/RESTRAINT SYSTEM FAILURES 1970 THROUGH 1978 (INCOMPLETE)

	Aircraft Type	Location	Date	Total On Board	Crew Fatal	Crew Serious	Crew Minor, None	PAX Fatal	PAX Serious	PAX Minor, None	Fire	Fire Fatalities	Fuselage Breaks	Seat/ Restraint Damage	Notes
Turbulence Accidents															
T1	DC-8-63F	Near Okinawa, Ryukyu Is.	4-20-70	200	0	2	8	0	1	189	--	--	--	Yes	•
T2	B707-331B	Near Los Angeles, Calif.	8-28-73	152	0	2	9	1	2	138	--	--	--	Yes	*
T3	B727-35	Near Grand Isle, La.	11-17-74	74	0	0	7	0	2	65	--	--	--	Yes	*
Ground Impact Accidents															
G1	DC-9-33	Near St. Croix, V.I.	5-02-70	63	1	2	3	22	35	0	No	--	0	Yes	*
G2	MARTIN 404	Atlanta, Ga.	5-30-70	33	0	3	1	1	27	1	No	--	1	Yes	
G3	DC-9-32	Louisville, Ky.	9-08-70	94	0	0	5	0	0	89	No	--	1	Yes	*
G4	DC-8-62	Jamaica, N.Y.	9-15-70	156	0	0	10	0	8	138	No	--	1	Yes	*
G5	DC-8-63F	Anchorage, Alaska	11-27-70	229	1	6	3	46	43	130	Yes	44	2	Yes	*
G6	B727-200	St. Thomas, V.I.	12-28-70	55	0	2	5	2	9	34	Yes	2	2	Yes	*
G7	CONVAIR 340/440	New Haven, Conn.	6-07-71	31	2	1	0	26	2	0	Yes	26	0	No	*
G8	FH 227B	Albany, N.Y.	3-03-72	48	2	1	0	14	31	0	No	--	0	Yes	*
G9	B737/222	Chicago, Ill.	12-08-72	61	3	1	2	42	9	4	Yes	34	2	Yes	*
G10	DC-9-31	Chicago, Ill.	12-20-72	45	0	0	4	10	9	22	Yes	10	0	No	*
G11	L-1011	Miami, Fla.	12-29-72	176	5	10	0	94	67	0	No	--	*	Yes	*
G12	DC-8-61F	Jamaica, N.Y.	6-23-73	128	0	2	7	0	6	113	No	--	0	Yes	*
G13	FH 227B	St. Louis, Mo.	7-23-73	44	1	2	0	37	4	0	Yes	0	1	Yes	*
G14	DC-9-32	Chatanooga, Tenn.	11-27-73	79	0	2	3	0	1	73	No	--	1	Yes	*
G15	DC-9-31	North Canton, Ohio	11-27-73	26	0	3	2	0	13	8	No	--	1	Yes	*
G16	DC-10-30	Boston, Mass.	12-17-73	154	0	1	13	0	2	138	No	--	1	Yes	*
G17	B707-321B	Pago Pago, American Samoa	1-30-74	101	10	0	0	86	5	0	Yes	96	0	No	
G18	B727-224	Denver, Colo.	8-07-75	134	0	5	2	0	10	117	No	--	1	Yes	*
G19	F-27B	St. Lawrence Isl, Alaska	8-30-75	32	3	1	0	7	19	2	Yes	0	3	Yes	*
G20	B727-200	Raleigh, N.C.	11-12-75	139	0	0	8	0	1	130	No	--	0	Yes	*
G21	B727-81	Kechikan, Alaska	4-05-76	50	0	5	2	1	6	36	Yes	0	2	Yes	*
G22	B727-95	St. Thomas, V.I.	4-27-76	88	2	2	3	35	17	29	Yes	*	2	Yes	*
G23	LOCKHEED 188A	Guam, Marianas Is.	6-04-76	45	12	0	0	33	0	0	Yes	28	0	Yes	*
G24	DC-9-31	Philadelphia, Pa.	6-23-76	106	0	4	0	0	82	20	No	--	0	Yes	*
G25	DC-9-31	New Hope, Ga.	4-04-77	85	2	1	1	60	21	0	Yes	20	4	Yes	*
G26	B727-235	Escambia Bay, Fla.	5-08-78	58	0	2	4	3	9	40	No	--	0	Yes	*
G27	DC-8-61	Portland, Ore.	12-28-78	189	2	2	4	8	21	152	No	--	1	Yes	*

NOTES:

T1 Triple seat unit came out of tracks.
T2 Two seat belts failed.
T3 Seat belt failure.
G1 Resulted in NTSB Special Study AAS-72-2, Passenger Survival in Turbojet Ditching.
Twenty-two fatalities were due to drowning.
Fabric to metal seat belt buckles used.
Two infants on board included in fatalities.
Aircraft floated for five to six minutes.
G3 The overhead hat racks fell and oxygen service panels opened.
G4 Primary seat failures in fuselage break area.
Overhead, interior trim failures.
G5 Overhead racks collapsed, gallery gear came out of galley.
G6 Rain shield, class divider collapsed, oxygen masks fell down.
G7 Carryon baggage rack collapsed on flight attendant.
G8 Longitudinal floor fracture.
Injuries were to lower extremities, chest, spine.
G9 Overhead, interior trim failures.
G10 Flight attendant seat failed to retract - many minor injuries - back sprains.
G11 Many seats remained atached to floor pallets, other failed at attachment fittings.
Large sections in cabin area disintegrated during impact.
Survival of occupants often attributed to integrity of seat/restraint system.
G12 Overhead, interior trim failures.
G13 Aircraft floor distorted upward.
G14 Serious injuries were compression fractures.
G15 Overhead, interior trim failures.
G16 Multiple seat failures due to floor damage.
Overhead, interior trim failures.
G18 A substantial amount of debris flew around cabin.
G19 Multiple seat failures due to floor damage.
Extensive floor damage.
G20 Overhead, interior trim failures.
G21 Debris, passenger injuries included spinal, leg and rib fractures.
G22 All fatalities had combination of impact injuries and smoke inhalation.
G23 Some crushing of fuselage occurred.
G24 Overhead, interior trim failures.
Good seat study.
G25 Extensive fuselage damage.
G26 Three fatalities due to drowning.
G27 Fatal injuries due to penetration of fuselage by trees.

TABLE 2. COMPARISON ON NONCATASTROPHIC AIR TRANSPORT AIRCRAFT ACCIDENTS OCCURRING FROM 1950 THROUGH 1959 (REFERENCE 4) AND 1955 THROUGH 1964 (REFERENCE 19), TO THOSE OCCURRING FROM 1970 THROUGH 1978 (INCOMPLETE)

	REF 4*			REF 19**	
	Category 1	Category 2	Category 3	(Civil Only)	This Study
Number of Cases	89	92	14	42	27
Persons on Board	2052	3016	655	1422	2529
Fatal Injury, Percent	9.4	4.3	13.7	43***	24***
Serious Injury, Percent	5.3	4.3	3.7	18	20
Crashes with Fire, Percent	-	-	-	58	44
Fire Fatalities, Percent	-	-	-	17	13

NOTE: * Ref 4: Paullin, R. L., and E. B. Heyl: A review of Civil Transport Aircraft Safety Belt Experience.

** Ref 19: Haley, J. L., J. W. Turnbow, and G. J. Walhout: Floor Accelerations and Passenger Injuries in Transport Aircraft Accidents.

*** Excluding Drownings.

of one-fourth in the incidence of postcrash fire, from 58 percent reported in the Haley study to 44 percent in the present study. The difficulties of associating a definitive cause for fatalities in cases where fire is involved are well known. Since rapid evacuation of the aircraft is the primary defense against death due to fire, factors pertinent to the evacuation process can be the underlying cause of a fatality, even though the "cause of death" may be listed as due to fire or inhalation of toxic products of combustion. This is well illustrated by the case of a Convair 340/440 which crashed on approach to the runway and subsequently burned (case G7). Fifteen nonsurviving passengers were found near the rear service door. The flight attendant stationed near the rear door died of asphyxiation, but suffered injuries during the crash which rendered her "physically unable to operate the rear service door." The true cause of these "fire fatalities" may well have been the impact injuries to the flight attendant, or the inability of the passengers to operate the rear door. No simple, single cause factor for these fatalities can be proven; they were included in the data of this study as fire fatalities. This case illustrates an instance of author's judgment. The deaths could have been considered as "unknown causes" and the injury rates changed accordingly.

Table 2 presents a comparison of the data from three studies of non-catastrophic air transport accidents. To understand the significance of these results, the source of these fatal injuries must be considered. The cause of the fatalities is predominantly due to loss of fuselage structural integrity, caused by disintegration or penetration/crushing of it by some outside structure, or by loss of seating or restraint integrity which allows the occupant to impact the aircraft structure or be thrown from the aircraft. The serious injuries are often caused by a restrained passenger experiencing a restraint injury or secondary impact with something inside the cabin, or by some action which takes place during the evacuation process. Thus, the reduction in fatal injuries from causes other than fire could be a result of the increased protection offered by a larger, heavier aircraft with better energy absorbing capacity between the impacted surface and the occupant and/or the increased regulatory requirements. Such a trend should be evident in a plot describing the fatalities or injuries as a function of the aircraft size (see figures 1 and 2). (Of course such a trend could also be determined statistically, but it is the belief of the authors that the uncertainties in the data collection and reporting process preclude valid statistical analysis.) Figure 1 shows the percentage of fatalities which occurred in crashes without fire fatalities plotted against the design maximum landing weight for the aircraft involved. Data for the present study and for the civil transport accidents of reference 19 (excluding crew only accidents) are shown. Figure 2 gives a similar plot for the percentage of serious injuries involved in these crashes. In both figures, a slight downward trend may be present, but this indication may be caused by the small number of cases involving aircraft with maximum landing weights greater than 200,000 pounds.

The problem of fuselage floor deformation as a contributing factor to seat failure and resulting injuries has been frequently reported (references 2, 6, 14, 15, 19, and 23). The present study again confirms that factor. Fuselage separation or residual floor deformation was noted in over 60 percent of the cases studied, corresponding closely to the 57 percent reported in reference 19. These deformations generally take two forms, either longitudinal crashing of the floor towards the center of the aircraft (compare figure 2-5 in reference 23) or circumferential fracture around the fuselage with transverse floor buckling or fracture. Seats in

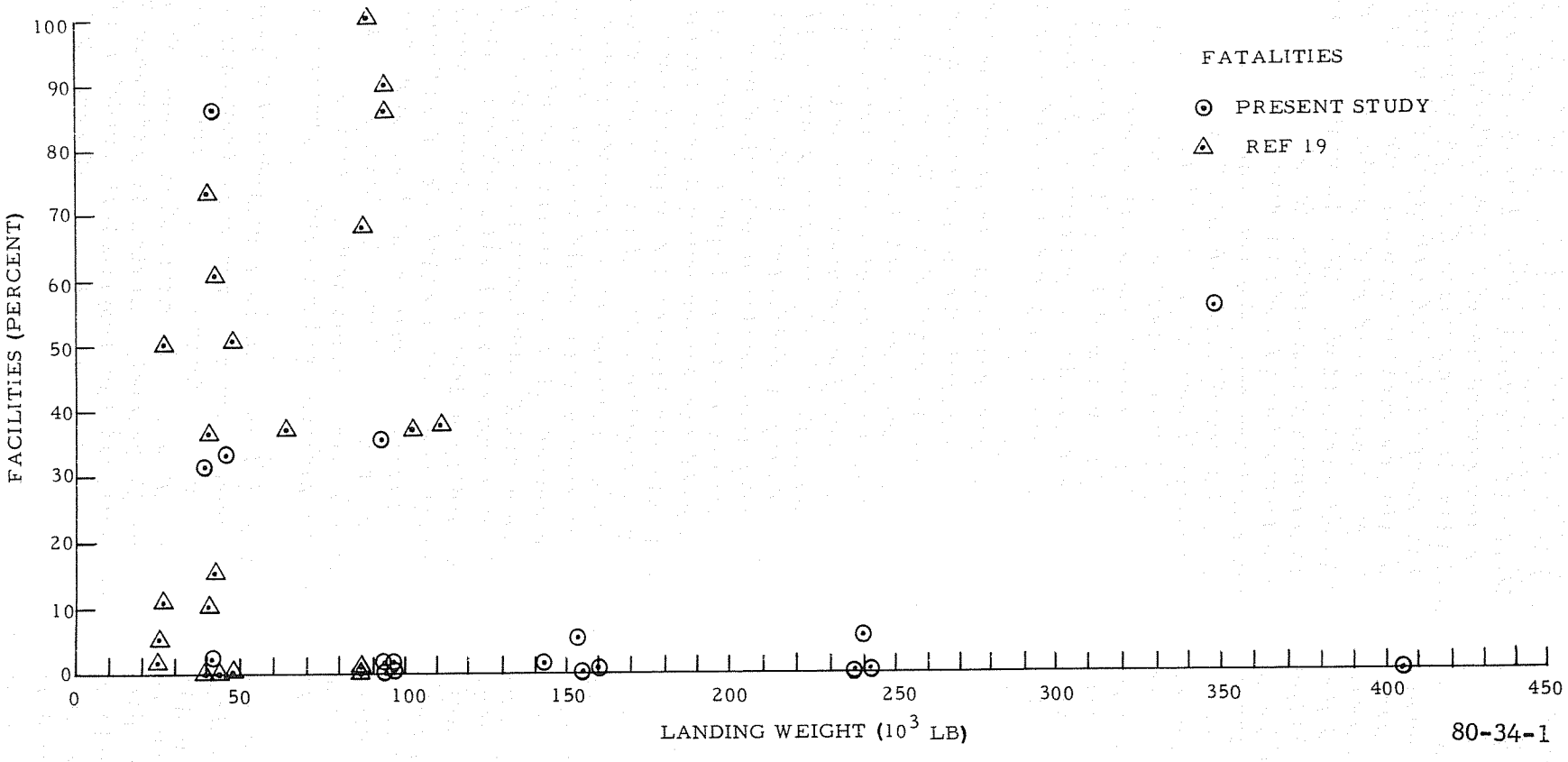

FIGURE 1. PERCENTAGE OF FATALITIES IN CRASHES WITHOUT FIRE FATALITIES PLOTTED AGAINST MAXIMUM AIRCRAFT LANDING WEIGHT

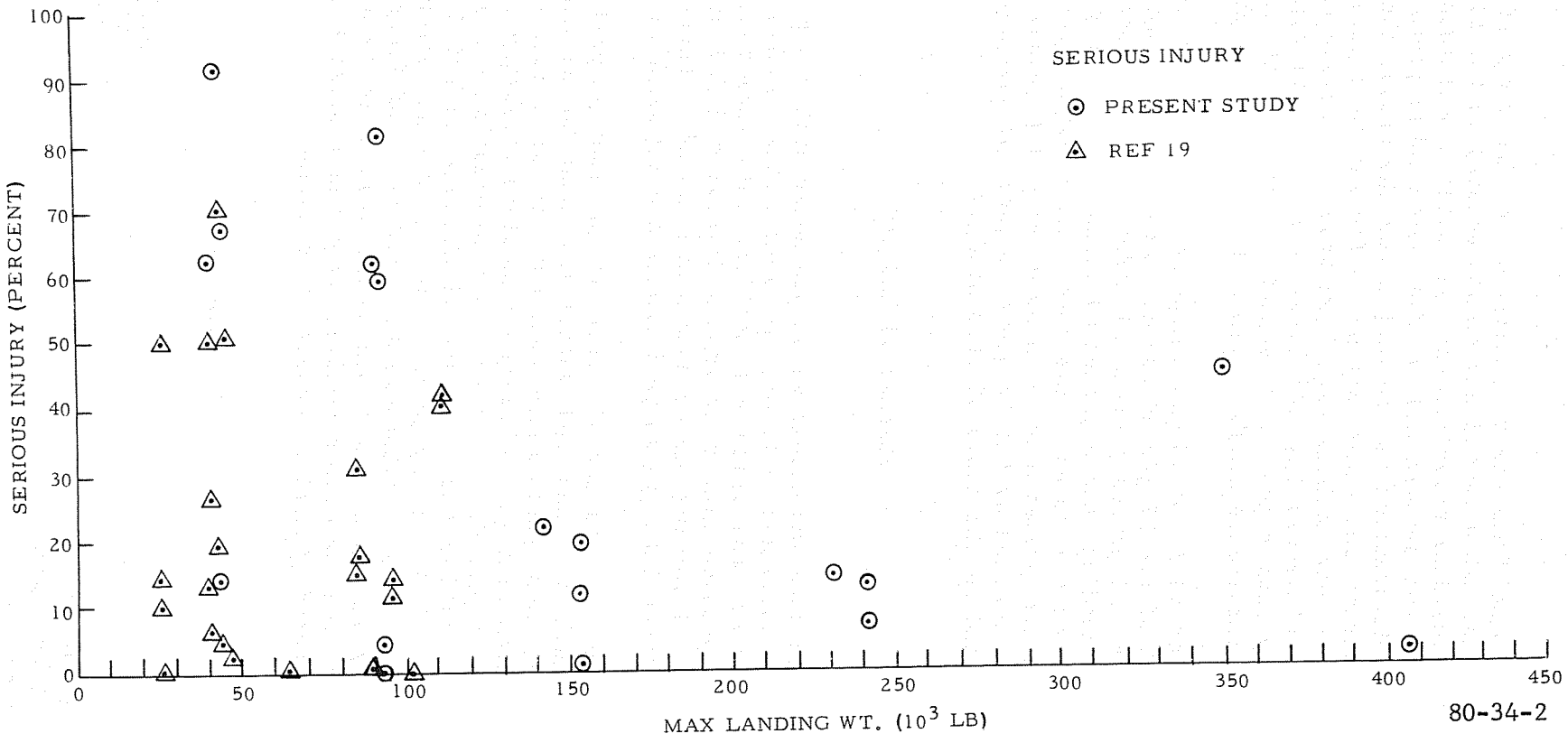

FIGURE 2. PERCENTAGE OF SERIOUS INJURIES IN CRASHES WITHOUT FIRE-RELATED SERIOUS INJURIES PLOTTED AGAINST MAXIMUM AIRCRAFT LANDING WEIGHT

these areas break loose from their attachment to the aircraft, even though the track to which the seat was attached may remain secured to the floor. It should be recognized that the residual floor deformation noted in postcrash investigations is often much less than the dynamic deformation which takes place during the crash. Even if no residual deformation is apparent after the crash, the floor deformation which takes place during the crash may be sufficient to fracture seat/attachment components. Although test methods have been developed to evaluate the effects of floor deformation (references 23, 24), they are not often applied to civil air transport seating systems since their validity with respect to floor deflection occurring in actual survivable crash accidents has not been established.

Though floor deformation is a primary cause of seat failure, it should not overshadow the fact that of the 27 ground impact cases in this study which involve seat restraint factors, 6 (22 percent) occurred under in-flight turbulence or what was essentially a "hard landing" and experienced loads significantly less than commonly associated with aircraft crashes. The fact that problems can exist under those conditions indicate the presence of much more serious problems under crash loads. This conclusion is supported by the frequent failures of overhead and interior trim components as reported in the cases of this study.

SUMMARY OF RESULTS

A comprehensive data base was developed on passenger seat/restraint system performance in survivable transport category airplanes; the results are summarized in table 1. The sources from which all accident data were taken are presented in appendix A. Twenty-seven ground accidents involving 2,529 occupants, and three turbulence accidents involving 426 occupants are listed. Abstracts of the 30 cases involving seat or restraint system performance are included in appendices B and C.

While the data base contains certain limitations, some general correlation can be extracted. Although injuries and fatalities seem to be decreasing in recent survivable crashes, seat performance continues to be a factor in these crashes. Failures ranging from seat pan collapse to complete breakaway of the seat assembly from the floor are reported. Floor or cabin deformation frequently is a cause of seat failure, indicating that the use of ductile materials or load limiting methods in the seat structure may be of value. Good seat performance under adverse conditions, appears to be attributable to a reduction of floor deformations or to the use of energy absorption concepts (seat legs that bend but don't break). Flailing injuries, due to either bending over the restraint system or secondary impact with the aircraft interior, appear to be common.

CONCLUSIONS

Comprehensive, accurate data on crash injury protection capabilities of air carrier seating and restraint systems are severely limited by inconsistent, often incomplete reports on the crash investigations. To improve the data base for studies in this area, a uniform, mandatory investigation procedure should be established. As a minimum, this procedure should specify:

1. The floor/seat/restraints performance with sufficient engineering detail to enable analysis of failures,

2. The injuries sustained by passengers from seat or restraint (failure) or from the seats themselves;

3. An analysis of cabin deformities as related to the damaged seats.

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13. The Relative Crash Protective Qualities and Deficiencies of Passenger Seat MIL-S-7877 (Aer) in Forward and Aft Facing Positions, Aeronautical Medical Equipment Laboratory, Report No. NAM AE-6303, November 15, 1954.

14. Hasbrook, A. H., Design of Passenger "Tie-Down", Aviation Crash Injury Research, Av-CIR-44-0-66, September 1956.

15. Hawkes, R., Air Crash Death or Injury May Be Prevented by Sound Detail Design, Aviation Week, November 5, 1956.

16. Fryer, D. I., Aircraft Passenger-Seat Design and Crash Survival, Flying Personnel Research Committee, FPRC 1055, August 1958.

17. Carroll, D. F., Collins, J. A., Haley, J. L., and Turnbow, J. W., Crashworthiness Study for Passenger Seat Design - Analysis and Testing of Aircraft Seats, Aviation Safety Engineering and Research, Av-SER-67-4, May 1967.

18. Pinkel, I. I. and Rosenberg, E. G., Seat Design for Crashworthiness, National Advisory Committee for Aeronautics Technical Note 3777, October 1956.

19. Haley, J. L., Turnbow, J. W., and Walhout, G. J., Floor Accelerations and Passenger Injuries in Transport Aircraft Accidents, USAAVLABS Technical Report 67-16, May 1967.

20. Swearingen, J. J., Hasbrook, A. H., Snyder, R. G., and McFadden E. B., Kinematic Behavior of the Human Body During Deceleration, FAA Report 62-13, June 1962.

21. Hasbrook, A. H., Crash Survival Study: National Airlines DC-6 Accident at Elizabeth, N.J. on February 11, 1952, Crash Injury Research Informative Accident Release No. 15, October 1953.

22. Pollard, D. W., Anderson, J. A., and Melton, R. J., A Description of the Civil Aeromedical Institute Airline Cabin Safety Data Bank: 1970-1976, FAA Office of Aviation Medicine Report No. AM-79-23, 1979.

23. Crash Survival Design Guide, U.S. Army Air Mobility Research and Development Laboratory, USAAMRDL Technical Report 71-22, October 1971.

24. The Product Liability Problem on Crashworthy Aircraft Seats, Aerospace Research Associates, ARA Report 199, February 8, 1980.

APPENDIX A

SOURCES OF INFORMATION

Accident abstracts for in-flight and ground impact accidents (appendices B and C) were compiled from the following data sources:

FAA/CAMI Cabin Safety Data Bank
FAA/CAMI Crash Injury Files
FAA Accident/Incident Records
FAA Crashworthiness Reports
NTSB Aircraft Accident Reports
NTSB Human Factors Group Reports
NTSB Structural Factors Group Reports
NTSB Aircraft Accident Files
NTSB Annual Reviews of Aircraft Accident Data, U.S. Air Carrier Operations

APPENDIX B

IN-FLIGHT ACCIDENTS

T-1

DATE: 04-20-70
LOCATION: Near Okinawa, Ryukyu Islands
AIRCRAFT OPERATOR: Airlift International, Inc.
AIRCRAFT DATA:
Make, Model: McDonnell Douglas, DC-8-63F
Serial Number: 46061
Registration Number: N6162A
TYPE OF ACCIDENT: Turbulence
PHASE OF OPERATION: In-flight
AIRCRAFT DAMAGE: Minor

Pax (Passenger) Seating Configuration. This aircraft was configured for 221 passenger seats.

Airframe Deformation/Crash Loads. No airframe deformation was reported. The readout of the flight data recorder showed that during the encounter with the severe turbulence (approximately 1-minute duration) the vertical velocity varied from +2.78 g's to -1.69 g's with the aircraft climbing about 800 feet before descending about 6,000 feet.

Pax Seat Performance. A triple seat unit (row 38-right) in the passenger compartment came out of the floor tracks.

Pax Seat Manufacturer(s)/Model(s). Information not in available reports.

Pax Restraint System Performance. Several passenger statements indicated that their seatbelts broke during the turbulence; however, no broken seatbelts or slipping seatbelts were documented.

Pax Restraint System Manufacturer(s)/Model(s). No data available.

Miscellaneous Cabin Interior Performance. Ten holes were found punctured in the overhead hatracks from row 6 back to aft row. It was reported from occupant statements that items from the coatrack area and the shelf above it were airborne during the turbulence; galley items were likewise flying around the cabin.

OCCUPANT/INJURY INFORMATION

Injuries	Crew	Passengers
Fatal	0	0
Serious	2	1
Minor/None	10	199

Flight attendants were in the process of completing meal service when turbulence struck. Injuries were generally to the back and head.

Narrative. An Airlift International, Inc., DC-8-63 encountered turbulence while operating at 29,000 feet mean sea level approximately 80 miles northeast of Hengchun, Taiwan. The "Fasten Seat Belt" sign had been activated for about 30 minutes. Just prior to encountering the severe turbulence, an announcement was made instructing the passengers to keep their seatbelts fastened. The turbulence lasted approximately 1 minute. Two flight attendants and one passenger sustained serious injuries while 10 passengers sustained minor injuries. The captain made an unscheduled landing at a nearby U.S. Air Force base. Postlanding inspection showed only minor damage in the passenger compartment.

T-2

DATE: 08-28-73
LOCATION: Near Los Angeles, California
AIRCRAFT OPERATOR: Trans World Airlines, Inc.
AIRCRAFT DATA:
Make, Model: Boeing 707-331B
Serial Number: 18916
Registration Number: N8705T
TYPE OF ACCIDENT: Disturbance longitudinal control surfaces
PHASE OF OPERATION: In-flight
AIRCRAFT DAMAGE: No substantial structural damage

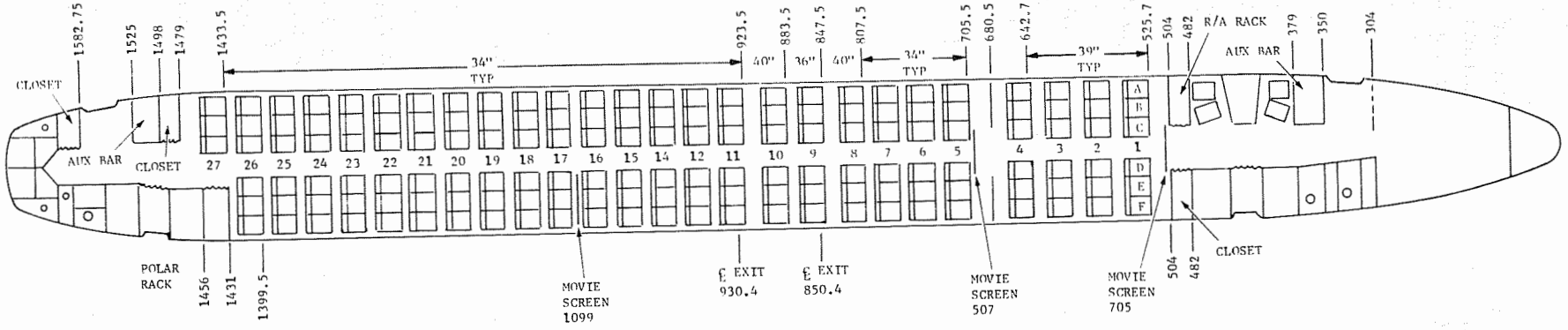
Pax Seating Configuration. This aircraft had a two-class cabin configuration. The front cabin (first class) had four rows of double seat units on either side of the aisle, two entry doors forward on either side of the cabin, a lounge area, a galley, and lavatories. The aft cabin area (coach section) had 22 rows of triple seat units on either side of a center aisle (figure B-1).

Airframe Deformation/Crash Loads. There was no airframe deformation. As the flight descended through FL 220 at 350 knots indicated airspeed, the aircraft pitched up abruptly, then down. The pitching oscillation consisted of about 55 cycles with maximum peak to vertical acceleration loads at the aircraft's center of gravity of +2.4 g's to -0.3 g's.

Pax Seat Performance. None

Pax Seat Manufacturer(s)/Models(s). Not given in available reports.

Pax Restraint System Performance. According to flight attendant and passenger interviews, two seatbelts failed at seats 27B and 18A. Before the investigator arrived at the scene, the belts were replaced; however, in the nonroutine maintenance record an entry indicated that seat 27B had mismatched belts that had been replaced. Flight attendant statements indicate one passenger's seatbelt had come loose from the seat. It is not clear if this was seat 18A or 27B or if it was another seat. Additional note by another flight attendant was that 27B and 18A be checked. "Seatbelts separated from connections at lower part of seat — were lost in confusion of objects under seats — moved passengers to first class seats — how could this happen?" (See last page, Human Factors Report.)



NOTES:

1. ALL STATIONS SHOWN ARE TRUE STATIONS.
2. ℄ OF OVERWING EMERGENCY EXITS ARE STATION 850.4 TRUE AND 930.4 TRUE
3. ALL STATIONS AND MEASUREMENTS REFERENCE NEAREST BULKHEAD FACE AND/OR FWD. FACE OF FRONT CHAIR LEG FAIRING AT FLOOR LEVEL.

80-34-B-1

FIGURE B-1. TRANSWORLD AIRLINES, INC., BOEING 707-331B, N8705T SEATING CONFIGURATION

Miscellaneous Cabin Interior Performance. The contents of the overhead storage racks spilled onto the floor and seats during the gyrations. The contents of the auxiliary bar waste container spilled on the floor in the aft galley area.

OCCUPANT/INJURY INFORMATION

Injuries	Crew	Passengers
Fatal	0	1
Serious	2	2
Minor/None	9	138

The seriously injured passengers were standing in the aft galley.

Narrative. This Boeing 707-331B experienced longitudinal oscillations (porpoised) while descending through the 22,000-foot pressure altitude at a speed of 350 knots indicated air speed. There were about 50 oscillations that lasted for a total of approximately 2 minutes. During this time, one flight attendant and three passengers were injured; of the injured passengers, one was injured critically and died 2 days later.

T-3

DATE: 11-17-74
LOCATION: Near Grand Isle, Louisiana
AIRCRAFT OPERATOR: National Airlines, Inc.
AIRCRAFT DATA:
Make, Model: Boeing, B-727-35
Serial Number: 18812
Registration Number: N4611
TYPE OF ACCIDENT: Turbulence
PHASE OF OPERATION: In-flight cruise
AIRCRAFT DAMAGE: None

Pax Seating Configuration. Data not in available reports.

Pax Seat Performance. None reported.

Pax Seat Manufacturer(s)/Model(s). Data not in available reports.

Pax Restraint System Performance. A seatbelt buckle at seat 23D had separated. The seatbelt assembly was retrieved in four pieces. The adjusting roller from the buckle was not retrieved. When the belt was reassembled by installing a roller, the assembly worked properly. No formal load tests were conducted.

Pax Restraint System Manufacturer(s)/Model(s). Seatbelt Assembly, metal-to-metal, American Safety, part No. 444899.

Miscelaneous Cabin Interior Performance. Three passenger service units were damaged at row 23, seats B, E, and F. Other unrestrained items flew around the cabin.

OCCUPANT/INJURY INFORMATION

Injuries	Crew	Passengers
Fatal	0	0
Serious	0	2
Minor/None	7	65

Narrative. A National Airlines, Inc., Boeing 727-35 encountered heavy turbulence at an altitude of about 31,000 feet. The turbulence lasted for a short while, but during this time 2 of the 74 passengers on board the aircraft sustained serious injuries. The aircraft experienced no structural damage. One passenger's seatbelt assembly failed.

APPENDIX C

GROUND IMPACT ACCIDENTS

LIST OF ILLUSTRATIONS
APPENDIX C

LIST OF ILLUSTRATIONS (Continued)

LIST OF ILLUSTRATIONS (Continued)

DATE: 05-02-70
LOCATION: Near St. Croix, Virgin Islands
AIRCRAFT OPERATOR: Antilliaanse Luchtvaart Maat Schappij
AIRCRAFT DATA:
Make, Model: DC-9-33 (owned by Overseas National Airways, Inc.)
Serial Number: 47407
Registration Number: N935F
TYPE OF ACCIDENT: Ditching
PHASE OF OPERATION: Landing
AIRCRAFT DAMAGE: Main part of fuselage intact

Pax Seating Configuration. The aircraft passenger cabin was configured into a single class consisting of 21 seat rows with two seats (A and B) on the left side of the airplane and a triple row of seats (C, D, and E) on the right side of the airplane (figure C-1).

Airframe Deformation/Crash Loads. The aircraft's major fuselage sections remained intact at impact. "The direction of the inertial resultant of body acceleration was forward and down with a slight lateral vector to the left for those occupants seated forward and up for those seated aft of the center of gravity." (Quoted from "Special Study Passenger Survival in Turbojet Ditchings A Critical Case Review," NTSB-AAS-72-2.) Because the stopping distance and uniformity of deceleration are unknown, it is impossible to calculate one magnitude of deceleration. Passengers generally described the deceleration as severe to violent.

Pax Seat Performance. "Approximately half of the survivors who commented on seat integrity reported seats being torn loose at impact. One statement described seats with occupants being catapulted from left side of the forward against the bulkhead" (sic), quoted from "Report of Human Factors/Witness Group." Since the aircraft sank, it was impossible to examine the seats. It is also known that the breakover feature of the seat backs of air transport seats may be confused with seat failure; however, descriptions of the damage by survivors and the nonsurvival of the occupants of the first three rows on the left of the cabin imply that these rows were affected by failure.

Pax Seat Manufacturer(s)/Model(s). Data not in available reports.

Pax Restraint System Performance. Seven instances of seatbelt failures were reported.

Pax Restraint System Manufacturer(s)/Model(s). All the passenger seats were equipped with seatbelts of the fabric-to-metal type. Specific information about manufacturers/models was not in available files.

Miscellaneous Cabin Interior Performance. Contents of the forward-facing galley unit were spilled on the floor at impact. This galley had been secured, and according to NTSB reports, the spillage was due to failure of the locking mechanisms. The cockpit door jammed.

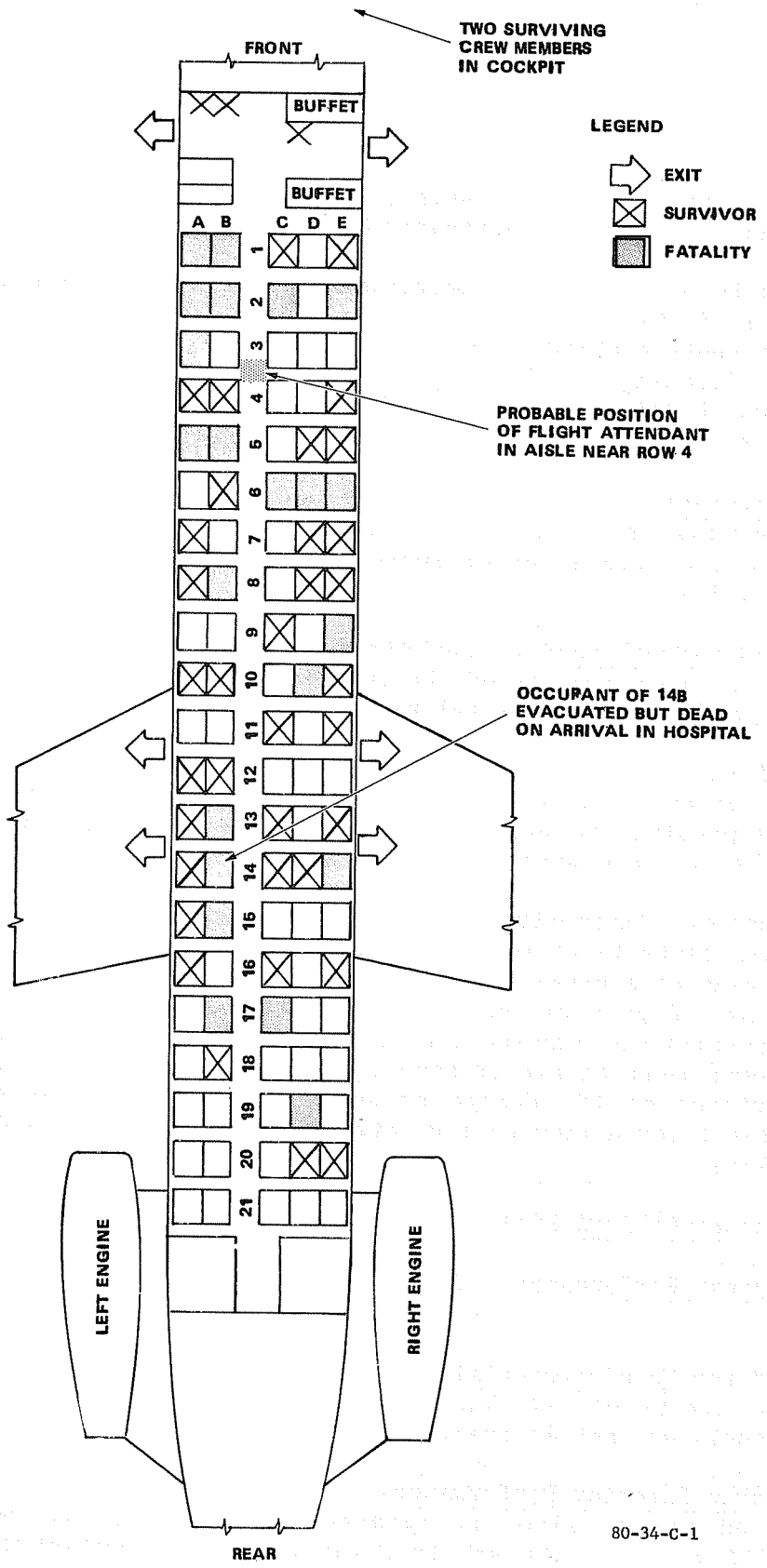


FIGURE C-1. ANTILLIAANSE LUCHTVAART MATT SCHAPPIJ DC-9-33, N935F SEATING DIAGRAM, INCLUDING SEAT LOCATIONS OF INJURED/FATALITIES AND EVACUATION ROUTES

OCCUPANT/INJURY INFORMATION

Injuries	Crew	Passengers
Fatal	1	22
Serious	2	35
Minor/None	3	0

A preliminary survey indicates that of the injuries received by passengers, spinal injuries predominated. Of the 16 injured passengers hospitalized at St. Croix, the following fractures were confirmed by X-ray: four rib, one shoulder, thirteen spinal, and one left clavicle injury. (Some people had two or more injuries, and there were 2 minimal undetermined injuries.)

Narrative. After an automatic direction finding approach and three circling approaches to Juliana Airport (St. Maarten) in poor weather, during which a landing could not be made, the flight departed for St. Croix in a low-fuel state. The aircraft descended to the water in anticipation of a ditching. When fuel exhaustion was reached, the engines flamed out and the aircraft ditched. Forty persons, including thirty-five passengers and five crewmembers, survived. Twenty-three persons, including two infants and one stewardess, did not survive. The aircraft floated for between 5 and 6 minutes.

G-2

DATE: 05-30-70
LOCATION: Atlanta, Georgia
AIRCRAFT OPERATOR: Lehigh Acres Development, Inc.
AIRCRAFT DATA:
Make, Model: Martin, 404
Serial Number: 14116
Registration Number: N40412
TYPE OF ACCIDENT: Collision with ground
PHASE OF OPERATION: Emergency landing on highway
AIRCRAFT DAMAGE: Destroyed

Pax Seating Configuration. The aircraft was equipped with 40 passenger seats. The seat rows were numbered 1 through 10 with double seat units on each side of the center aisle.

Airframe Deformation/Crash Loads. The fuselage was separated on a diagonal between fuselage stations (FS) 536 and 701. (The fuselage is presented schematically in figure C-2 and pictorially in figure C-3.) In addition, the fuselage was deformed vertically at an approximate 15° angle in the vicinity of FS 430. The major forces to the aircraft occurred in the aft, up, and from the right direction.

Pax Seat Performance. Passenger seat failures were numerous and of all categories seat attachment leg failures, seat position locking failures, seat leg failures, etc. (figure C-4). It was estimated that about one-third of the passenger seats were broken and detached from the floor. Because the seats were not numbered,

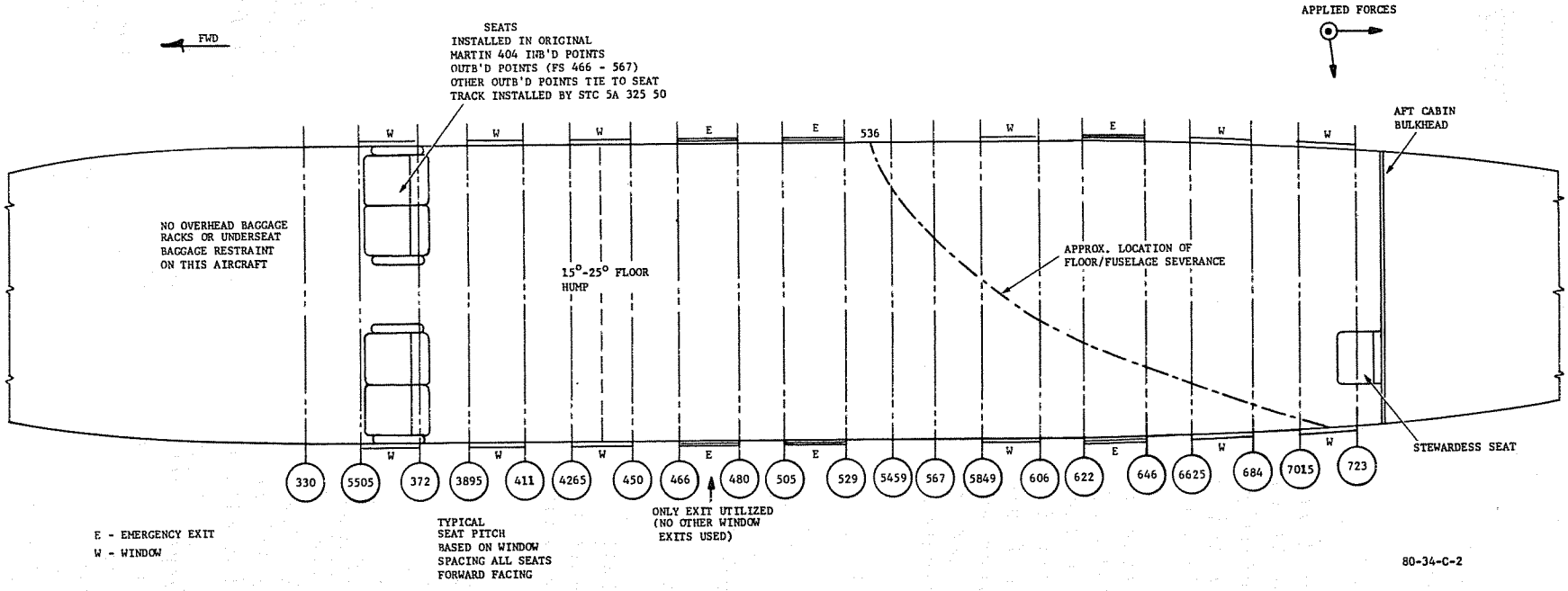


FIGURE C-2. LEHIGH ACRES DEVELOPMENT, INC., MARTIN 404, N40412 AIRFRAME DAMAGE (SCHEMATIC VIEW)

FIGURE C-3. N40412 AIRFRAME DEFORMATION

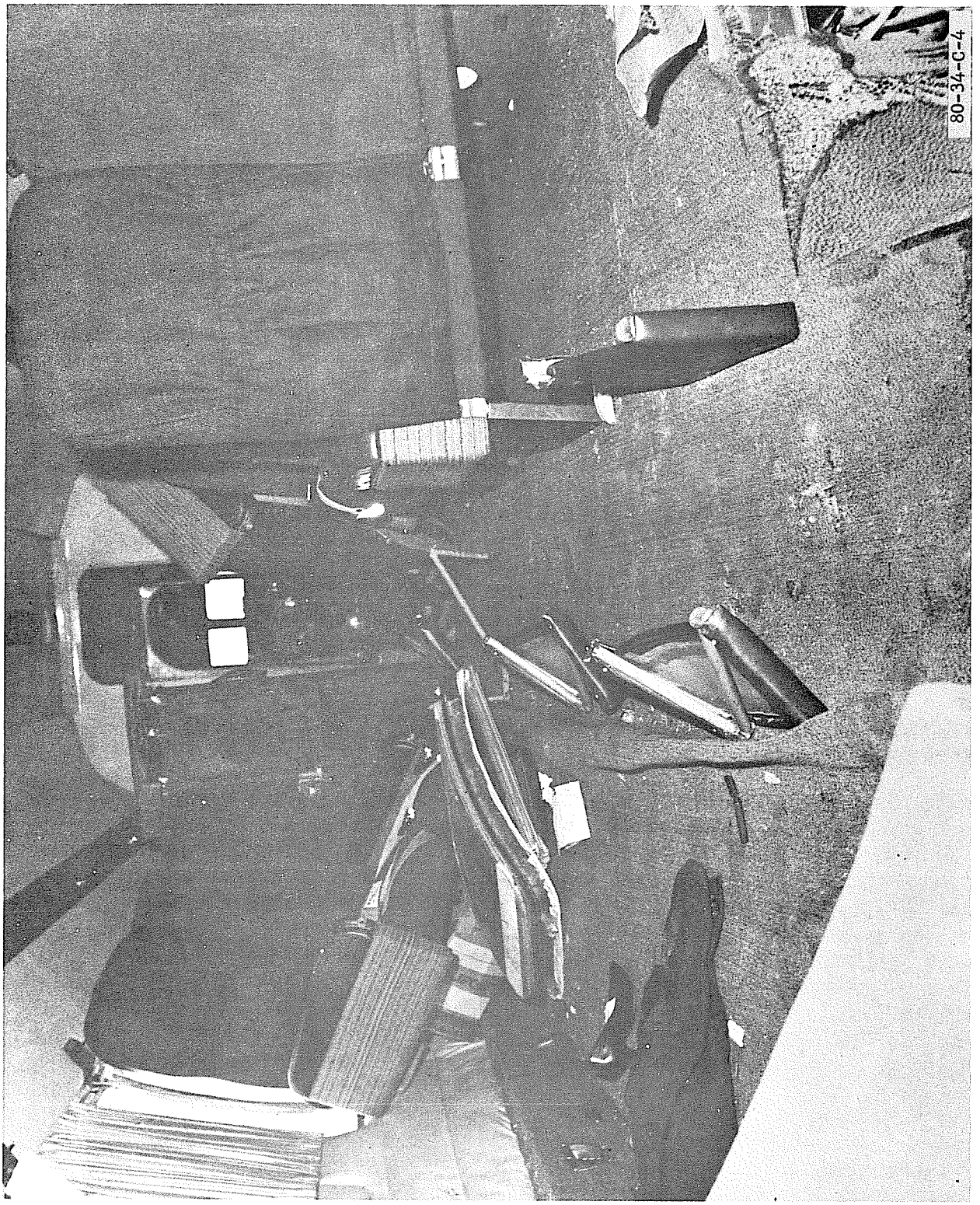


FIGURE C-4. N40412 SEAT FAILURES

their exact location in the fuselage cabin, prior to impact, could not be established; however, the side of the aircraft from which they originated was determined. All seats subject to failure forces were loaded downward and to the right.

Pax Seat Manufacturer(s)/Model(s). Transport Equipment, models TE-303-1 and 303-2 with CAA TSO-25 Piedmont model RS 404126.

Pax Restraint System Performance. All belts and buckles withstood the loads, with the exception of one belt whose friction buckle and bolt were missing. One belt was found unmatched on the seats; however, there was no sign of distress or high loading on this belt.

Pax Restraint System Manufacturer(s)/Model(s). The passenger seatbelts were of a variety of makes and models: (a) Air Associates, model P/N M-7500, TSO-C22; (b) Unknown manufacturer, model 1500A, TSO unknown; and (c) Cummings and Sanders, model M-4090, TSO-22e.

Miscellaneous Cabin Interior Performance. No information available.

OCCUPANT/INJURY INFORMATION

Injuries	Crew	Passengers
Fatal	0	1
Serious	3	27
Minor/None	1	1

All injuries were caused by impact.

Narrative. A Martin 404, operated by Lehigh Acres Development, Inc., experienced engine difficulties and was forced to attempt an emergency landing on a highway. The aircraft skidded along the highway, struck the side of a bridge, and came to rest atop the bridge. Impact with the bridge separated the fuselage between FS 536 and 701. About one-third of the passenger seats and seat frames were broken and detached from the floor. The accident was classified survivable. Data indicate that all seats were subjected to failing forces loaded downward and to the right. Twenty-eight of the twenty-nine passengers on board the aircraft were injured, one fatally. Injuries to the survivors included contusions, abrasions, lacerations, fractured ribs, limbs, vertebrae, and pelvis.

DATE: 09-08-70
LOCATION: Louisville, Kentucky
AIRCRAFT OPERATOR: Delta Air Lines, Inc.
AIRCRAFT DATA:
Make, Model: McDonnell Douglas, DC-9-32
Serial Number: 47108
Registration Number: N3329L

TYPE OF ACCIDENT: Undershoot
PHASE OF OPERATION: Landing
AIRCRAFT DAMAGE: Substantial

Pax Seating Configuration. The aircraft was configured into two classes; the first-class section consisted of 12 double seat units, half on each side of the center aisle for six rows (figure C-5). The coach class consisted of 13 rows of double and triple seat units. The double units were on the left side of the center aisle while the triple seat units were on the right side. All seats were facing forward.

Airframe Deformation/Crash Loads. The fuselage had fractured and buckled between FS 737 and FS 794 (figures C-6, C-7). The fracture paths were practically identical on both sides of the fuselage. It extended from the top fuselage centerline at FS 786 around the fuselage to FS 775 and down to approximately 2 inches above the window line. The fracture at the top fuselage centerline was 27 1/2 inches wide. The fracture then progressed forward to the belt frame at FS 756 and down the window openings. Below the windows, the fracture followed the aft edge of the belt frame at FS 756 and terminated in the vicinity of the inboard flap track fittings and wheel-well door frames.

The top fuselage exterior skin displayed compression buckles forward of the vertical stabilizer between FS 996 and FA 1019. Buckling was also in evidence on both sides of the fuselage exterior skin above the wing area. The buckling on the left side extended between FS 572, 6 inches above the cusp line to 32 inches above the cusp line at FS 592. The buckling on the right side extended between FS 550, 12 inches above the cusp line to 31 inches above the cusp line at FS 579. Light buckling was also in evidence on both sides of the fuselage above the windows between FS 594 and FS 639.

The cabin floor had separated approximately 5 inches at the fracture (figure C-8). The area below this fracture revealed that the shrouds over the auxiliary power unit (APU) fuel line and the left and right engine fuel lines had pulled loose at the bulkhead. However, there was no evidence of fuel leakage. The computed landing weight was 92,000 pounds; the airspeed at touchdown was probably 130-132 knots.

Pax Seat Performance. At the fuselage break, the right side seat track had broken at the forward seat attachment; the attach fitting was out of the track (figure C-9). The left side seat had broken also at the break, and a small section had torn away completely at the aft outboard seat attachment. However, the seat remained attached in the track.

Pax Seat Manufacturer(s)/Model(s). No information.

Pax Restraint System Performance. None reported.

Pax Restraint System Manufacturer(s)/Model(s). No information.

Miscellaneous Cabin Interior Performance. The overhead hatracks had separated at a joint in the area of the break. A passenger's statement indicated that a ceiling panel was down.

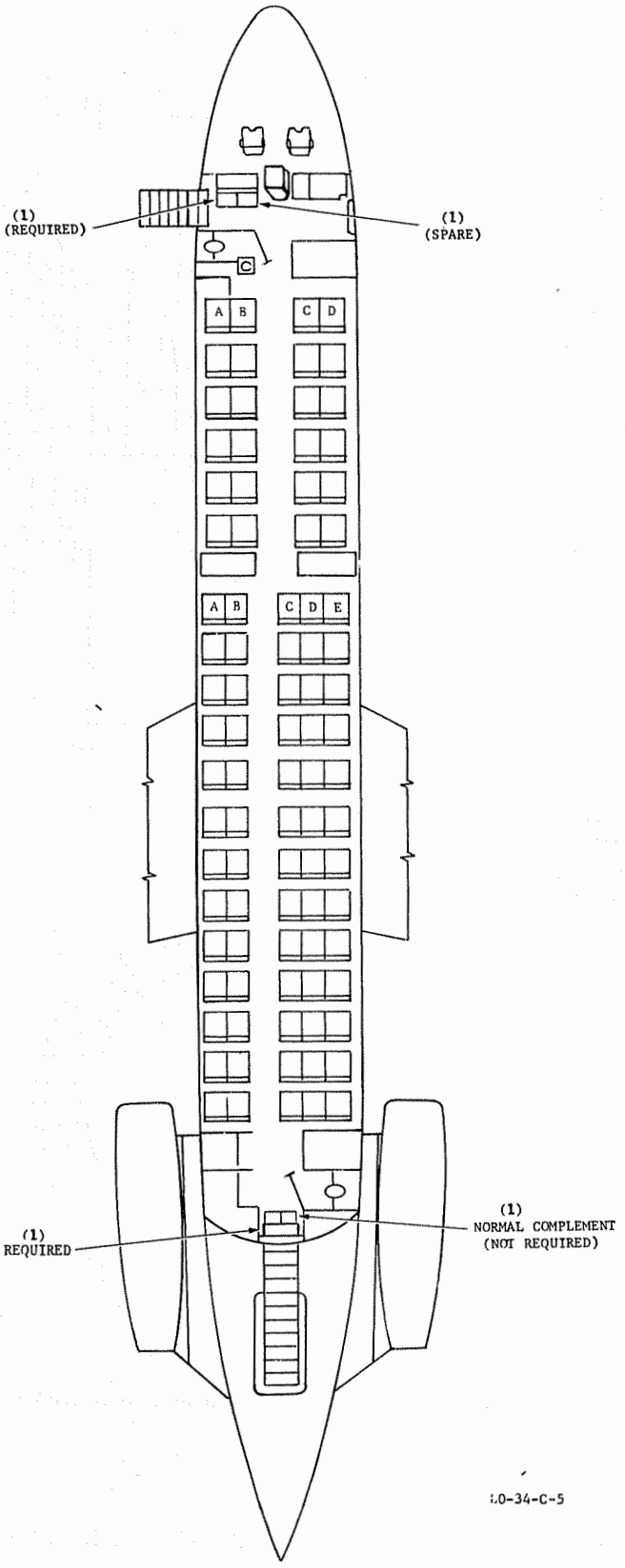
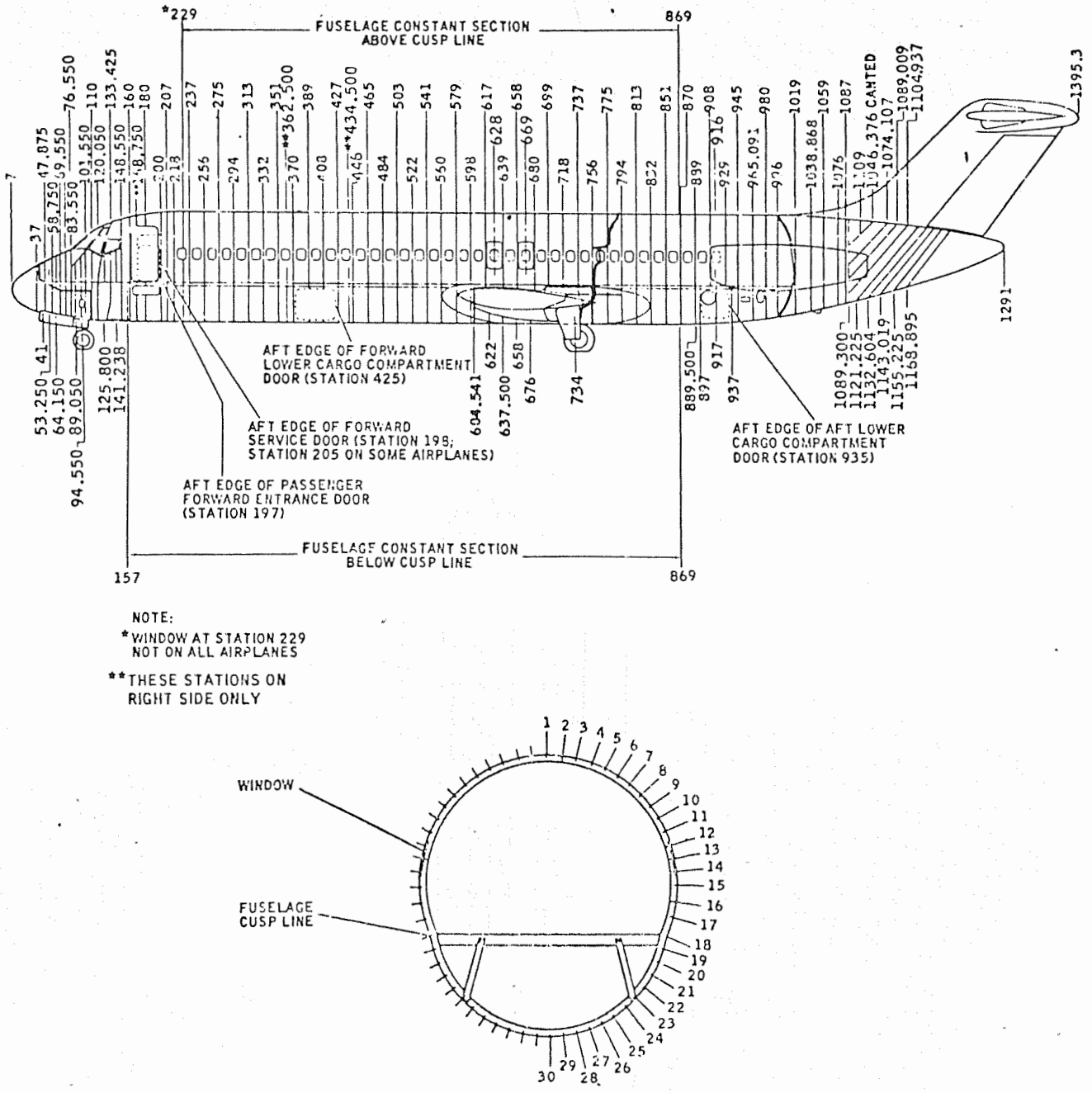


FIGURE C-5. DELTA AIRLINES, INC., DC-9-32, N3329L SEATING CONFIGURATION



FUSELAGE LONGERON NUMBERING ARRANGEMENT 80-34-C-6

FIGURE C-6. DC-9-30 SERIES AIRPLANES FUSELAGE STATION NUMBERS AND LONGERON ARRANGEMENT

FIGURE C-7a. N3329L AIRFRAME DEFORMATION VIEW (Sheet 1 of 2)

FIGURE C-7b. N3329L AIRFRAME DEFORMATION VIEW (Sheet 2 of 2)

FIGURE C-8. N3329L INTERIOR CABIN FLOOR SEPARATION

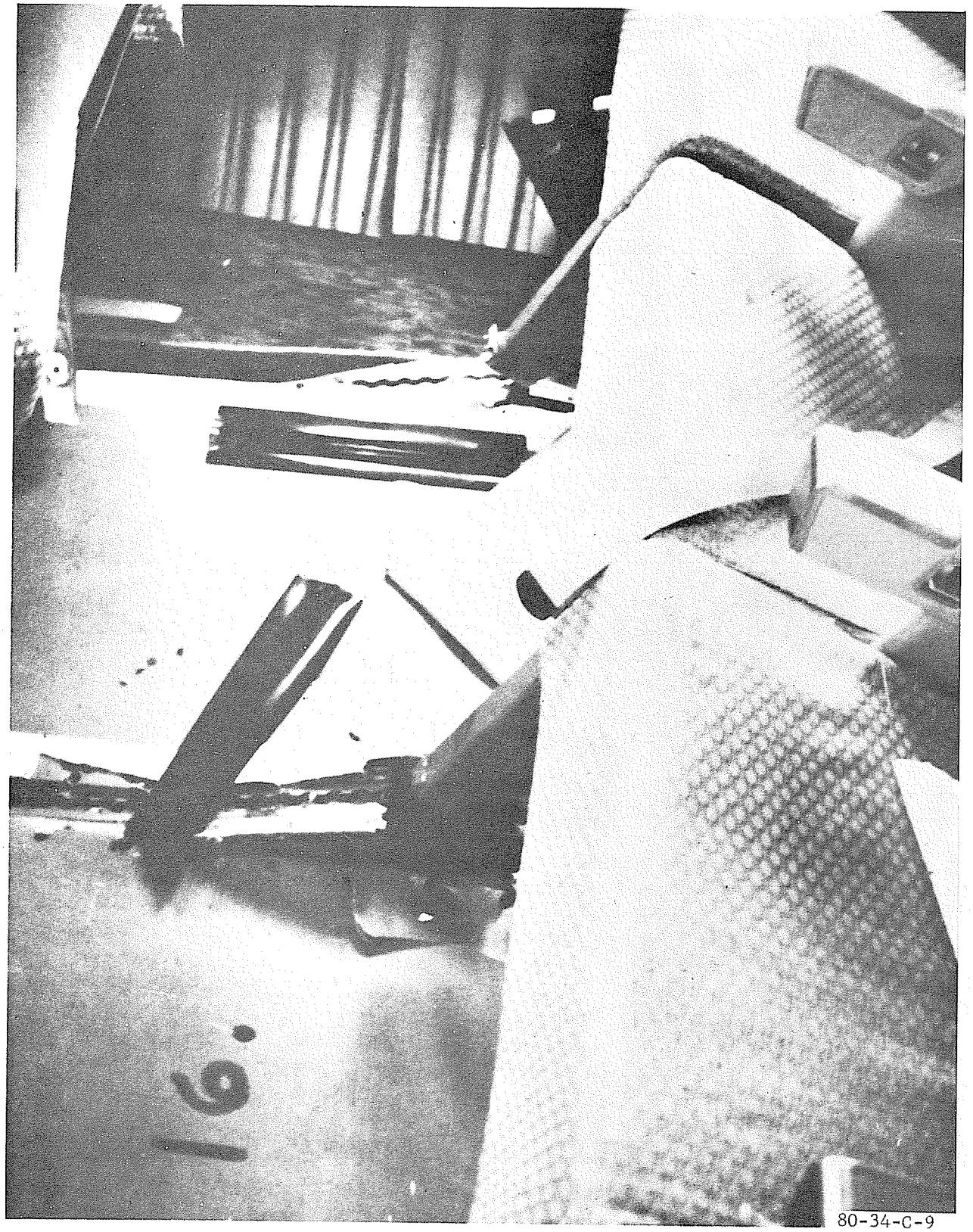


FIGURE C-9. SEAT LEG/SEAT TRACK FAILURES

OCCUPANT/INJURY INFORMATION

Injuries	Crew	Passengers
Fatal	0	0
Serious	0	0
Minor/None	5	89

One flight attendant and 14 passengers received minor injuries which can be attributed to the hard landing.

Narrative. A Delta Air Lines DC-9-32 touched down short of the runway, bounced, and touched down a second time beyond the runway threshold. The aircraft came to rest 4,457 feet from the edge of the runway threshold. It was substantially damaged during the initial ground impact. The aircraft fuselage was fractured circumferentially. Fire damage was in evidence on the seat pressure bulkhead at both the forward and aft lower sides. There were 89 passengers and 5 crewmembers on board.

All occupants evacuated the aircraft, using the emergency exit slides and overwing exits. One crewmember and 14 passengers received minor injuries as a result of the accident.

G - 4

DATE: 09-15-70
LOCATION: JFK International Airport, Jamaica, New York
AIRCRAFT OPERATORS: Alitalia Airlines
AIRCRAFT DATA:
Make, Model: McDonnell Douglas, DC-8-62
Serial Number: 46026
Registration Number: IDIWZ (Italian Registry)
TYPE OF ACCIDENT: Hard landing
PHASE OF OPERATION: Landing
AIRCRAFT DAMAGE: Substantial

Pax Seating Configuration. The first class section in the front of the airplane contained four rows of double seats, numbered 1, 2, 3, and 4 with the seats being labeled A, B, C, and D; seat A being the window seat on the left side of the airplane and seat D being the window seat on the right side of the airplane. Immediately behind this first class section was a section of triple seats. These seats were labeled A, B, C, D, E, and F, seat A being on the left side of the airplane. The first row of these triple seats was row 1 in this section and the last row was row 25. On this aircraft there were no rows 13 and 17.

Airframe Deformation/Crash Loads. The passengers described the initial impact in varying degrees ranging from normal to very hard. They also reported that they were forced to the right side of their seats during initial impact and then were thrown about during the deceleration. The aircraft weight at the time of the accident was approximately 212,245 pounds. The aircraft landed at a point 1,700 feet

beyond the approach end of the runway. It was estimated that the aircraft proceeded down the runway for 2,000 feet before breaking in two places, finally coming to rest in soft soil, at an angle of 90° to the runway. During the deceleration its left wing contacted the runway. The aft section of the aircraft came to rest at a tilt angle of 15° right wing down and 9° tail down. This section measured 23 feet 4 inches from the last seat row to the break area. The fuselage structure was complete from FS 0 to FS 1040. A separation began in the fuselage at FS 1040 and continued downward and aft in an irregular tear to FS 1140. This resulted in a complete separation from the fuselage structure (figure C-10). The lower right side of the fuselage between FS 857 and FS 980 sustained extensive crushing damage. The aft portion of the fuselage from FS 1040 to FS 1830 was complete including the empennage section. This section had sustained minor scraping damage to the lower structure.

Pax Seat Performance. The seats directly in the break area were seat rows 16, 15, and 14 (on this aircraft there were no seat rows 17 and 13). All the seats in row 14 (A, B, C, D, E, and F) were deformed downward and slightly forward (figure C-11). Row 14 was clear of the aircraft with the exception of the seat leg nearest to seat 14F; this seat had a 12-inch piece of the floor track still attached. Seat row 15 (A, B, and C seats) showed no damage; 15 (D, E, F section) showed that the floor track was ripped away from under seat 15D; however, no other damage was apparent. Seat row 16 showed no damage. Seat rows 3 and 4 on the left side of the aircraft were slightly bent to the right (towards the aisle). Seat row 7 was bent drastically to the right, it was rolled away from the left side wall of the aircraft 3 1/2 inches. Seat row 9 was even more drastically bent to the right, it was pulled away from the wall 9 inches. The investigator stated that failures may have been due to decelerative forces. Technical Standard Order requirements for these seats are: 9 g's forward, 4 1/2 g's downward, and 1 1/2 g's sideward loading.

Pax Seat Manufacturer(s)/Model(s). No information available.

Pax Restraint System Performance. No failures reported.

Pax Restraint System Manufacturer(s)/Model(s). Not available in CAMI files.

Miscellaneous Cabin Interior Performance. Oxygen mask at seats 23D, E, and F, and 20D, E, and F were dropped down from their overhead storage in the aft section of the aircraft. A life raft storage compartment opened.

OCCUPANT/INJURY INFORMATION

Injuries	Crew	Passengers
Fatal	0	0
Serious	0	8
Minor/None	10	138

A description of the injuries and seat locations of the eight people still hospitalized 24 hours after the accident follows:

1. Contusions, lumbosacral area — 25E
2. Bad sprain, minor contusions and abrasions — 9C

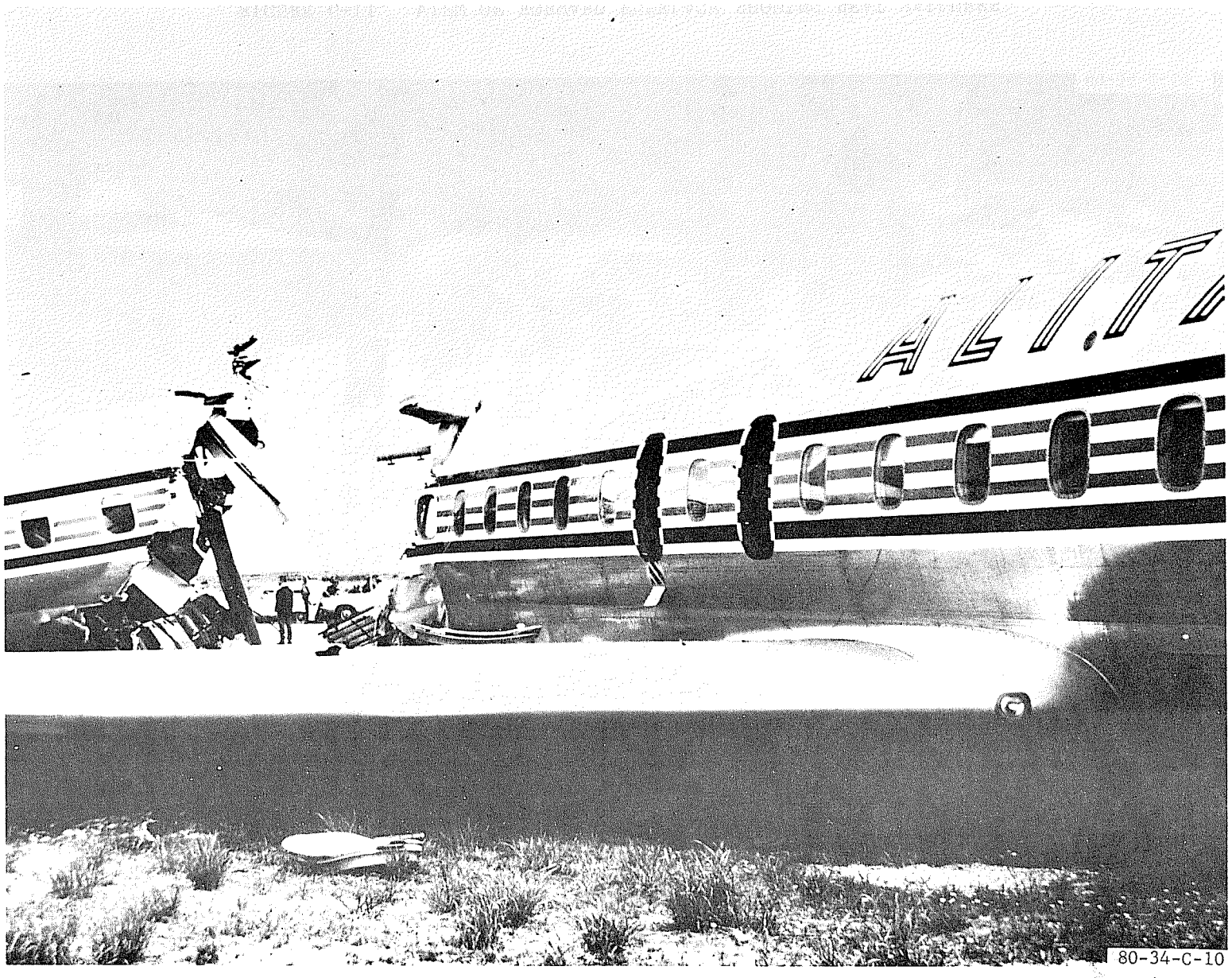


FIGURE C-10. ALITALIA AIRLINES DC-8-62, IDIWZ FUSELAGE DEFORMATION

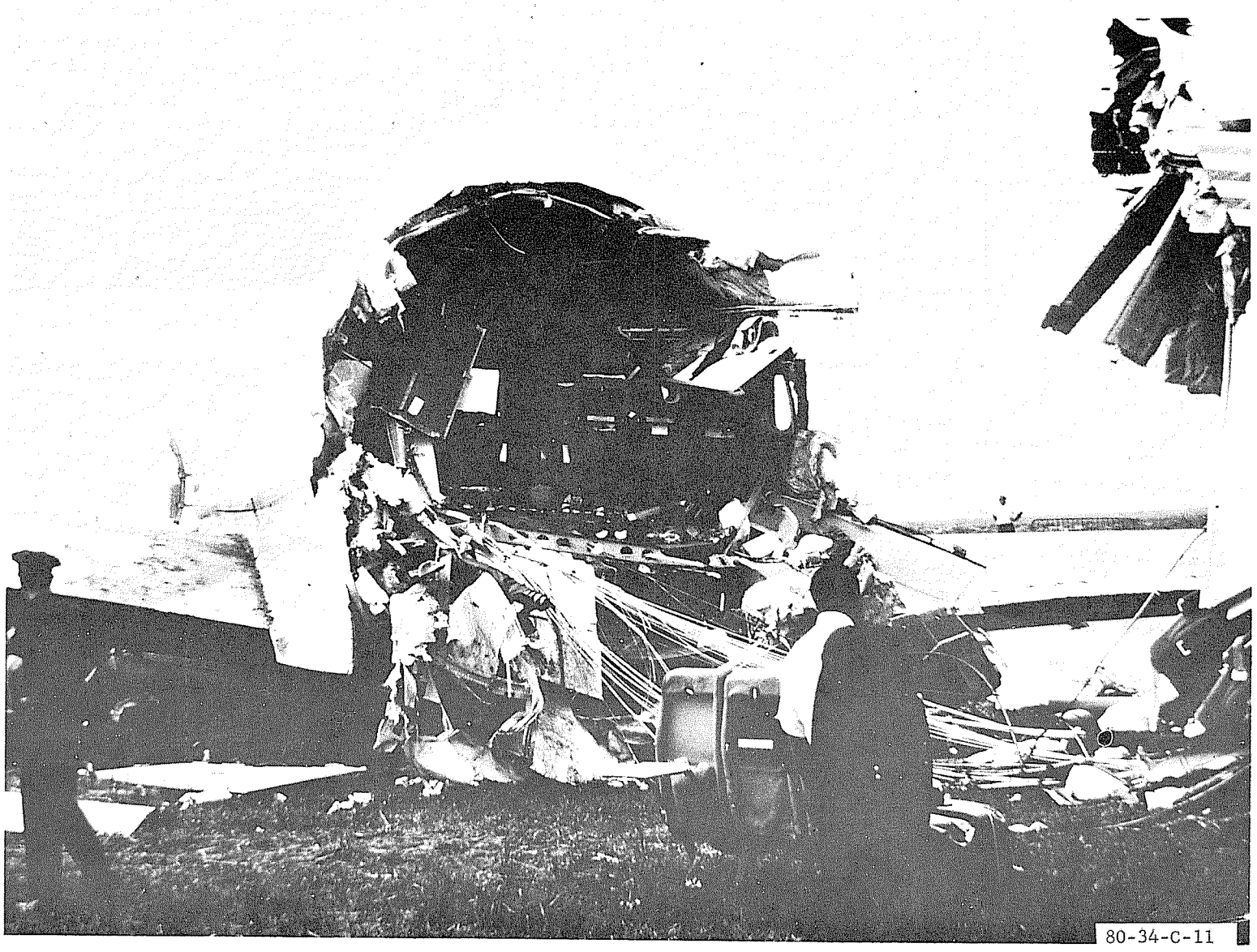


FIGURE C-11. VIEW OF FORWARD FUSELAGE SHOWING SEAT FAILURES

3. Pregnant, observation only; no injury woman or fetus	21D
4. Injured at hand, holding mother (next to her in seat)	8F
5. Had seatbelt fastened loosely, minor contusions and abrasions	8E
6. Minor contusions and abrasions, history of heart disease so held for observation	8D
7. Contusions, right lower ribs possible contusion, kidney contusion, left shoulder	2F
8. Possible coronary held for observation	N/A

Narrative. This DC-8-62 made a hard landing on runway 4R at JFK. The aircraft departed the left side of the runway. As it continued in a divergent path from the runway, it ground-looped to the left before coming to a stop. The fuselage split open in an area just aft of the wing. Three of the engines separated from the aircraft during the landing rollout. The passengers and crewmembers evacuated through the doors and breaks in the fuselage.

G-5

DATE: 11-27-70
LOCATION: Anchorage, Alaska
AIRCRAFT OPERATOR: Capitol International Airways, Inc.
AIRCRAFT DATA:
Make, Model: McDonnell Douglas, DC-8-63F
Serial Number: 46060
Registration Number: N4909C
TYPE OF ACCIDENT: Collided with ditches
PHASE OF OPERATION: Takeoff aborted
AIRCRAFT DAMAGE: Destroyed

Pax Seating Configuration. Rows 1 through 4 have triple seats on the left side of the center aisle only. Rows 5 through 8, 10 through 32, and 34 through 39 are triple seats on both sides of the center aisle. Rows 9 and 33 contain only a double seat unit on each side of the center aisle. Row 40 contains a triple seat unit on the left side and a single seat on the right side of the aisle. Seats in the rows are lettered from A at the left window position through F at the right window position. If a seat in a row is omitted, so is the corresponding alphabetical letter (figure C-12).

Airframe Deformation/Crash Loads. In this accident, there were three distinct and severe impacts reported by the survivors. The first impact involved strong vertical loads in the forward portions of the plane; the second impact produced considerable vertical loads throughout the aircraft; the third impact involved primarily longitudinal decelerative forces. Major structural damage occurred on the second impact (the center section of the plane struck the far side of a drainage ditch) at which time a circumferential fracture occurred near FS 1320. Specifically, seats in rows 36 and 37 broke free. The aft section of the cabin was separated from the forward cabin by approximately 30 feet.

Pax Seat Performance. Final fire damage was so severe that any extensive examination of the aircraft cabin was precluded. However, survivors reported 24 seat failures; 2 units were outside the aircraft. (Seats at rows 36 and 37 were near

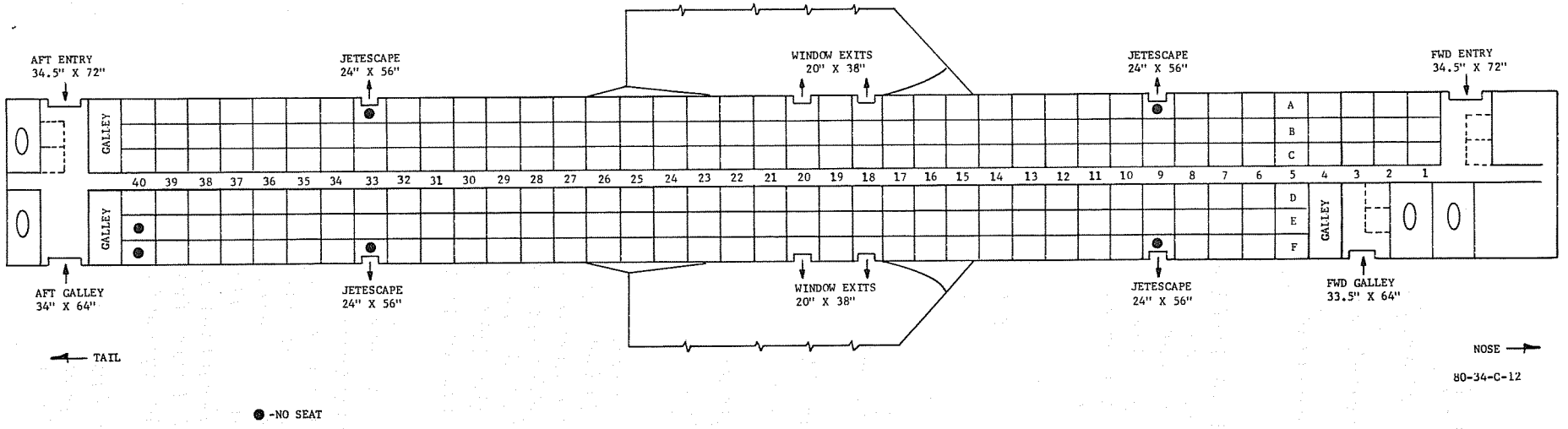


FIGURE C-12. CAPITAL INTERNATIONAL AIRWAYS, INC., DC-9-63F, N4909C SEATING ARRANGEMENT

the circumferential fuselage break. They reportedly failed completely. However, the NTSB Human Factors Factual Report states that passengers from rows 35, 36, and 37 — six passengers total — found themselves in their seats outside the aircraft.) Ten reportedly failed completely (row 3, row 36), and 12 came partially loose (row 1, row 40).

Pax Restraint System Performance. Only one-quarter of the passenger statements indicated whether metal-to-metal or metal-to-fabric seat buckles were used (23 percent had metal-to-fabric). Although one dependent's seatbelt came loose on impact, her husband reported that she had not been able to secure it thoughout the trip.

Pax Seat Manufacturer(s)/Model(s). No data available.

Miscellaneous Cabin Interior Performance. Most of the overhead luggage racks collapsed throughout the aircraft cabin hindering access to the aisle. These racks were secured at the aisle side of the ceiling structure by aluminum straps and at the outboard side to the fuselage structure with hinges at each end of the unit. The aircraft's manufacturer indicated that the design strength was for 9 g's forward and 7 g's down, with a 2 g vertical strength when loaded with 200 pounds. Galley gear came out of both galleys and blocked or partially blocked the exits. One of the two main entry doors on the left side was reported jammed and inoperative. Of the two galley service doors, one was reported blocked and inoperative; the other was partially blocked, although it was opened sufficiently for some passengers to evacuate.

OCCUPANT/INJURY INFORMATION

Injuries	Crew	Passengers
Fatal	1	45
Serious	6	43
Minor/None	3	130

Forty-five passengers and one flight attendant were fatally injured in the accident. One additional passenger died in the hospital less than 24 hours after the accident. The primary cause of death was fire, with evidence of inhalation of combustion products and/or searing of the larynx and trachea. There was no evidence of extremity fractures that would have prevented escape.

Of the fatalities, only two cases of crash injury were demonstrated. The flight attendant had a minor wedge fracture of the first lumbar vertebra and one of the passengers had a tear of the small intestine and a partial tear of the large intestine. There were 34 occupant impact injuries, the most common being fractures of the vertebrae and some fractures of the lower extremities. The passenger in seat 37D (one of those found outside the airplane) suffered a "fracture, closed, vertebra lower lumbar region" (CAMI report). The remaining passengers in rows 35, 36, and 37 sustained burns but received no impact injuries. Investigation of accident files disclosed minor injury to one passenger in row 1; however, this injury was sustained when the passenger jumped to the ground. Since accident investigators were unable to establish the seat locations of all occupants, the condition of the persons in row 40 could not be determined.

Narrative. A Capitol International Airways, Inc., DC-8-63F Military Air Command flight crashed during an attempted takeoff. There were three distinct and severe impacts reported by the occupants. The aircraft broke into three major sections. Fire erupted before the aircraft came to rest and was followed by several explosions.

G-6

DATE: 12-28-70
LOCATION: St. Thomas, Virgin Islands
AIRCRAFT OPERATOR: Trans Caribbean Airways, Inc.
AIRCRAFT DATA:
Make, Model: Boeing, 727-200
Serial Number: 20240
Registration Number: N8790R
TYPE OF ACCIDENT: Gear collapse
PHASE OF OPERATION: Approach, landing
AIRCRAFT DAMAGE: Destroyed

Pax Seating Configuration. The passenger cabin was configured as follows (figure C-13). Forward thrift section; five forward-facing triple seat units on the left side and two forward-facing triple seat units on the right, identified as rows 1 through 5 longitudinally and A through F laterally. First class section; three forward-facing double seat units on the left and right, identified as rows 6 through 8 longitudinally and A through D laterally. Aft thrift section: 16 forward-facing triple seat units on each side of the cabin, identified as rows 9 through 25 longitudinally (row number 13 is omitted) and A through F laterally. Row 26 is a double seat unit on the right, and row 27 is a triple seat unit also on the right.

Airframe Deformation/Crash Loads. The airframe sustained extensive structural damage with two complete fractures (figure C-14) of the fuselage and a fracture of the vertical fin. The fuselage sheared vertically at FS 700 and broke laterally at FS 940. The forward section of the aircraft came to rest atop a 17-foot-high embankment at about a 20° angle to the edge. The aft section, which had broken away at FS 940, had come to rest making a 60° angle with the center section which had dropped approximately 4 to 6 feet below the top of the embankment.

Although the peak magnitude and deceleration of the crash forces cannot be calculated with any degree of accuracy, the total g forces generated by the impact with the hill are estimated to have been in the order of 5-10 g's peak magnitude applied in excess of 30 g's to the longitudinal axis of the aircraft.

Pax Seat Performance. There were 10 reported passenger seat unit failures (figure C-14). Passenger accounts and the examination of the seat found in the wreckage area indicate there were lateral failures that occurred as a result of the sideward impact forces generated when the aircraft came to rest against the hill. The impact angle in relation to the longitudinal axis of the aircraft was in excess of 30°.

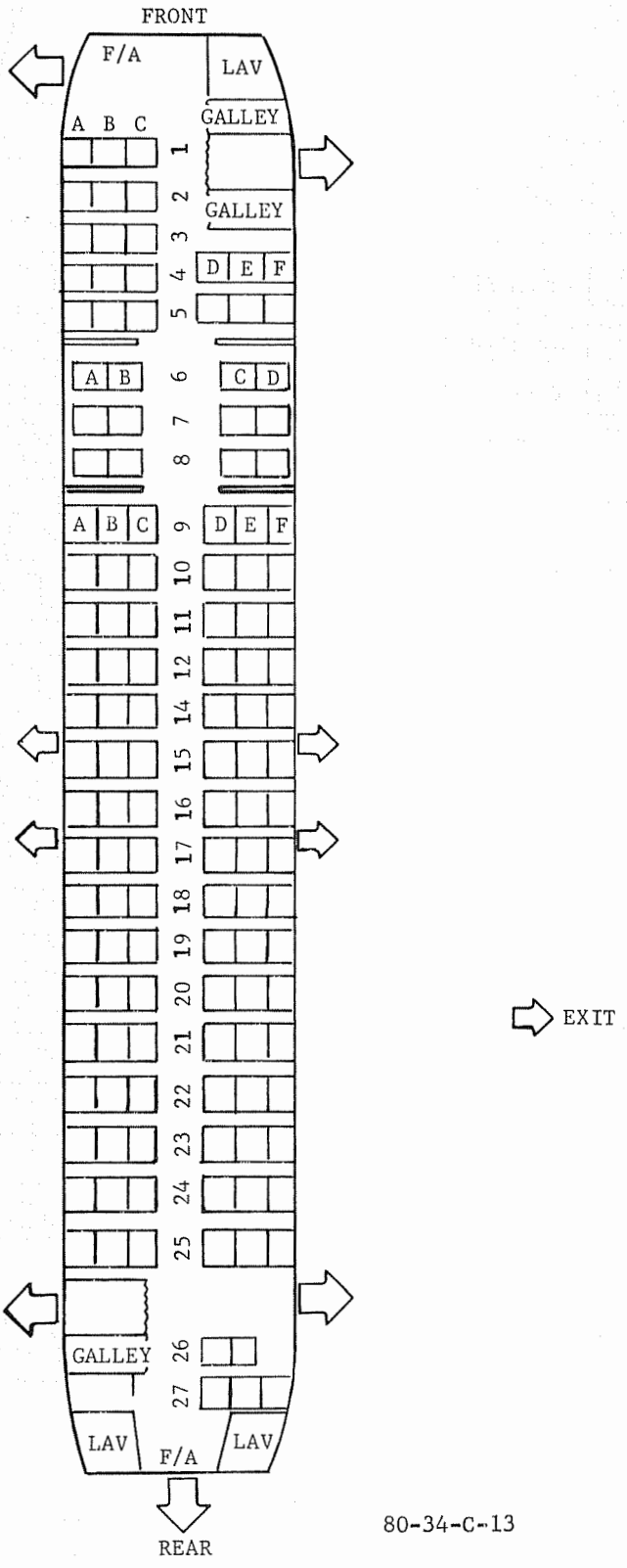


FIGURE C-13. TRANS CARIBBEAN AIRWAYS, INC., BOEING 727-200, N8790R SEATING CONFIGURATION

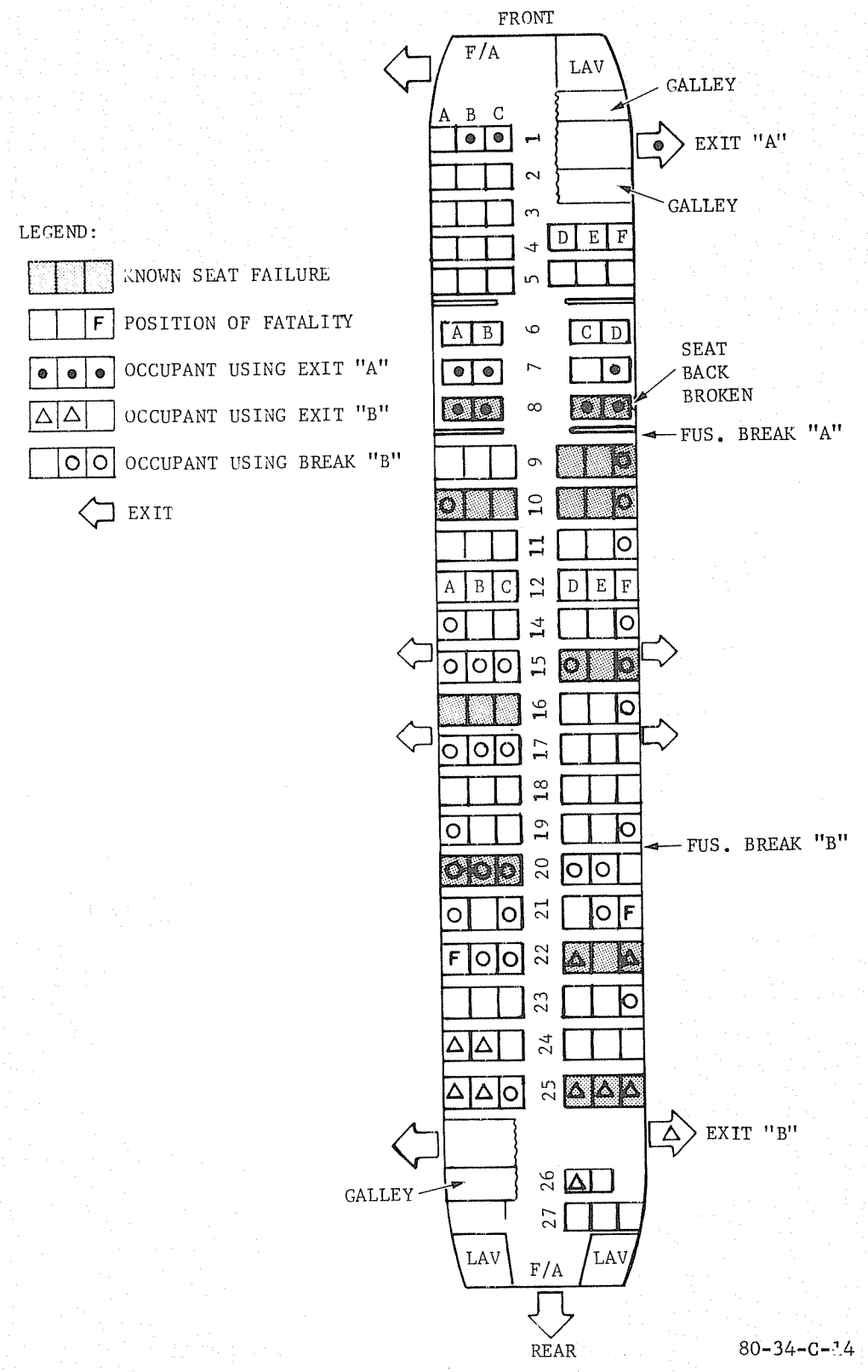


FIGURE C-14. SCHEMATIC VIEW OF N8790R ILLUSTRATING FUSELAGE BREAKS, SEAT FAILURES, AND OCCUPANT EVACUATION ROUTES

Seat failures based on referenced witness statements were as follows:

Row	Seat	Remarks
8	A,B,C,D	torn loose from floor; C, D, seat back broken
9	D,E,F	torn loose from floor; located at vertical separation of fuselage
10	A,B,C,D E,F	torn loose from floor; located at vertical separation of fuselage
15	D,E,F	torn loose
16	A,B,C	torn loose, empty unit
20	A,B,C	torn loose, unit aft of fuselage break
22	D,E,F	torn loose
25	D,E,F	torn loose

Pax Seat Manufacturer(s)/Model(s). Hardman Tool and Engineering Company, model unknown. Conformance to CFR 14 Part 25.785; upward 2.0 g, forward 9.0 g, sideward 1.5 g, downward 4.5 g.

Pax Restraint System Performance. No restraint system failures reported in accident data.

Pax Restraint System Manufacturer(s)/Model(s). No data available.

Miscellaneous Cabin Interior Performance. According to passenger statements the main cabin entry door (forward left side) was blocked by the plastic rain shield, which failed and fell in front of the exit. The class divider between first and thrift sections (rows 8-9) collapsed, blocking vision and access between those two sections. Several occupants reported that on the second touchdown, oxygen masks and other loose articles in the cabin fell down. Flight attendants stated that galley equipment littered the floor in the galley area.

OCCUPANT/INJURY INFORMATION

Injuries	Crew	Passengers
Fatal	0	2
Serious	2	9
Minor/None	5	37

The two fatalities were attributed to fire. According to the NTSB Human Factors report, one fatality reportedly was trapped by debris between two seats in row 22. While the body of the other fatality was recovered, free from its seat on the ground in the area of the aft break in the fuselage. Also the NTSB reported that the major occupant injuries were; three spinal injuries, one leg fracture (which occurred during evacuation), five other types of bone fractures, one concussion, one shoulder dislocation, one spleen rupture, and six contusions. Evidence suggests these injuries (with the one exception above) occurred at impact.

Narrative. A Boeing 727 touchdown was hard: the aircraft bounced on landing, bounced again, yawed to the right, slid out of the airport boundary, and came to

rest on the slope of a hill. In the process of coming to a stop, the aircraft fuselage broke into three major sections. A fire started in the left wing root area and consumed the entire cabin and cockpit area to such an extent that examination of the environmental structure was precluded. Based on witness statements there were 28 seat failures (10 units). Only one right triple seat unit was recovered. Passenger accounts and examination of the seat found in the wreckage area indicated that the seats failed to the left and forward on impact with the hill. The impact angle, in relation to the longitudinal axis of the aircraft, was in excess of 30°. The total g forces generated by the impact with the hill were estimated by the NTSB to have been in the order of 5 to 10 g's peak magnitude applied in excess of 30° to the longitudinal axis of the aircraft. There was no reference in the literature to restraint system failures. A majority of the occupant survivors had seatbelt bruises on the hips and abdomen. One of the two fatalities reported was trapped by debris between two seats; the cause of death for both fatalities was attributed to burns.

G-7

DATE: 06-07-71
LOCATION: New Haven, Connecticut
AIRCARFT OPERATOR: Allegheny Airlines, Inc.
AIRCRAFT DATA:
Make, Model: Allison Prop Jet Convair 340/440
Serial Number: 384
Registration Number: N5832
TYPE OF ACCIDENT: Landed short
PHASE OF OPERATION: Approach, landing
AIRCRAFT DAMAGE: Destroyed

Pax Seating Configuration. No data available.

Airframe Deformation/Crash Loads. The airplane struck three adjoining buildings located 4,890 feet from the threshold of runway 02 (510 feet to the right of the centerline). The fuselage came to rest 270 feet from the initial impact. The forward section of the fuselage which contained the cockpit was broken open and sustained massive damage due to the impact. The remainder of the fuselage, with the exception of a circumferential fracture and separation at FS 790, remained in one section, but sustained almost total destruction by fire.

Pax Seat Performance. Reports indicate no passenger seat failure.

Pax Seat Manufacturer(s)/Model(s). No information available.

Pax Restraint System Performance. No failures reported.

Pax Restraint System Manufacturer(s)/Model(s. Not available in CAMI files.

Miscellaneous Cabin Interior Performance. Could not be determined because of extensive fire damage.

OCCUPANT/INJURY INFORMATION

Injuries	Crew	Passengers
Fatal	2	28
Serious	1	2
Minor/None	0	0

The surviving cockpit crewmember and the fatally injured crewmembers sustained severe impact injuries. In addition, although the official cause of death was chemical asphyxiation, the flight attendant sustained fractures of the upper posterior rib, fracture of the left clavicle, and fracture of the third thoracic vertebra. All of the passengers died of chemical asphyxiation and thermal injury or a combination of both.

Narrative. The Allegheny Prop jet landed in some buildings 4,890 feet from the threshold and 510 feet to the right of the centerline. According to the NTSB, this was a survivable accident, with the exception of the cockpit area, the fuselage structure remained sufficiently intact. When the fire was extinguished, 15 of the 27 nonsurviving passengers were found near the rear service door. The others were found near the center and forward cabin section (figure C-15).

DATE: 03-03-72
LOCATION: Albany, New York
AIRCRAFT OPERATOR: Mohawk Airlines, Inc.
AIRCRAFT DATA:
Make, Model: Fairchild Hiller, FH-227B
Serial Number: 541
Registration Number: N7818M
TYPE OF ACCIDENT: Propeller failure, collided with residence
PHASE OF OPERATION: Landing, final approach
AIRCRAFT DAMAGE: Destroyed

Pax Seating Configuration. The passenger cabin contained a single class, consisting of 11 rows of double seat units, one unit on each side of the center aisle. All seat units except those in row 6 were facing forward. The four seat units in rows 5 and 6 were bolted together with those in row 6 facing aft. The seating configuration is illustrated in figure C-16.

Airframe Deformation/Crash Loads. The aircraft fuselage came to rest tilted approximately 20° to the left of the upright position. The bottom of the fuselage was demolished. The passenger compartment floor was fractured longitudinally from the aft door to the wing support structure and forward of the fuselage support structure to the cockpit bulkhead. The floor structure, to which the seat units were attached, was deformed upward on each side of the longitudinal structure. The top of the fuselage was compressed downward and many fuselage side panels had separated. Fuselage integrity and occupiable cabin space was compromised to the

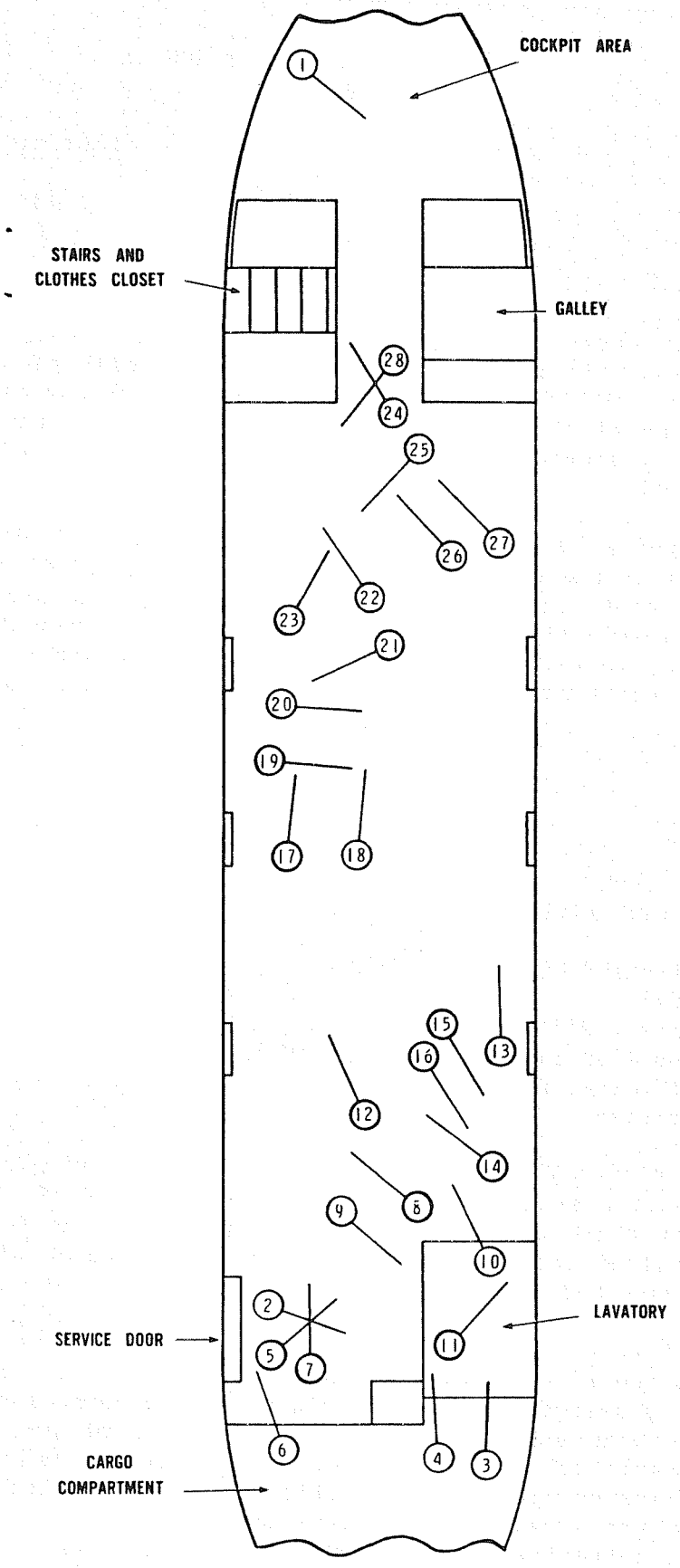


FIGURE C-15. FATALITY LOCATIONS, ALLEGHENY AIRLINES, N5832

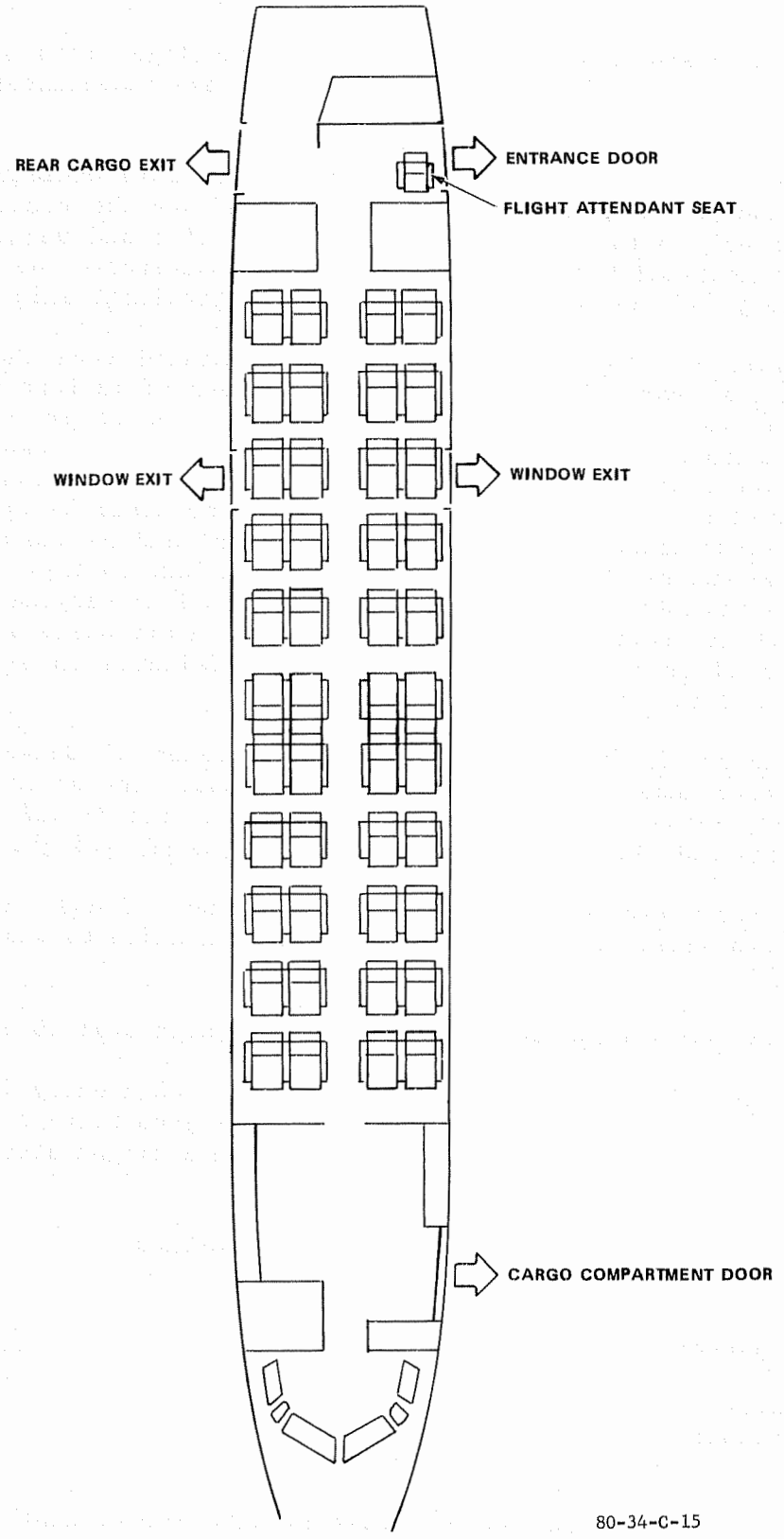


FIGURE C-16. MOHAWK AIRLINES, INC., FH-227B, N7818M SEATING ARRANGEMENT

extent of severe elliptical deformation in the fuselage cross section. The occupiable area from the galley area aft to the baggage compartment was essentially intact.

NTSB calculation of the mean g forces generated in this accident indicated that the following ranges of g loads most likely acted on the occupants during this crash: longitudinal 15 to 25 g's; lateral 5 to 10 g's; and vertical 5 to 15 g's. The NTSB also calculated that, assuming a 5° noseup attitude, the crash force angle was approximately 10° upward relative to the longitudinal axis of the aircraft.

Pax Seat Performance. Most of the seats had separated from the aircraft floor. Examination of the seats showed that varying degrees of failure occurred. In all cases, the front legs exhibited either compressive collapse or complete failure at a point just below the leg-to-chassis attachments, while bending and tension failure were illustrated in the rear leg supports. The force components were in a left and downward direction. Additional failures occurred by fracture of the lip of the front leg-to-track studs (minimum five cases) and by the pulling out of the front leg of the entire stud and its shank (minimum four cases). The frames of all but three seats were intact. Seatbacks were deformed in varying degrees with four detached from their frames. Some armrests had broken off while others were bent to the left. The floor track extrusions exhibited failures in several places from excessive side and forward loading.

Pax Seat Manufacturer(s)/Model(s). Aerospace Division of Universal Oil Products Company, Aerotherm model 691-2 conforming to TSO-C39. The seats were designed per drawing P 691-2, known as the Zephyr II Tourist Seat for FH-227 and were marked to be able to withstand the following loads: 7.5 g's down, 4.5 g's up, 3.0 g's side.

Pax Restraint System Performance. All seatbelts were found intact and properly attached. In two cases, the seatbelts were cut by a knife to facilitate removal of the occupant.

Pax Restraint System Manufacturer(s)/Model(s). No data available.

Miscellaneous Cabin Interior Performance. The main cabin entry door was pinned due to structural deformation of the door opening. Carry-on baggage tiedown webbing and the side partition of the baggage rack collapsed on a flight attendant.

OCCUPANT/INJURY INFORMATION

Injuries	Crew	Passengers
Fatal	2	14
Serious	1	31
Minor/None	0	0

NOTE: Injuries to the 31 passenger survivors were predominantly spinal and lower extremity fractures. The fatally injured sustained crushed rib cage injuries and lower extremity fractures.

Narrative. While on final approach, a Mohawk Airlines FH-227B crashed into an occupied house. The aircraft struck the residence near ground level and came

to rest with the passenger section almost completely buried within and under wreckage of the house. There was no fire or explosion. The bottom of the fuselage was demolished. The passenger cabin floor had fractured longitudinally; most seats had separated from the cabin floor. Of the 45 passengers, 31 survived the impact.

G-9

DATE: 12-08-72
LOCATION: Chicago, Illinois (Midway Airport)
AIRCRAFT OPERATOR: United Air Lines, Inc.
AIRCRAFT DATA:
Make, Model: Boeing 737-222
Serial Number: 19069
Registration Number: N9031U
TYPE OF ACCIDENT: Stall
PHASE OF OPERATION: Final approach, landing
AIRCRAFT DAMAGE: Destroyed

Pax Seating Configuration. The aircraft had 87 passenger seats; 20 in the first class section and 67 in the coach section. The first class section had five double seat rows on each side of the center aisle. The right side of the coach section had 11 rows of triple seat units and the left side had 10 rows of triple seat units plus two rows of double seat units in the aftmost rows. There was a main cabin door and a galley service door in the forward section, and a main cabin door and a galley service door in the aft section.

Airframe Deformation/Crash Loads. The aircraft was sinking in a nose-high attitude when it contacted electrical powerlines. It continued to sink and in the final stages of deceleration, four houses and two garages were extensively damaged. Four houses and one garage were destroyed by aircraft impact and postimpact ground fire. Several trees and two telephone poles were broken by the impact. The damage was limited to a swath 90 feet wide and 500 feet long. During the initial contacts, portions of the aircraft, which was reportedly still nose-high and slightly right wing low, struck several houses. The aircraft crashed into three more houses, finally sliding to a hard stop with the nose of the aircraft lodged in the basement of the fourth house (figure C-17). Passengers reported a pull to the left. There were two sizeable breaks in the right side of the fuselage (forward of row 6 and between seat rows 9 and 10). Most survivors described the decelerative force as one which threw them forward against their seatbelts hard enough to badly bruise and/or cut their lower abdomen and hips.

Pax Seat Performance. The passenger survivors were seated in rows 8 through 12 and 16 and 17. With the exception of two passengers who could not remember, all survivors stated that their seatbelts remained intact and most reported bruises to attest to this fact. Survivors on the right side of row 8, 10, and 11 had difficulty releasing their respective seatbelts because their seats, though intact, had come partially loose and were leaning forward, consequently semisuspending the occupants by their seatbelts. There was no floor in front of seat 8F, so the occupant had to step on a cable to relieve pressure before his seatbelt buckle would release. No first class seats were recovered intact. All seats received some degree of fire damage. Typical seat damage and track deformation are illustrated in figures C-18 and C-19.

FIGURE C-17. UNITED AIRLINES BOEING 737-222, N9031V ACCIDENT SITE

FIGURE C-18. N9031U SEAT DEFORMATION AND FIRE DAMAGE

FIGURE C-19. N9031U SEAT TRACK DEFORMATION

Pax Seat Manufacturer(s)/Model(s). Not given in available reports.

Pax Restraint System Performance. No restraint failures reported in this accident.

Pax Restraint System Manufacturer(s)/Model(s). Not given in available reports.

Miscellaneous Cabin Interior Performance.

Passengers reported numerous loose objects were tossed about the cabin. Ceiling panels and overhead bins reportedly fell into the aisle. Survivors also reported that all cabin lights went out after impact; no lights were visible during evacuation.

OCCUPANT/INJURY INFORMATION

Injuries	Crew	Passengers
Fatal	3	42
Serious	1	9
Minor/None	2	4

Thirty-four of the passenger fatalities could be attributed to burns and eight to trauma. The serious injuries were all impact injuries. CAMI and NTSB data differ concerning the number of fatalities versus the number of serious injuries. CAMI data were used because of pertinent autopsy reports.

Narrative. The aircraft crashed while making a nonprecision-instrument approach to runway 31L at the Chicago Midway Airport. The accident occurred 1.5 nautical miles southeast of the end of runway 31L. The aircraft crashed and was destroyed by impact and subsequent fire.

G-10

DATE: 12-20-72
LOCATION: Chicago O'Hare International Airport, Illinois
AIRCRAFT OPERATOR: North Central Airlines, Inc.
AIRCRAFT DATA:
Make, Model: McDonnell Douglas, DC-9-31
Serial Number: 47159
Registration Number: N954N
TYPE OF ACCIDENT: Collision with another aircraft which was on the ground
PHASE OF OPERATION: Takeoff
AIRCRAFT DAMAGE: Destroyed (by fire)

Pax Seating Configuration. The passenger compartment consisted of one class with 20 rows of seats. Each row had a double seat unit to the left of the aisle and a triple seat unit to the right of the aisle. There was a main cabin door located on the front left side of the aircraft and a galley service door opposite on the right side of the aircraft. There were two window exits on either side of the aircraft.

The tail section was fitted with a jettisonable tail cone for use in emergency egress, and an airstair for normal deplaning. There were two lavatories; one on either side of the aisle in the rear of the aircraft. There were two galley units installed; both units were in the forward right corner of the cabin.

Airframe Deformation/Crash Loads. The DC-9 was taking off on runway 27L, and a CV-880 was taxiing across the runway when the collision occurred (figure C-20). The DC-9 came to a stop on runway 32L on a magnetic heading of 352°, approximately 900 feet northwest of the intersection of runways 32L and 27L (figure C-20). Gouge and skid marks indicate that the DC-9 left runway 27L and made a curved path to the point where it stopped on runway 32L. The right main landing gear was torn off and the nose gear and left main landing gear had failed rearward; however, the DC-9 came to rest in an upright attitude. Passengers described the collision as being a slight bump. The subsequent touchdown of the aircraft and the crash slide were described as being comparable to normal landings. Deceleration forces were described as very slight with some side-to-side motion. None of the passengers reported being thrown forward into the seat in front of them.

Pax Seat Performance. All the seats were completely burned and only the frames remained intact. Only one seat may have received impact damage. The damaged seat was located in the rear of the cabin on the left side of aircraft.

Passenger Seats	Manufacturer	Model No.
Triple Units	P.L. Porter & Co.	SL-6300-2-K
Double Units	P.L. Porter & Co.	SL-6300-2-F

Pax Restraint System Performance. There were no restraint system failures in this accident.

Pax Restraint System Manufacturer(s)/Model(s). Passenger Seatbelts, Cummings & Sanders, model 9600-3.

Miscellaneous Cabin Interior Performance. The forward flight attendant seat failed to retract against the bulkhead and hampered movement ot the exit. There is very little in the rest of the passenger's statements to indicate any other significant debris or obstacles to evacuation.

OCCUPANT/INJURY INFORMATION

Injuries	Crew	Passengers
Fatal	0	10
Serious	0	9
Minor/None	4	22

Nineteen of the passengers received injuries ranging from serious to minor. Ten of the passengers suffered smoke inhalation and burns. The rest of the injured passengers received various injuries, including back sprains and ankle sprains. One of the seriously injured passengers died in the hospital 5 days after the accident. None of the fatally injured passengers received any impact (traumatic) injuries; all the fatalities were attributed to smoke inhalation or burns or a combination.

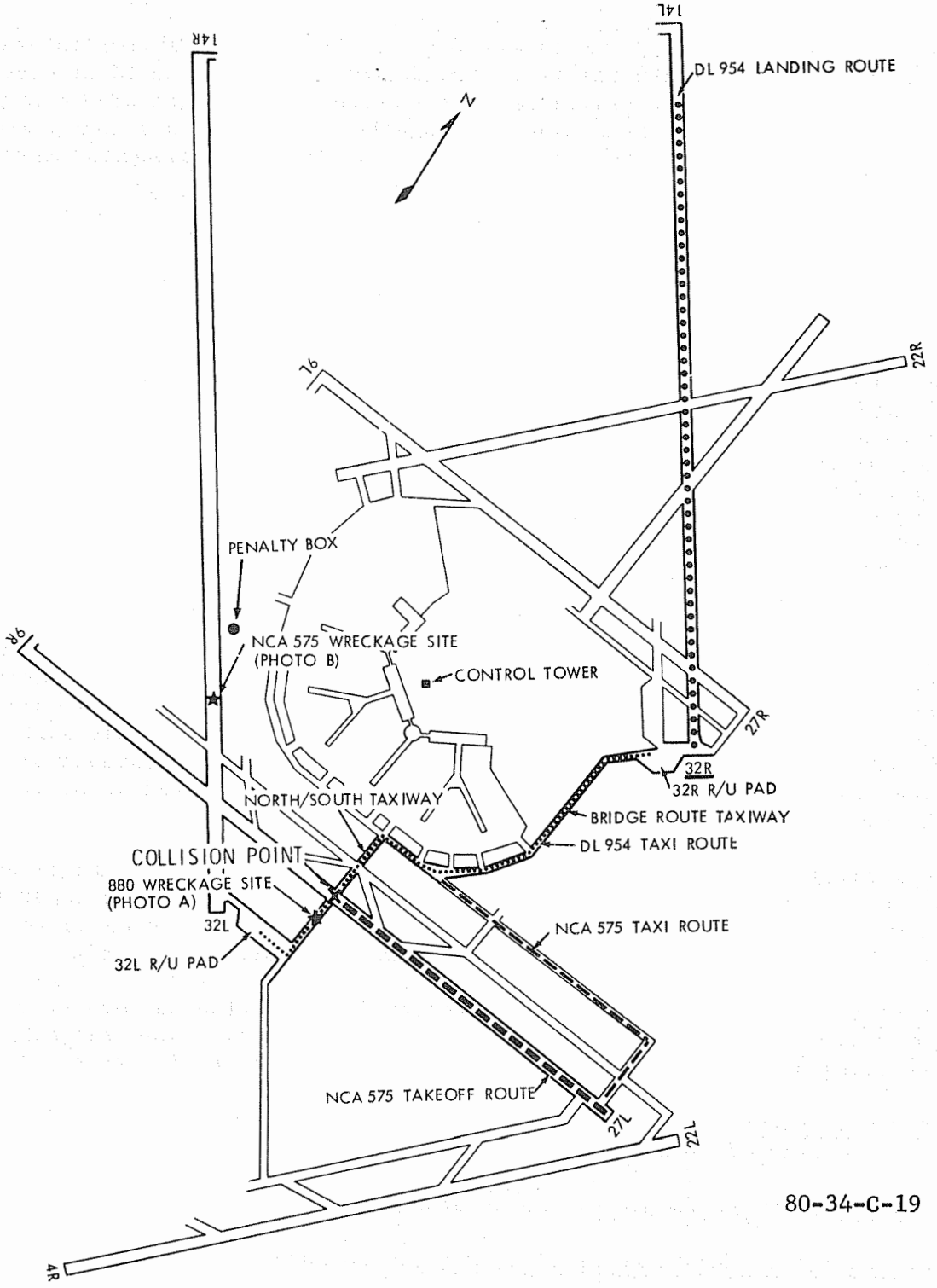


FIGURE C-20. OVERVIEW OF LANDING/TAXI/TAKEOFF ROUTES, CHICAGO O'HARE INTERNATIONAL AIRPORT, N954N ACCIDENT SITE

Narrative. While taking off on runway 27L at the Chicago O'Hare International Airport, a DC-9 collided with the tail of a Convair 880. The accident occurred at the intersection of the north-south taxiway and runway 27L. The DC-9 continued on for 300 yards before coming to a stop, was engulfed in flames, and subsequently was gutted by fire. The four crewmembers and 31 of the 41 passengers successfully evacuated the aircraft.

G-11

DATE: 12-29-72
LOCATION: Miami, Florida
AIRCRAFT OPERATOR: Eastern Air Lines, Inc.
AIRCRAFT DATA:
Make, Model: Lockheed, L-1011
Serial Number: 193A-1011
Registration Number: N310EA
TYPE OF ACCIDENT: Collision with ground/water
PHASE OF OPERATION: In flight, uncontrolled descent
AIRCRAFT DAMAGE: Destroyed

Pax Seating Configuration. First class section contained five rows (1-5) of three double seat units each. Tourist class section was divided into three sections: the first section contained six rows of four double seat units each; the second section contained 15 rows of four double seat units each and two double seat units on each side of the galley lift; and the third section consisted of three rows of four double seat units. All seats in the tourist class were lettered A, B, C, D, E, F, G, and H from left to right; all seats faced forward.

Airframe Deformation/Crash Loads. The aircraft disintegrated to a large extent on impact. The cockpit and forward lounge section of the aircraft were separated from the rest of the fuselage. The walls and ceiling were torn away up to the cockpit entrance. Only fragmented sections of the passenger cabin were found.

Pax Seat Performance. Even though the aircraft disintegrated on impact, many seats and seat tiedown structures remained relatively intact. The majority of the passenger seats had failed at leg attachment points and at basic frame attachments.

Pax Seat Manufacturer(s)/Model(s). Burns Aero Seat Company — stressed and tested to the requirements of 14 CFR 25.785.

Pax Restraint System Performance. No information available.

Pax Restraint System Manufacturer(s)/Model(s). No information available.

Miscellaneous Cabin Interior Performance. No data available.

OCCUPANT/INJURY INFORMATION

Injuries	Crew	Passengers
Fatal	5	94
Serious	8	50*
Minor/None	0	17

*Includes two persons who died as a result of their injuries, but who survived for a period of eight days or longer after the accident.

The surviving occupants exhibited various severe injuries, the most prevalent were lower extremity fractures. Other prevalent injuries were fractures of the ribs, the spine and the pelvis. At least 14 persons sustained various degrees of burns.

Narrative. A Lockheed L-1011 operated by Eastern Air Lines, Inc., crashed while turning towards final approach to Miami International Airport. The aircraft disintegrated to a large extent, but many seats and seat tiedown structures remained relatively intact. The aircraft impacted tail first and cartwheeled to a stop. Failures of seat structures indicated that rearward forces were generated in the crash.

DATE: 06-23-73
LOCATION: Jamaica, New York
AIRCRAFT OPERATOR: Loftleidir Icelandic Airlines, Inc.
AIRCRAFT DATA:
Make, Model: McDonnell Douglas, DC-8-61F
Serial Number: Not available in files
Registration Number: N8960T
TYPE OF ACCIDENT: Hard Landing
PHASE OF OPERATION: Landing
AIRCRAFT DAMAGE: Substantial

Pax Seating Configuration. The passenger compartment was a one class configuration with 34 rows of triple seat units on either side of a center aisle. The rear of the cabin had two galleys and four restrooms. The passenger compartment was configured with two entry doors at the rear of the cabin, two window exits on either side of the cabin in the wing area, and two floor-level jet escapes on each side of the cabin — one forward of the wing leading edge, and one just aft of its trailing edge. There were also entry doors on either side in the forward part of the compartment.

Airframe Deformation/Crash Loads. The pilot of the DC-8 was executing an Instrument Landing System approach to runway 31R when the aircraft ground spoilers were inadvertently deployed at an altitude of approximately 30 feet. The spoiler deployment resulted in the aircraft's sustaining a hard landing. The aircraft struck the ground tail first, 20 feet short of the displaced runway threshold on the centerline of runway 31R. From that point, the aircraft slid and stopped

6,048 feet farther down the runway. The No. 1 engine separated from the aircraft 720 feet from the initial point of impact.

Compression caused buckling just inboard of the No. 2 and No. 3 pylons and on the underside of the fuselage from the center of the lower aft cargo door rearward about 12 feet. Stringers and formers were also scraped and damaged. Both main landing gears collapsed. The entire lower skin of the fuselage, from the right rear cargo door aft, including the tail skid, was severely scraped and buckled. The nose landing gear remained intact and without visible damage. The main landing gear wheels did not fracture.

Pax Seat Performance. Two rows of seats on the right side in the rear of the cabin failed in a rearward and downward manner. (The aft legs of four passenger seats collapsed.)

Pax Seat Manufacturer(s)/Model(s). Not given in available reports.

Pax Restraint System Performance. No failures reported.

Pax Restraint System Manufacturer(s)/Model(s). Not applicable and not given in available reports.

Miscellaneous Cabin Interior Performance. The interior of the cabin was extensively damaged by the hard landing. The overhead bins, with the passenger service unit panels attached, split longitudinally and essentially isolated the passengers in the window seats from the rest of the aircraft. In the right aft portion of the aircraft (the section with the seat failures), two ceiling-mounted liferafts fell into the aisle and constituted egress obstacles. Due to impact, the right aft galley door slide pack came loose from the door and girt bar attach fittings. An aft flight attendant seat reportedly failed at impact in a downward manner.

OCCUPANT/INJURY INFORMATION

Injuries	Crew	Passengers
Fatal	0	0
Serious	2	6
Minor/None	7	113

According to the NTSB, six passengers received serious injuries from the impact of the hard landing. All injured passengers received back or neck injuries. The location of the injured passengers within the aircraft was not stated in available reports. In addition, the NTSB reported that the failure of overhead hatracks resulted in neck injuries to several passengers.

Narrative. A DC-8 made a hard landing resulting in multiple miscellaneous cabin failures including passenger seat failures. Six passengers and two flight attendants sustained serious impact injuries.

DATE: 07-23-73
LOCATION: Lambert Field, St. Louis, Missouri
AIRCRAFT OPERATOR: Ozark Airlines
AIRCRAFT DATA:

Make, Model: Fairchild, FH-227B
Serial Number: 513
Registration Number: N-4215
TYPE OF ACCIDENT: Crash due to thunderstorm
PHASE OF OPERATION: Approach for landing
AIRCRAFT DAMAGE: Destroyed

Pax Seating Configuration. The passenger cabin had 11 rows of forward facing seats; two seats on each side of a center aisle for a total of 44 seats. The flight attendant seat was attached to the aft galley wall and was aft facing. This seat faced a cargo net which separated the passenger cabin from the rear cargo compartment.

Forward of the passenger compartment was a cargo compartment which was separated from the passenger cabin by a movable partition. Located in the forward cargo compartment was a cargo door designated as an emergency exit for use only under the direction of a flight crewmember.

Airframe Deformation/Crash Loads. The airplane struck tree tops 55 feet above the ground in a nose-up attitude while approaching runway 30L. About 280 feet west of the initial impact, the left wing struck trees; 200 feet still farther west the aircraft struck a large tree and continued for another 140 feet where it struck the ground. The fuselage was found lying on its left side broken open circumferentially just aft of the cockpit.

Impact forces were such that all passenger seats were scattered in a 360° pattern around the fuselage. Rescue personnel indicated that most of the passengers were found still restrained in their seats.

Due to aircraft contact with several groups of trees on the flight path, an accurate estimate of the impact velocity and stopping distance cannot be made.

Pax Seat Performance. All of the seats broke loose from the floor and most of the pax were found still strapped to seats. According to Human Factors Report, the first three rows of seats failed in a left forward direction. Seats in rows four through seven failed in a right forward direction, and the remaining seats aft of row seven failed in a left forward direction. (NTSB Accident Report has a different failure pattern; This report follows this section as an attachment.)

Pax Seat Manufacturer(s)/Model(s).

Manufacturer: Transportation Equipment Co.
Banton, Connecticut
Model: 691E-2L

Complied with FAA TSO C39 -
Date: 5-67
9 g forward, 7.5 g down, 5 g up, 3 g side

Pax Restraint System Performance. Only three seatbelts failed. One buckle was jammed in the full open position, one buckle failed at the buckle attach point, and one belt failed at the seat attach point.

Pax Restraint System Manufacturer(s)/Model(s). Cummings and Sanders, Inc., Model 9600-3.

Miscellaneous Cabin Interior Performance. Apparently many miscellaneous failures.

OCCUPANT/INJURY INFORMATION

Injuries	Crew	Passengers
Fatal	1	37
Serious	2	4
Minor/None	0	0

Typical injuries to fatally injured passengers included: compound fractures to the extremities, massive skull fractures, crushed chests, dismemberment, decapitation, fourth degree burns, massive internal injuries, and other severe traumatic injuries.

Although this accident was placed in the "nonsurvivable" category, it was noted that "both pilots probably would have received only minor injuries had their upper torsos been restrained by shoulder harnesses," and that "the unrestrained occupants (due to seat/restraint failures) were ejected with sufficient force to produce fatal injuries upon collision with unyielding objects."

Narrative. This FH-227B crashed 2.3 miles southeast of Lambert Field, St. Louis after encountering downdrafts which accompanied severe thunderstorms. The accident occurred while the flight was making an Instrument Landing System approach to runway 30L. The airlane impacted several trees; all the seats were torn from the floor during the final deceleration along the ground.

ATTACHMENT
SEAT STUDY

Terry F. Wallace
Crash Injury Technician
Protection & Survival Lab., ACC-119

Report of Seat Study - Submitted to NTSB Human Factors Group Chairman and FAA Accident Coordinator during the investigation.

Ozark Air Lines, Inc.: Fairchild FH-227B, Flight 809, N-4215; St. Louis, Mo. (Lambert Field), 7-23-73, 1744 CDT.

I arrived on the scene at noon Tuesday, 7-24-73.

The seats and seat structure were scattered 360 around the wreckage. Personal belongings and luggage were still present in the forward and aft portions of the cabin. Luggage and personal property were removed from under the debris and given to Ozark officials.

The seats marked 1C and 1D were found on the hillside forward of the chain link fence, approximately 20 feet from the front portion of the fuselage. There were also a purse and other personal items recovered in this area.

The seats were all of the same manufacturer and carried the same part numbers (P/N) with the exception of six, which were used in the front three rows. These seats were taken out for cargo space. The P/N were 691E 2L and 2R--all others are 696A 2L and 2R. Although one seat was found in row 9 with the P/N 691E 2R, the seats are interchangeable.

All passenger seatbelts were metal-to-metal type, manufactured by Cummings and Sanders, Inc.; 1500-lb. loading; date of mfg.: 1-71; model 9600-3; P/N 4476621.

Apparently the tree (large, approximately 2 1/2 feet in diameter) started opening the cabin near seat row 4. Seat row 4 through seat row 7 were completely destroyed and partly burned. Indications on the tree trunk where the airplane impacted showed parts of the seat track embedded in the wood along with human tissue and hair.

The stewardess' seat indicates a small amount of down loading. The brace on the seat is bent slightly. After the galley failed and went forward, it appears the stewardess was thrown forward enough to enable her to slip out of the metal-to-material seatbelt.

On Wednesday and Thursday, the seats were removed from the crash site and taken to the National Guard area. On Friday, they were mocked up according to the known positions and the numbering system on the seat frames and backs. The seats were documented and pictures taken of them.

Right Side of Aircraft: Row 1C and D - Left rear leg has approximately 4 inches of seat track still attached. Both seatbelts are intact. The seat structure indicates some down loading on the D side. The D seatback was broken loose but still attached to the seat. This is the seat found on the hill beyond the fence.

Row 2C and D - The seat failed to the left and was torn up. The D seatbelt was cut. The C seatbelt was intact.

Row 3C and D - Both seatbacks were broken from impact from the rear. Both seatbelts were cut; legs were missing from the seats.

Row 4C and D - D belt cut, C belt intact. Seat torn up, back torn off. Heavy impact from the aisle to side. Seat failed to the right from being impacted on the left.

Row 5C and D - Seat completely destroyed. Front frame only part that fit this area.

Row 6C and D - Both belts cut. C back broken off. Aisle armrest missing. Seat indicates failure to the right. Both nylon seat supports intact.

Row 7C and D - Seat completely destroyed. D belt cut, C belt intact.

Row 8C and D - Seat failed to the left. C belt cut. D belt intact. Impact from the left on the C seatback; the aisle armrest broken free.

Row 9C and D - Both belts cut. Seat destroyed.

Row 10C and D - Severe impact into C seatback from the rear. Seat legs almost straight with one seat-to-track mounting pad missing. Both seatbelts intact.

Row 11C and D - Completely destroyed. It is possible the galley crushed this seat when it was thrown forward.

Left Side of Aircraft: Row 1A and B - Both seatbelts cut. B seatback broken off (possible passenger - Nickey Cordin). A seatback impacted from the rear; seat legs torn off. Serving tray smashed. Seat failed to the left.

Row 2A and B - B belt cut; A belt intact. B seatback impacted from the rear. Center armrest bent to the left. Seat failed downward. The A position failed down and slightly aft.

Row 3A and B - Both seatbelts intact. A seat impacted from left side and failed to the right. This could have been caused when the aircraft impacted the tree. B seat appears to have been unoccupied; the seat cushion and back cushion are still in place and the seatback was folded over flat against the seat cushion.

Row 4A and B - Seat legs broken off. The rear frame broken off. A belt cut; B belt intact, but loose on the aisle side of the seat. Both backs broken off the seat. The seat failed to the right. Left side of front brace bent forward and to the right. This is apparently where the tree entered cabin.

Row 5A and B - Both seatbelts burned off. Seat burned. Seat structure bent and twisted where the tree impacted.

Row 6A and B - Burned. A seatbelt burned off; B seatbelt failed where the belt is tied to the belt to seat attachment. The metal bar broke out of the attachment.

Row 7A and B - Seat partly burned; both seatbelts burned off and part of seat frame gone.

Row 8A and B - Seat destroyed by left side impact; both seatbelts intact. Seatbacks broken loose. The rear frame was bent forward in the middle from left to right impact.

Row 9A and B - This seat was marked 11A and B, but having no left armrest, it would have to be at the left rear window exit. The A seatbelt was cut; the B seatbelt was intact. Seat failed to the left and down. The A seatback was in good condition. Slight impact on the B seatback.

Row 10A and B - Seat failed to the left. B seatback was broken loose from the seat. Seat had some down loading. Both belts cut. The seat shows to have received an impact from the right rear approximately 45°. Legs twisted out of track.

Row 11A and B - Both belts cut. Seat failed to the right. A seatback shows impact from the rear and was broken loose from the seat frame. The seats were all accounted for, but it is impossible to determine if the seats were in the same position in the aircraft as they are in the mock-up. Due to the high deceleration forces the seats were torn loose from their mountings and allowed to tumble free in the entire cabin area.

G-14

DATE: 11-27-73
LOCATION: Chattanooga, Tennessee
AIRCRAFT OPERATOR: Delta Air Lines, Inc.
AIRCRAFT DATA:
Make, Model: McDonnell Douglas, DC-9-32
Serial Number: 47032
Registration Number: N3323L
TYPE OF ACCIDENT: Collided with approach lights or runway
PHASE OF OPERATION: Final approach, landing
AIRCRAFT DAMAGE: Destroyed

Pax Seating Configuration. The aircraft was configured into two classes; the first class section consisted of 10 double seat units, 1 unit on each side of the center aisle. The coach class consisted of 14 double and 14 triple seat units. The double units were on the left side of the center aisle and the triple units were on the right.

Airframe Deformation/Crash Loads. The aircraft struck the approach lights and then a dike. From this point it careened and slid at an angle of 17° to the left of the runway centerline and came to rest 490 feet past the runway threshold and 249 feet left of the centerline. The lower portion of the fuselage from FS 37 to FS 229 experienced extensive damage (figure C-21). Skin wrinkles were evident on the left side below the cabin window at FS 775. Punctures existed in the lower fuselage between FS 275 and FS 408 with the largest one being approximately 3 feet long running between FS 275 and FS 313. Additional punctures were noted between FS 775 and FS 794. The aircraft floor from row 29 to the rear galley was distorted upward. The seat tracks between row 29 and 31 were fractured and completely separated (figures C-22 and C-23).

Pax Seat Performance. Five seats showed impact damage: (1) The sheet metal seat bottom of the right side aisle seat of row 16 was displaced downward, approximately 2 inches. (2) Both window and aisle seats of row 29 were damaged in the same mode as the seat in row 16. (3) The same as (2). (4) The armrest on the seat below the window of row 31 was deformed downward. (5) The seat bottom of the aisle seat of row 39 was completely free of the aft transverse tube. This seat also showed downward loading.

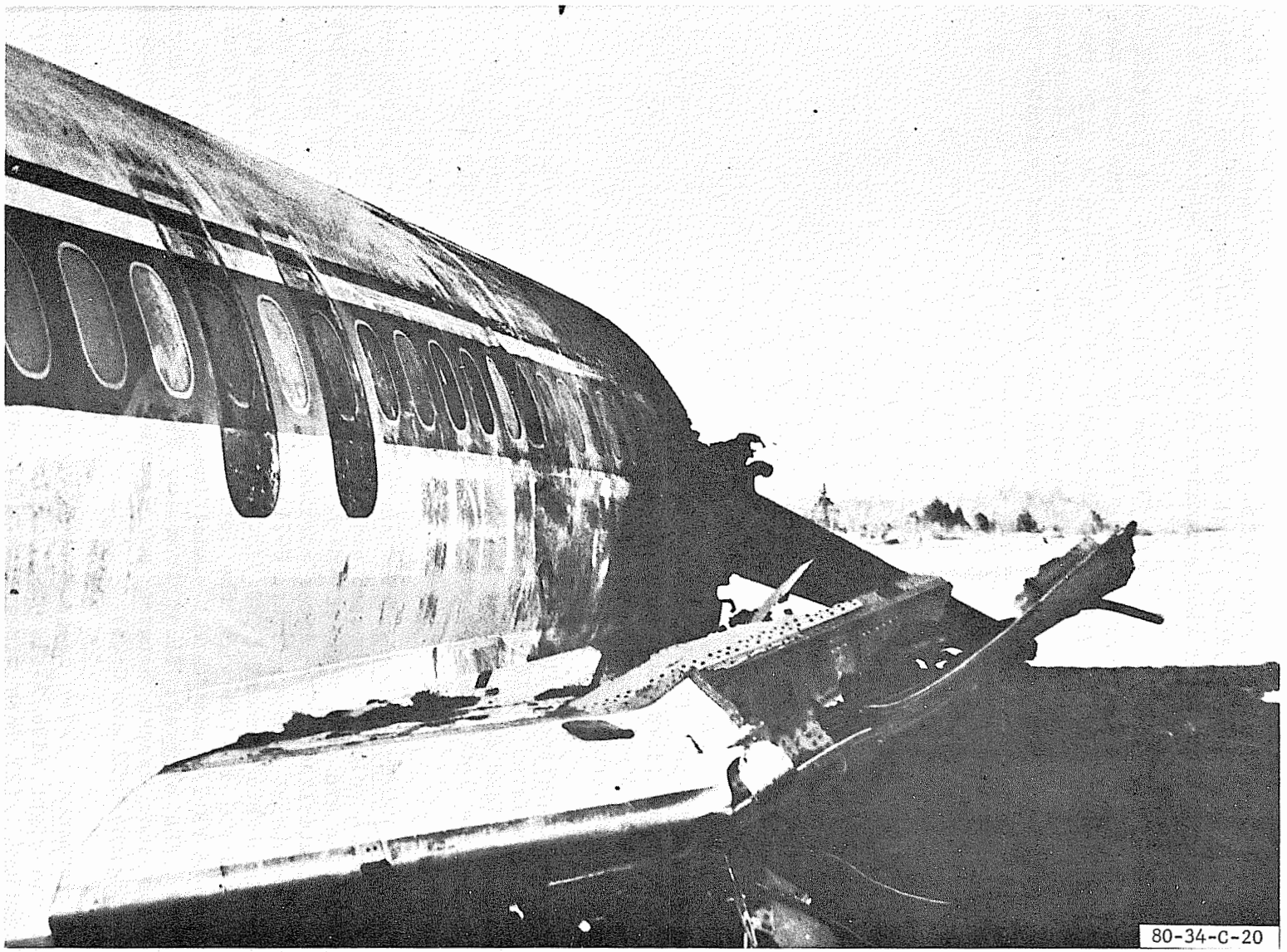


FIGURE C 21. N3323L AIRFRAME DEFORMATION

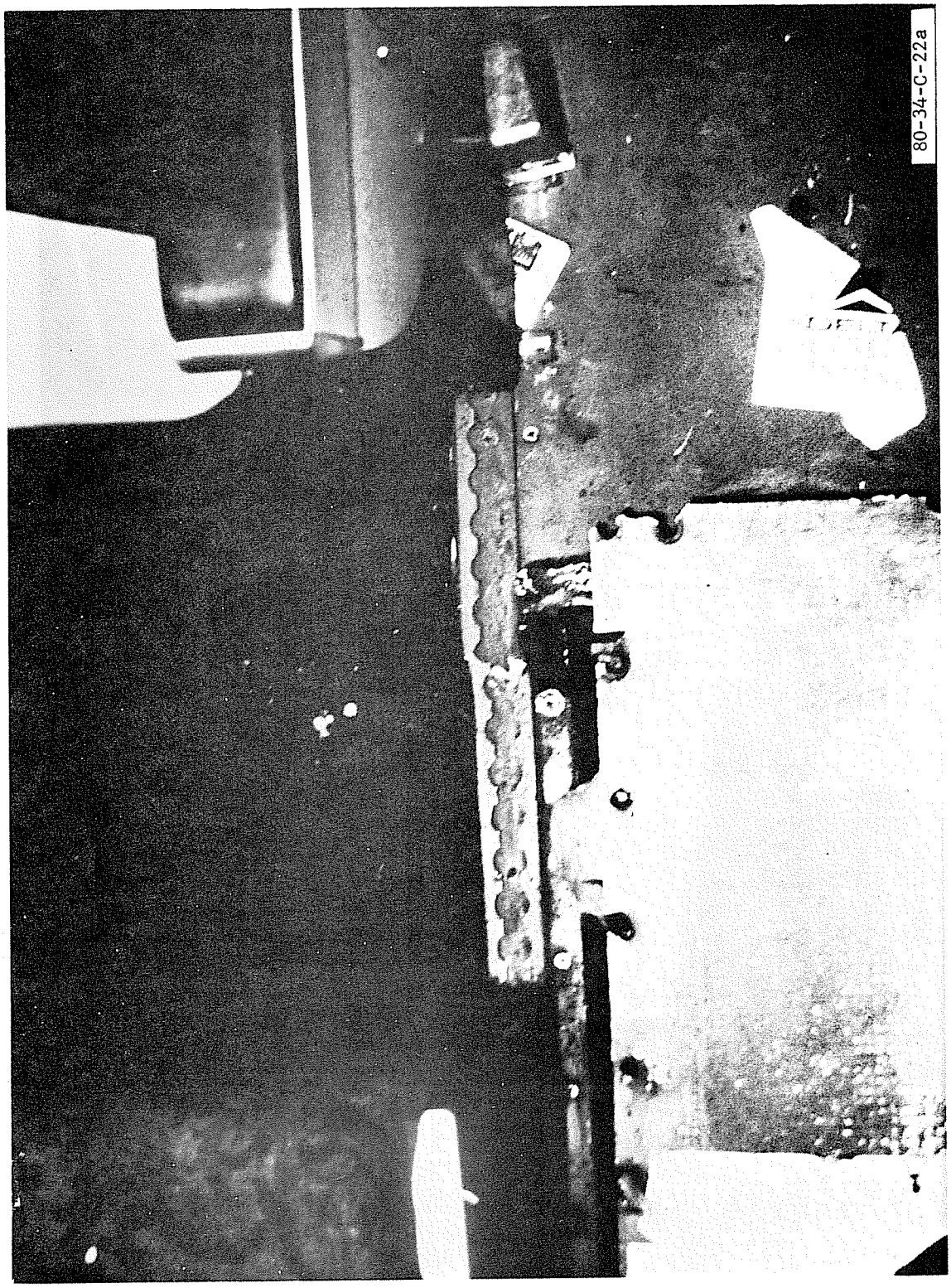


FIGURE C-22. N3323L SEAT TRACK DEFORMATION

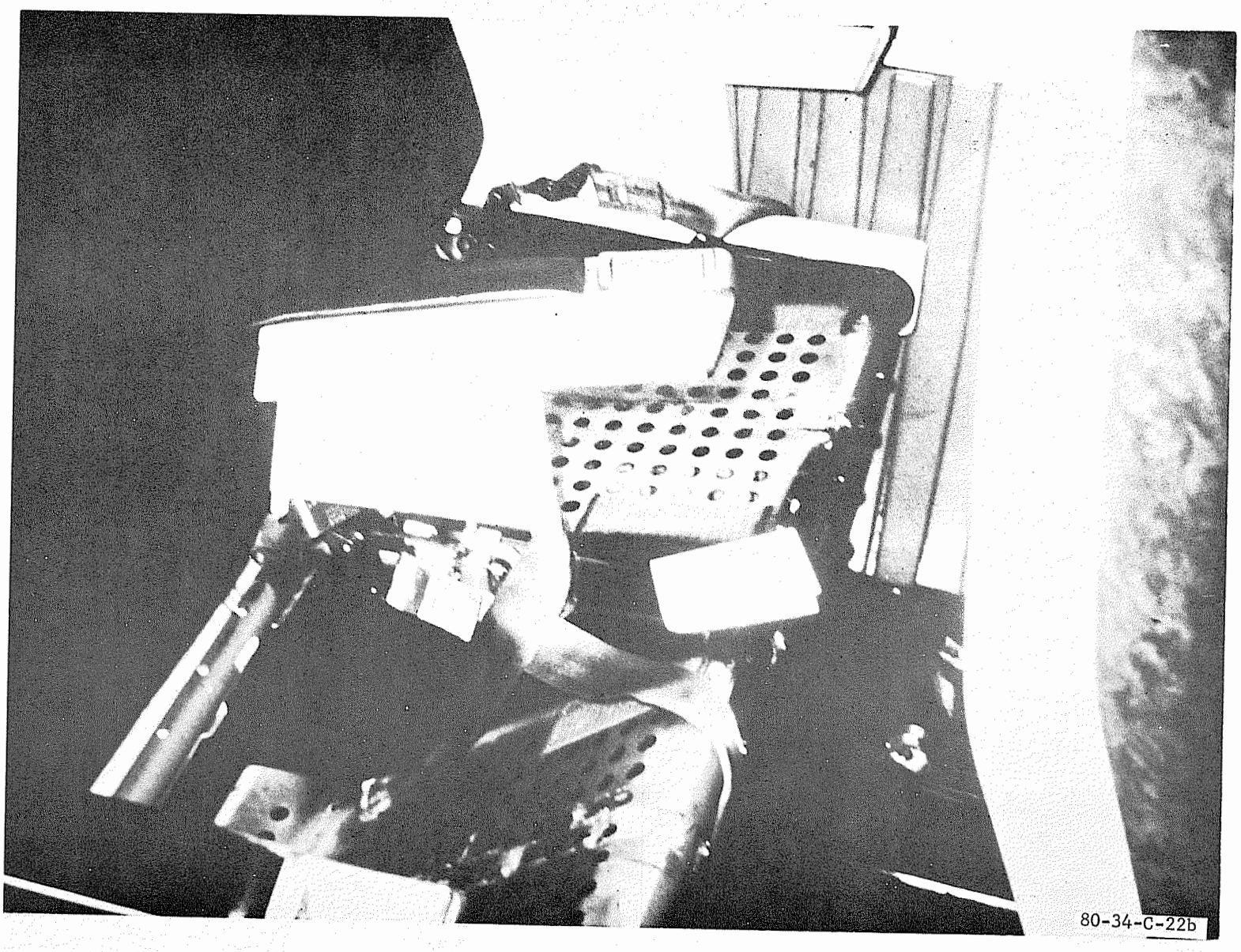


FIGURE C-23. SEAT DEFORMATION IN N3323L ACCIDENT

Pax Seat Manufacturer(s)/Model(s). First class seats: Webber Aircraft, Division of Walter-Kidde Co., part Nos. 807200 401 (left side) and 807202-402 (right side). TSO-C39: Coach seats; Webber Aircraft, Division of Walter-Kidde Co., part Nos. 807201-427 (left side) and 807202-427 (right side).

Pax Restraint System Performance. There were no failures reported.

Pax Restraint System Manufacturer(s)/Model(s). Cummings and Sander, Inc.; part No. DE 1001-1 (metal-to-metal).

Miscellaneous Cabin Interior Performance. The aft galley contents and equipment were scattered about the floor and general work area. Also the tray carriers were found scattered around the floor.

OCCUPANT/INJURY INFORMATION

Injuries	Crew	Passengers
Fatal	0	0
Serious	2	1
Minor/None	3	73

There were also two minor crew and five minor passenger injuries. The captain sustained a compression fracture of the Thoracic Vertebra (T-12), and the copilot sustained a compression fracture of T-11, T-12, and L-11. The passenger seated in the aisle seat row 16 sustained a T-12 compression fracture.

Narrative. A McDonnell Douglas DC-9-32, operated by Delta Air Lines Inc., crashed while attempting to execute a landing. The aircraft made initial ground contact with an approach light. Subsequently, it struck a dike and some other approach lights before coming to rest. A fire of short duration erupted in the rear cabin following initial impact; the fire self-extinguished before the aircraft came to a stop. The passengers self-evacuated. Of the 74 cabin occupants and crew, 6 passengers and 3 crewmembers received injuries. Five seats were damaged as a result of the impact.

G-15

DATE: 11-27-73
LOCATION: North Canton, Ohio
AIRCRAFT OPERATOR: Eastern Air Lines, Inc.
AIRCRAFT DATA:
Make, Model: McDonnell Douglas, DC-9-31
Serial Number: 47267
Registration Number: N8967E U.S. Civil Aircraft Register at CAMI documents aircraft assigned to the "N" number as being another type/make/model than a DC-9.
TYPE OF ACCIDENT: Slid off end of runway
PHASE OF OPERATION: Landing
AIRCRAFT DAMAGE: Substantial structural

Pax Seating Configuration. The cabin was configured for two classes (figure C-24). The front section (first class) had 14 seats. There were three rows of double seats on the left side of the center aisle and four rows of double seats on the right side of the center aisle. Directly in front of the seats on the left side was a lavatory.

The aft section (coach class) of the cabin contained 15 rows of double seat units on the left side of the aisle and 15 rows of triple seat units on the right side of the aisle.

In the first class section of the airplane, forward of the lavatory, aft of the cockpit, on the left side of the airplane, there was a passenger entry door equipped with an airstair. Directly across from the passenger entry door was a service door between two galley units. These two doors served as primary emergency exits. Other emergency exits consisted of four overwing window exits at the end of seat rows 10 and 11; and an auxiliary tail exit route through the aft pressure bulkhead, back to a jettisonable tail cone.

Airframe Deformation/Crash Loads. After landing on runway 01, the aircraft did not stop, but continued for approximately 480 feet beyond the overrun end of the runway. It came to rest at the bottom of an embankment. The fuselage remained intact.

The major portion of the aircraft, which included the entire occupiable area, consisted of the fuselage from the radome (FS-7) back to the aft cabin pressure bulkhead (FS 996) with both wings attached. The tail section, with both engines broken off, was separated from the fuselage by about 30 feet.

Pax Seat Performance. Two passenger seats (6C and 12C), which were the aisle-side cantilevered seats of the triple seat units, collapsed downward to within 3 inches of the floor. Both of these seats also had the center two of four aft support springs between the fabric seat pan and seat structure stretched beyond their elastic limits and bent over the large structural crossmember.

Eleven other passenger seats exhibited the same pan spring overextension and bending signs. This damage was noted in seats on both sides of the aircraft from row 2 back through row 12. Seat number 9B had all four of its springs overstretched.

Pax Seat Manufacturer(s)/Model(s). The first class seats were manufactured by Weber and were model Nos. 807200-403 (left side) and 807200-204 (right side). The seat rows were numbered 1 through 4.

The aft cabin (coach) contained 15 rows of double seat units, Weber models 807201-407, -413, and -409 on the left side (A and B) and triple seat units, Weber models 807202-407, -403, and -409 on the right side of the aisle. The rows were numbered 5 through 20 with row 13 excluded.

Pax Restraint System Performance. No failures were reported.

Passenger Restraint System Manufacturer(s)/Model(s). Not given in available reports.

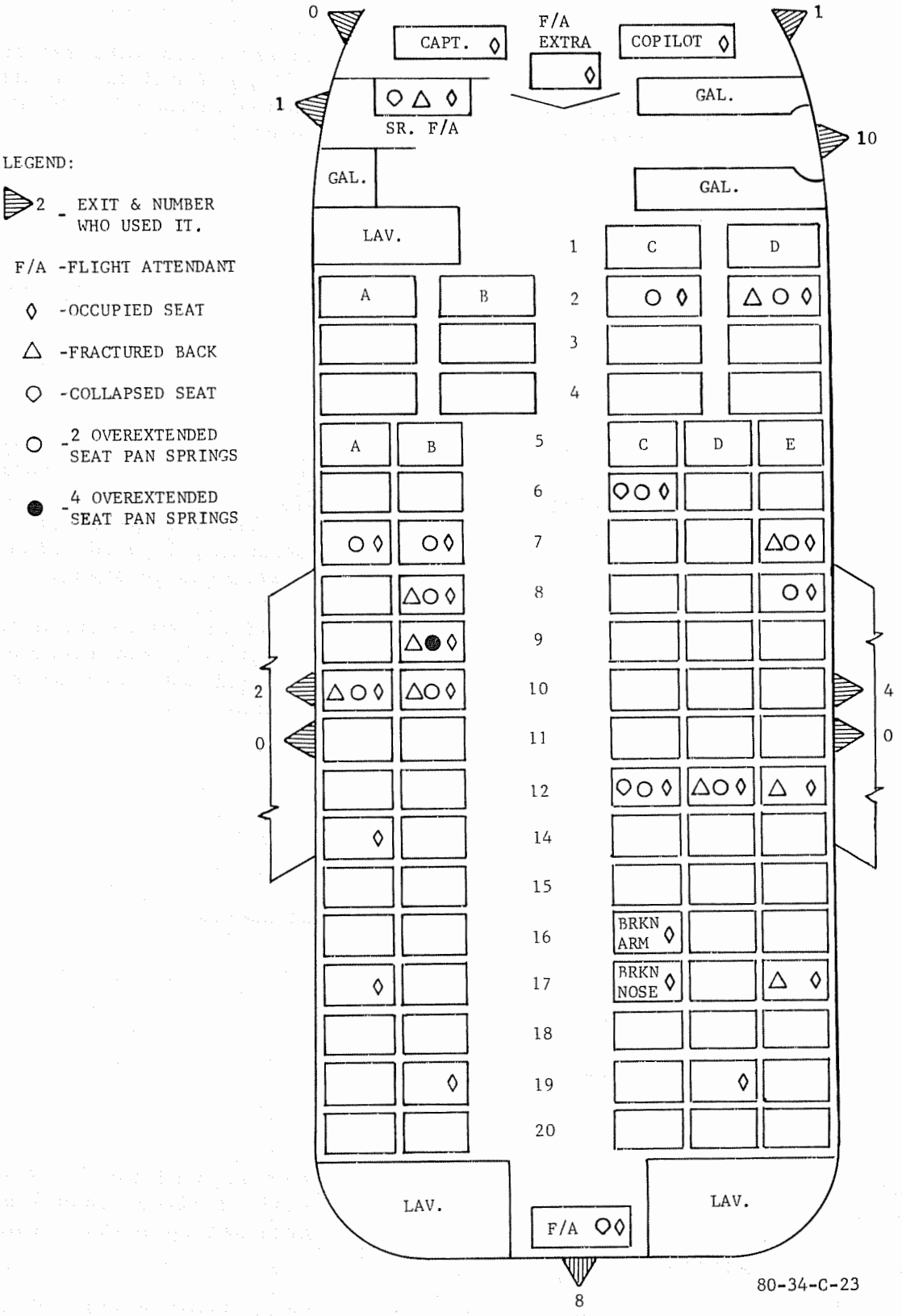


FIGURE C-24. EASTERN AIRLINES, INC., DC-9-31, N8967E SEATING ARRANGEMENT

Miscellaneous Cabin Interior Performance. All the galley units were intact. The overhead hatracks (storage bins) collapsed above seat rows 2 and 3. In the coach section, five parts of the left side hatracks from rows 5 through 16 and six parts of the right side and hatracks from rows 7 through 20 collapsed and then rested on the seatbacks.

OCCUPANT/INJURY INFORMATION

Injuries	Crew	Passengers
Fatal	0	0
Serious	3	13
Minor/None	2	8

There were two minor crew injuries and eight minor passenger injuries. Most of the passenger injuries could be attributed to the overhead racks collapsing. Seven of the passengers sitting in seats that displayed the overextended seat pan support springs suffered vertebral fractures. The two passengers in the cantilevered seats that collapsed downward were not seriously injured, although the support springs in both their seats showed the same overextension damage.

Narrative. The aircraft ran off the end of runway 01 after completing a precision approach and landing, traversed 110 feet of unpaved ground, and plunged over a 38-foot embankment. The aircraft was substantially damaged and sustained miscellaneous cabin failures, including passenger seat failures. All of the occupants sustained injuries of various types and degrees.

DATE: 12-17-73
LOCATION: Logan International Airport, Boston, Massachusetts
AIRCRAFT OPERATOR: Iberia Airlines
AIRCRAFT DATA:
Make, Model: McDonnell Douglas, DC-10-30
Serial Number: Not available in CAMI files
Registration Number: EC CBN
TYPE OF ACCIDENT: Landing, struck approach lights
PHASE OF OPERATION: Approach, landing
AIRCRAFT DAMAGE: Substantial structural damage

Pax Seating Configuration. The passenger cabin was configured for a 254-passenger capacity. There were three zones. Zone A contained 22 first class seats and a coach section which contained 42 seats. Zone B contained 84 seats. Zone C contained 128 coach seats.

Airframe Deformation/Crash Loads. The aircraft struck light piers and the right main gear was sheared. The aircraft was then airborne for approximately 1,200 feet, landed on runway 33L, veered off the runway to the right, and skidded to a stop about 3,000 feet from the threshold. The fuselage aft section had partially

separated near FS 1811. The aft section was twisted to the right and was resting on the tail cone with the right horizontal stabilizer touching the ground. A major floor failure occurred in the aft cabin approximately between FS 1530 and FS 1850. The floor was displaced upwards about 3 feet. A circumferential break was noted in the fuselage around the last row of seats of zone C and just forward of the rear exits. The gap created in the top of the fuselage measured approximately 2 feet across.

Pax Seat Performance. The floor displacement caused multiple failures of seat tracks and seat restraint components. However, no seats were completely detached. A fracture was observed in the floor-mounted seat track below the left side of seat 3D, and the forward seat leg was detached from the track. A floor panel failure was observed under seat 27D in zone B. Seat retention was not affected. Massive floor failure was observed from seat row 46 to 50 (zone C). The floor-mounted seat tracks were fractured in many places. The center seat units in this area exhibited leg attachment failures and simple track-to-stud separations but no seats were found completely detached. Seat track deformation was observed on the last 11 aisle side seat units on the left outboard side and on the last three seat units on the right outboard side.

Pax Seat Manufacturer(s)/Model(s). No information available.

Pax Restraint System Performance. No restraint system failures were reported.

Pax Restraint System Manufacturer(s)/Model(s). No information available.

Miscellaneous Cabin Interior Performance. Ceiling panels were dislodged.

OCCUPANT/INJURY INFORMATION

There were 167 persons on board consisting of 153 passengers and 14 crewmembers of whom 10 were flight deck crewmembers.

Injuries	Crew	Passengers
Fatal	0	0
Serious	1	2
Minor/None	13	151

Thirteen passengers were treated for minor cuts and bruises and were released. A flight attendant suffered a fracture of the left pubic ramus and the acetabulum. One passenger sustained a fracture of the left ankle and a compression fracture of the second lumbar vertebra (L2). The other seriously injured passenger sustained a fracture of the right ankle. These injuries were sustained in the evacuation.

Narrative. The aircraft crashed while attempting to execute a landing. The aircraft made initial ground contact with some approach lights and an embankment which sheared off its right main gear. The airplane continued airborne for approximately 1,500 feet. It landed on the runway and then veered off, finally skidding to a stop 3,000 feet from the threshold and 280 feet north of the runway.

DATE: 01-30-74
LOCATION: Pago Pago, American Samoa
AIRCRAFT OPERATOR: Pan American World Airways, Inc.
AIRCRAFT DATA:
Make, Model: Boeing 707-321B
Serial Number: 19376
Registration Number: N454PA
TYPE OF ACCIDENT: Undershoot
PHASE OF OPERATION: Final approach, landing
AIRCRAFT DAMAGE: Destroyed

Pax Seating Configuration. This Boeing 707 was configured as a 146 passenger capacity aircraft with the following arrangement: The forward, first class compartment had 4 rows of two double seat units. The next section was the economy class section which contained 20 rows of two triple seat units, 2 rows of single triple seat units, and 1 row of two double seat units for a total capacity of 130 passengers in this section.

Airframe/Deformation Crash Loads. The airplane crashed into some 25-foot tall trees 3,865 feet short of the runway threshold, at an elevation of 113 feet (ground elevation is approximately 88 feet here). The Boeing 707 continued through the jungle vegetation, struck a 3-foot-high lava rock wall, and stopped about 3,090 feet from the runway threshold. The wreckage path was about 775 feet long and 150 feet wide with a downward angle through the vegetation of about 3.5°. The swath path was somewhat left of the runway centerline and slightly lower on the right side at initial impact.

A portion of the center keel beam was found in the lava rock. In addition, the landing gear, the outer wing panels, the outboard ailerons, parts of the main and fillet wing flaps, all four engines, and the No. 3 pylon separated from the airplane; however, the fuselage remained intact. Fire was evident during the last 350 feet of the wreckage pattern.

Pax Seat Performance. There is no report of seat failures in existing reports.

Pax Seat Manufacturer(s)/Model(s). Not applicable and no data available in CAMI files.

Pax Restraint System Performance. There is no report of restraint failures in existing reports.

Pax Restraint System Manufacturer(s)/Model(s). Not applicable and no data available in CAMI files.

Miscellaneous Cabin Interior Performance. This aircraft was destroyed by fire. This plus the remote location where the accident occurred made it impossible to obtain accurate information about possible cabin equipment failures.

OCCUPANT/INJURY INFORMATION

Injuries	Crew	Passengers
Fatal	10	86
Serious	0	5*
Minor/None	0	0

*Includes one passenger who died nine days after the accident.

The surviving passengers received first, second, and third degree burns to the face, arms, legs, back, and chest. Two of the survivors had only face and hand burns. None of the passengers sustained impact trauma.

Narrative. A Pan American Airways Boeing 707 crashed into some trees 3,865 feet short of the runway at Pago Pago International Airport. During the deceleration it cut a swath through the vegetation and sustained progressive destruction. The fuselage remained intact but caught on fire. Of the 101 persons on board the aircraft, only 5 survived and one of these died 9 days after the accident. None of the deaths were attributed to impact injuries.

G-18

DATE: 08-07-75
LOCATION: Denver, Colorado
AIRCRAFT OPERATOR: Continental Air Lines, Inc.
AIRCRAFT DATA:
Make, Model: Boeing, 727-224
Serial Number: 19798
Registration Number: N88777
TYPE OF ACCIDENT: Collision with ground (uncontrolled)
PHASE OF OPERATION: Takeoff, initial climb
AIRCRAFT DAMAGE: Substantial

Pax Seating Configuration. The aircraft was configured into a first class and a coach section. The 22-seat first class cabin contained five and one-half rows of double seat units separated by a 22-inch wide center aisle. Seat rows were numbered 2 through 7 because row number 1 and seats 2D and F had been removed to accommodate the coat closet and the No. 2 galley. Seat A was by the left window and B was on the aisle, seat E was on the right side of the aisle and F was by the window (figure C-25). The coach cabin, which could be divided into two classes (coach and economy), contained 16 rows of triple seat units on each side of a 16 1/2-inch-wide center aisle. The seats are lettered laterally with seat A next to the left window and seat C on the left aisle, seat D on the right aisle and seat F next to the right window. These rows were numbered 8 through 24 with row 13 omitted. The aft cabin on the left side contained three double seat units numbered 25, 26, and 27.

Airframe Deformation/Crash Loads. The aircraft fuselage split at approximately FS 279 on the right side and just aft of the production joint at approximately FS 390 on the left side. This portion of the fuselage structure from FS 178 aft to FS 360

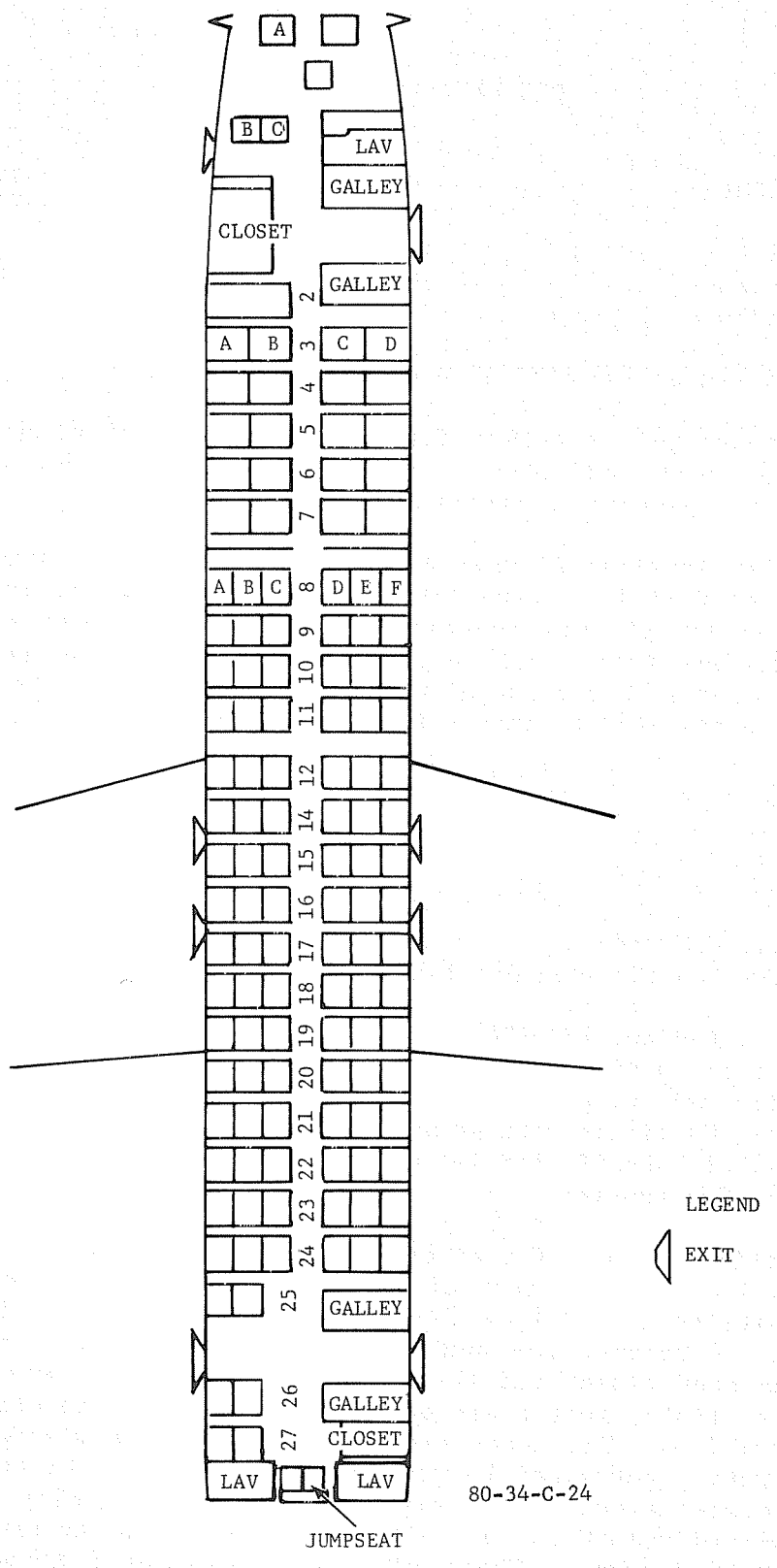


FIGURE C-25. CONTINENTAL AIRLINES, INC., BOEING 727-224, N88777 SEATING CONFIGURATION

sustained severe ground impact damage in a generally aft direction. The fuselage was also split open from the crown area to the external lower portion of the fuselage near FS 390. Numerous wrinkles were in evidence. The cabin floor section in the immediate area of FS 380 had buckled and caved in at the coat closet front attachment joints. The cabin floor tracks were fractured at a point about 14 inches aft of the coat closet rear attachment points. The forward galley remained intact and attached to the floor structure. However, this section of the cabin floor had collapsed toward the center aisle. The floor beams from FS 360 to FS 460 were severely damaged. The fuselage was also separated at about FS 1050 on the right side around to FS 1100 on the left side (figure C-26). The floor beams at FS 950 were fractured (figure C-27).

Passengers described the impact as tail-first and about as severe as a very hard landing. The forward and aft fuselage fractures occurred during the initial severe impact sequence. Although crash forces were initially primarily upward and aft during the skid to stop, some additional forces caused by a right skid resulted in bruises to the left side of some of the occupants.

Pax Seat Performance. The only seat damage caused by the cabin floor failure was to the underseat baggage restraint bars under seats 21C and 21D (see figure C-28) which were bent upwards. One forward outboard seat tiedown pin (on seat 27A) popped out of the floor track; however, this seat was not dislodged.

Pax Seat Manufacturer(s)/Model(s). No information in available reports.

Pax Restraint System Performance. Although two occupants were thrown from their seats during impact, no seatbelt failures were found in the cabin.

Pax Restraint System Manufacturer(s)/Model(s). Seatbelts; American Safety, No. CA 2011, 449470.

Miscellaneous Cabin Interior Performance. The cabin floor outer walls and the ceiling structure failed aft of the cockpit cabin bulkhead. The only other item torn loose in the forward cabin was the forward coat closet. The left forward main cabin door was unusable because of airframe deformation. In the aft cabin there was floor damage midway between the aft window exits and the rear of the cabin at row 21. In the rear of the aft cabin, the floor, outer walls, and ceiling structure failed in the area of the rear main cabin doors. Through the aft cabin, miscelleaneous sections of ceiling panels had been dislodged partially blocking the aisle and egress routes.

OCCUPANT/INJURY INFORMATION

Injuries	Crew	Passengers
Fatal	0	0
Serious	5	10
Minor/None	2	117

NOTE: Occupant injuries consisted of multiple contusions, abrasions, and lumbar or thoracic vertebrae fractures. Two occupants received fractures at the ankles during egress. The seat locations of the seriously injured aircraft occupants are illustrated in figure C-29. Figure C-30 shows the exits utilized by the occupants.

FIGURE C-26. N88777 FUSELAGE BREAK

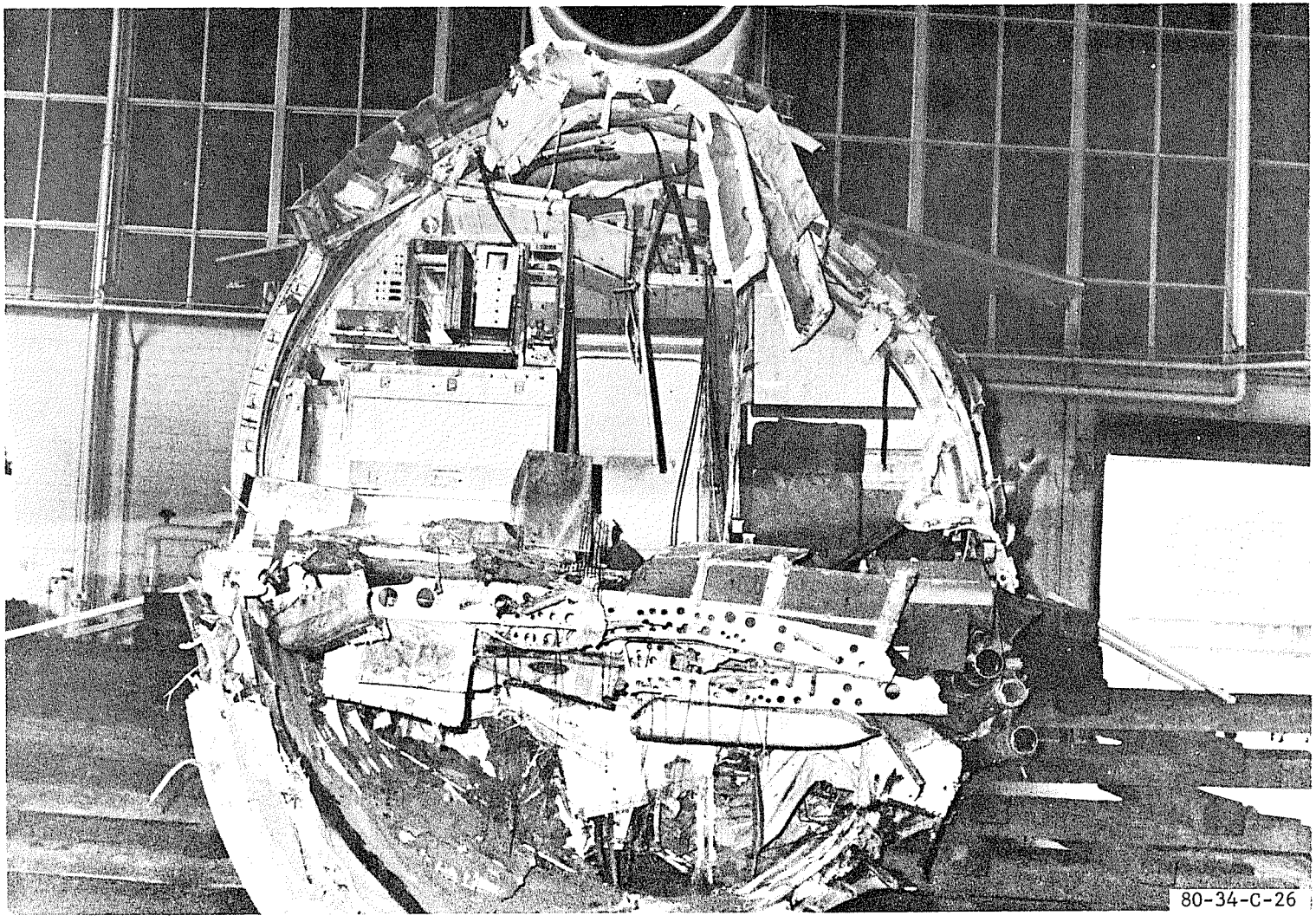


FIGURE C-27. N88777 CROSS SECTION AFT PORTION ILLUSTRATING FLOOR DEFORMATION

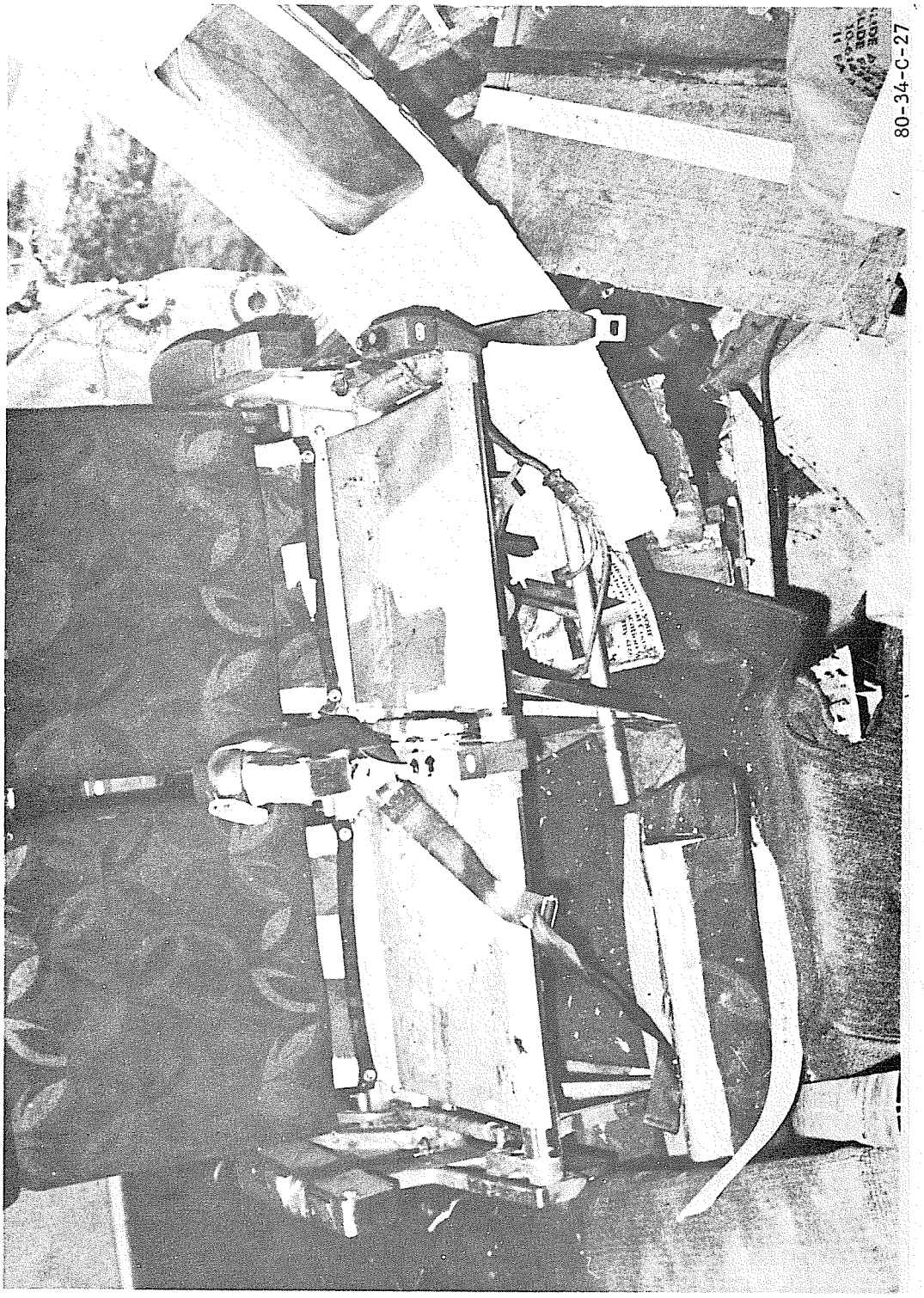
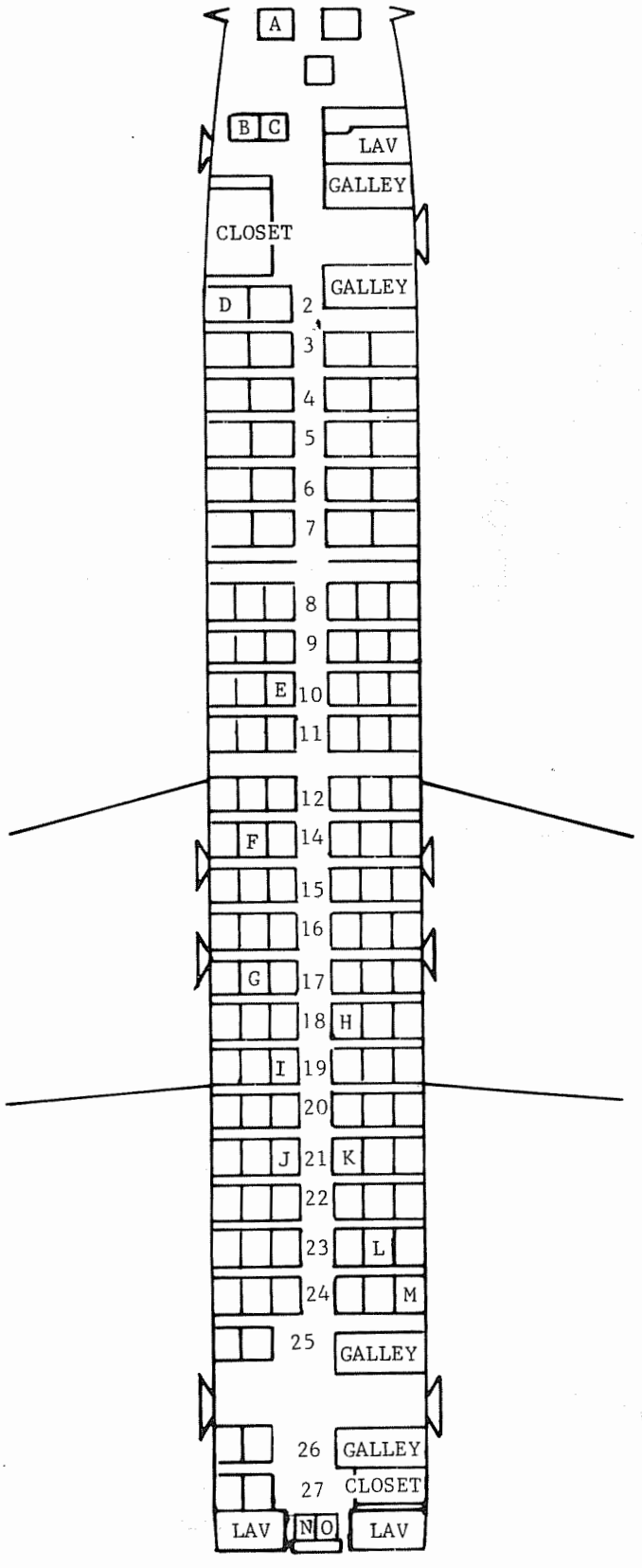


FIGURE C-28. N88777 SEAT DEFORMATION



INJURIES:

A - COMPRESSION FRACTURE OF ELEVENTH THORACIC VERTEBRA. LACERATION RIGHT SIDE OF SCALP AT HAIRLINE, WHICH WAS SUTURED WITH THREE STITCHES.

B - FRACTURE OF LEFT SEVENTH RIB. LACERATION OF RIGHT KNEE, WHICH HAD TO BE SUTURED. SPRAINED RIGHT FOOT.

C - COMPRESSION FRACTURE OF FIRST LUMBAR VERTEBRA. CONTUSIONS TO THE HEAD.

D - SEVERE NECK STRAIN AND RATHER SEVERE CERVICAL ARTHRITIS, BUT NO FRACTURES. (SERIOUS, BASED ON TIME IN HOSPITAL.)

E - FRACTURE OF RIGHT ANKLE.

F - COMPRESSION FRACTURE OF FIRST AND SECOND LUMBAR VERTEBRA.

G - FRACTURE OF TRANSVERSE PROCESS OF THIRD LUMBAR VERTEBRA ON LEFT SIDE.

H - MULTIPLE CONTUSIONS AND ABRASIONS. UPSET ABOUT CONDITION OF DAUGHTER. (SERIOUS, BASED ON TIME IN HOSPITAL)

I - COMPRESSION FRACTURE OF FIRST LUMBAR VERTEBRA.

J - FRACTURE OF LATERAL MALLEOLUS OF LEFT ANKLE. SPRAIN OF RIGHT ANKLE.

K - FRACTURE DISLOCATION OF TWELFTH THORACIC VERTEBRA FORWARD TO THE FIRST LUMBAR VERTEBRA. MASSIVE COMPRESSION FRACTURE OF FIRST LUMBAR VERTEBRA CAUSING PARAPLEGIA FROM THIS POINT DOWNWARD. OPEN COMPOUND FRACTURE OF TIBIA AND FIBULA OF RIGHT LOWER LEG. MASSIVE OPEN COMPOUND OF RIGHT MID AND FOREFOOT. ALSO CLOSED FRACTURE OF METATARSALS OF THE LEFT FOOT.

L - COMPRESSION FRACTURE OF FIFTH LUMBAR VERTEBRA.

M - COMPRESSION FRACTURE OF FIRST LUMBAR VERTEBRA.

N - CHIP FRACTURE OF GREATER TROCHANTER OF HEAD OF HUMERUS OF LEFT SHOULDER.

O - MULTIPLE CONTUSIONS AND BRUISES. (SERIOUS, BASED ON TIME IN HOSPITAL.)

80-34-C-28

EXIT

FIGURE C-29. N88777 SEAT LOCATIONS OF SERIOUSLY INJURED OCCUPANTS

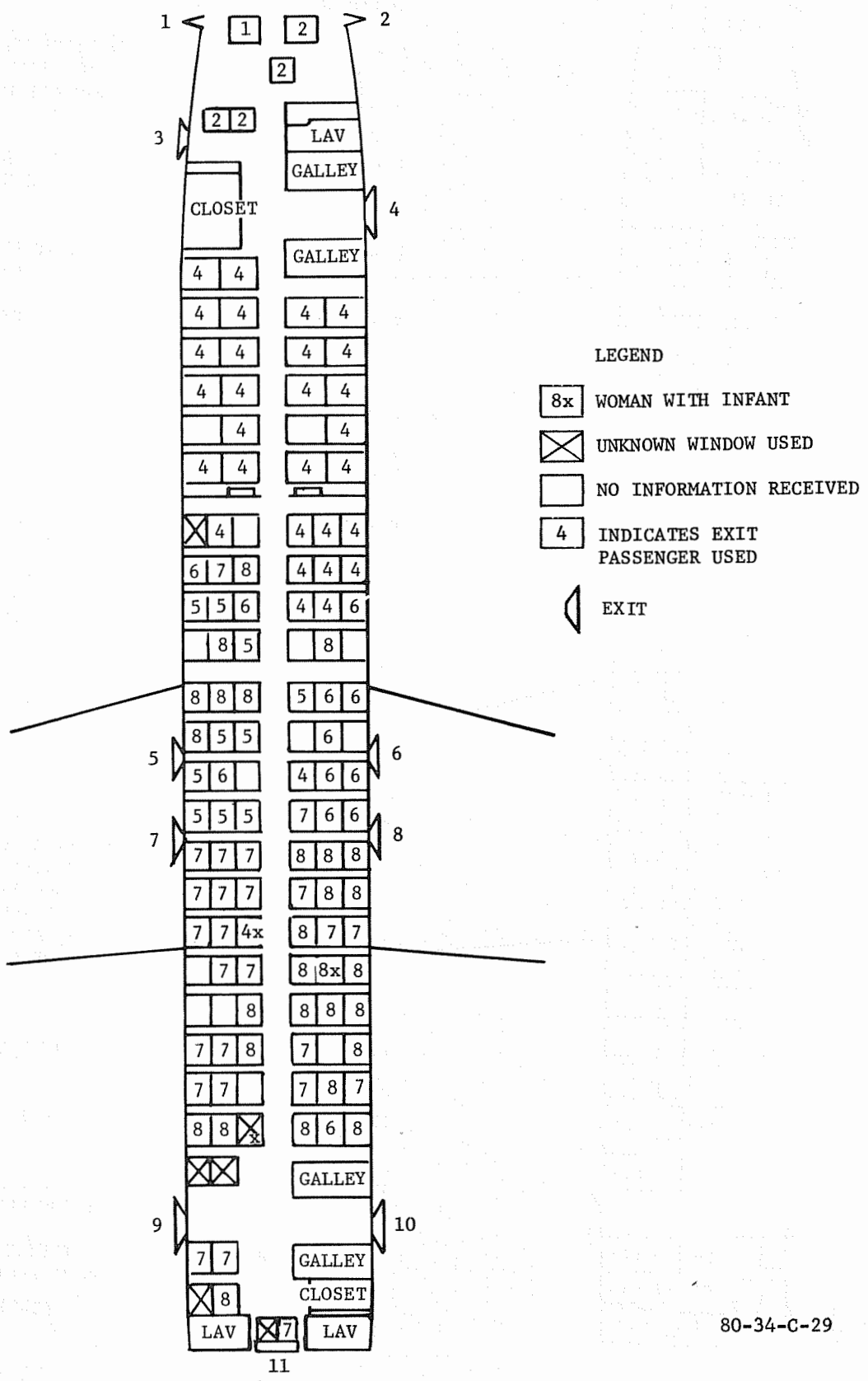


FIGURE C-30. N88777 EXIT UTILIZATION DIAGRAM

Narrative. A Continental Air Lines, Inc., Boeing 727-224 crashed just after raising its landing gear on takeoff from Stapleton International Airport, Denver, Colorado. The aircraft crashed within the boundary of the airport (figure 31). After several impacts the aircraft came to rest on a macadam road about 2,000 feet from the initial ground contact. The aircraft separated into three major sections. All the occupants survived the accident.

G - 19

DATE: 08-30-75
LOCATION: Gambell, St. Lawrence Island, Alaska
AIRCRAFT OPERATOR: Wien Air Alaska, Inc.
AIRCRAFT DATA:
Make, Model: Fairchild, F-27B
Serial Number: 21
Registration Number: N4904
TYPE OF ACCIDENT: Collision with ground/water, controlled
PHASE OF OPERATION: Landing, missed approach
AIRCRAFT DAMAGE: Destroyed

Pax Seating Configuration. The cabin was a combination cargo/passenger configuration. The forward portion of the cabin was fitted for cargo with a large cargo door on the left side of the aircraft immediately behind the cockpit. The cargo area and passenger section were separated by means of a bulkhead with a curtain covering. The passenger cabin was fitted with 28 passenger seats arranged in seven rows. There were seven double seat units down each side of the cabin with an aisle between the rows.

Airframe Deformation/Crash Loads. The aircraft overturned during the crash and came to rest inverted and heading in the opposite (180°) direction of flight. All structural fractures observed were typical of those caused by overload. Most of the lower fuselage structure and parts of the nose structure from FS 16 to FS 909 were located over a 178-foot distance (upslope from the initial impact point). The remaining fuselage side structures of the inverted aircraft were basically intact from the galley area forward to the forward cabin cargo area. The floor sections had been torn away. Some of the floor sections as well as the cabin interior and furnishings were consumed by fire. The top fuselage structure was in contact with the ground. The forward fuselage structure from FS 122 forward had been severely torn and crushed. From the orientation of the impact marks and wreckage path, it was determined that the aircraft had been in a climb attitude at the time of impact.

Pax Seat Performance. No passenger seats were found attached to the floor structure. Various types of failures of the seat-to-floor attachments had occurred: leg attachment fittings attached to floor tracks had the seat leg broken off just above the fitting, leg fittings had pulled out of the seat track, and metal had pulled from the seat track slot. Some seats had failed above the attachment fittings, with the legs showing forward bending prior to failures. Several seat pan springs had been stretched beyond their elastic limit. Some seats were found with the forward and aft horizontal seat pan support tubing bent downward. Of the seats examined and found to be bent, all showed bending in the forward direction; there was no evidence of lateral bending on any passenger seat.

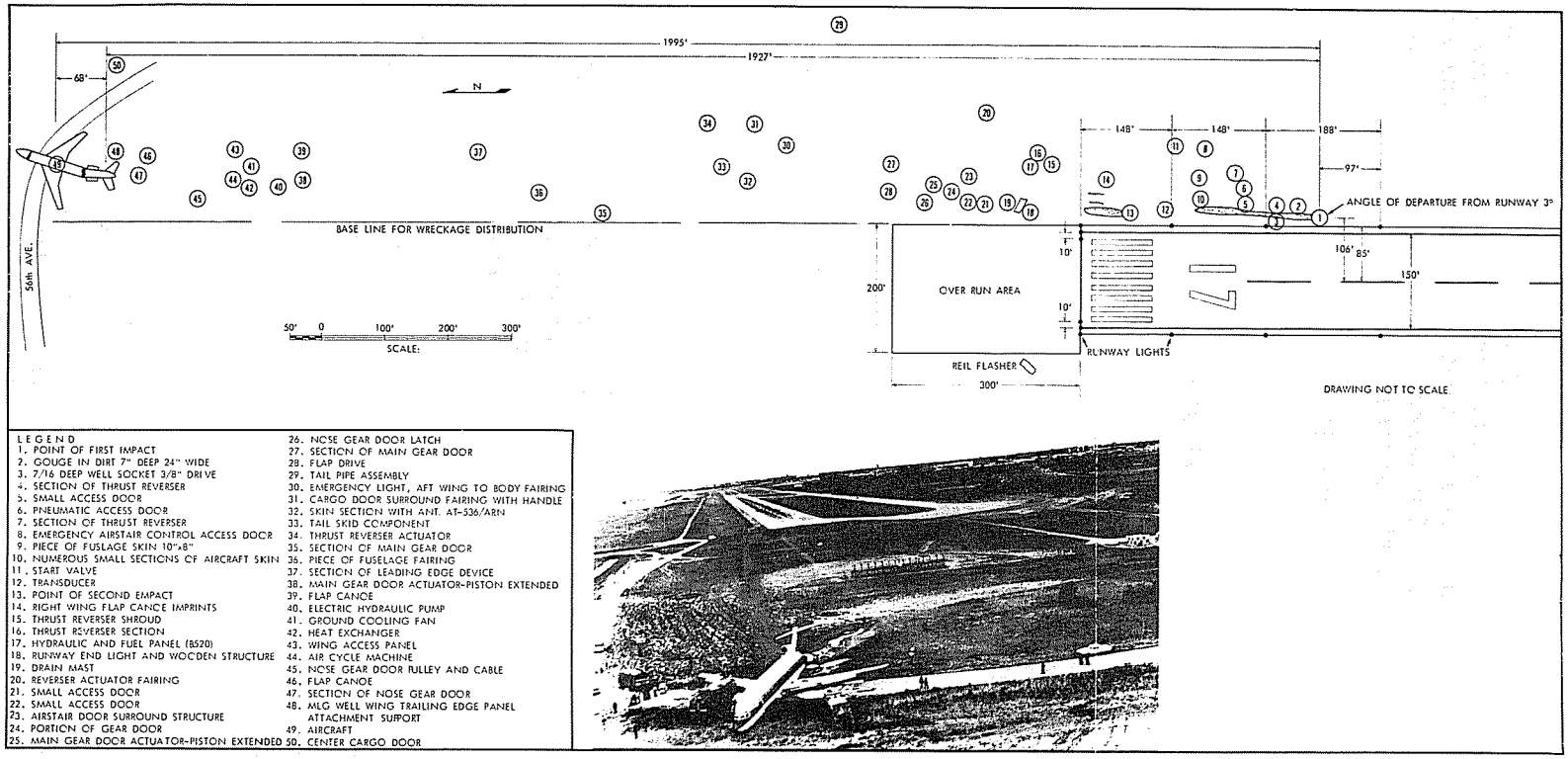


FIGURE C-31. WRECKAGE DISTRIBUTION, N88777

Pax Seat Manufacturer(s)/Model(s). No data in available reports.

Pax Restraint System Performance. There were no passenger seatbelt system failures reported.

Pax Restraint System Manufacturer(s)/Model(s). No data in available reports.

Miscellaneous Cabin Interior Performance. A substantial amount of debris was reportedly flying around the passenger cabin after the initial impact.

OCCUPANT/INJURY INFORMATION

Injuries	Crew	Passengers
Fatal	3*	7
Serious	1	19
Minor/None	0	2

*The Wien Alaska, Inc. cargo-loader is included in this figure.

NOTE: The seven fatally injured passengers sustained severe impact injuries. Of the 21 survivors, 2 escaped with only minor injuries. The remaining 19 received various impact injuries, including leg and arm fractures, multiple cuts, abrasions, and contusions.

Narrative. A Wien Air Alaska, Inc., Fairchild F-27B crashed into a mountain while attempting to land at Gambell Airport on St. Lawrence Island, Alaska. The aircraft sustained severe structural damage and overturned. Most of the seats came loose when the floor lost its structural integrity. According to the NTSB, the decelerative forces were within human tolerance. There was sufficient time for the survivors to escape or be rescued before the fire intensified. Seven passengers and three crewmembers were killed; the aircraft was destroyed by impact and fire.

DATE: 11-12-75
LOCATION: Raleigh, North Carolina
AIRCRAFT OPERATOR: Eastern Air Lines, Inc.
AIRCRAFT DATA:
Make, Model: Boeing 727-200
Serial Number: 20381
Registration Number: N8838E
TYPE OF ACCIDENT: Undershoot, collision with ground, controlled
PHASE OF OPERATION: Final approach, landing
AIRCRAFT DAMAGE: Substantial

Pax Seating Configuration. The passenger cabin was divided into two sections; first class and coach. The first class cabin was configured with five rows (2,3,4, 5, and 6) of double seat units on the left side of the center aisle. All seats were forward facing. The coach section contained 18 rows of triple seat units on

the left side of the center aisle (rows 7 through 25) and 21 rows of seats on the right side of the aisle (rows 7 through 28). All rows on the right side contained triple seat units, except row 27 which was a double seat unit, (figure C-32). All seats were forward facing in the coach section.

Airframe Deformation/Crash Loads. The fuselage was generally intact. There was circumferential compressive buckling in the upper skin at FS 660 and in the lower skin at FS 950 and FS 990. The aft airstair door had separated from the fuselage. The lower skin was abraded and damaged during the landing. All the failures examined were of the overload type.

Pax Seat Performance. In the first class section, only seats 2A, 2B, 3A, and 3B exhibited any failures. The seat legs of these units were displaced down and inboard and were approximately 3 inches lower than other first class seats. In the coach section, nine failures to spring-loaded seat pan extensions were noted (seats 9D, 18B, 21C, 21D, 23D, 23E, 24F, 25E, and 25F). Typical failures showed separation of sheet metal hinge clips from rivets securing the slips to the forward edge of the seat pans. Bending of metal and distortion of rivet holes indicated that the hinges had experienced a downward load.

Pax Seat Manufacturer(s)/Model(s). First class cabin seats: Burns Aero with part No. 86034.101, manufactured for TSO C39 and TSO C39A. Coach cabin seats: Hardman Company with part Nos. 16170-1, -2, model 9827. Row 20, seats A through E: Weber Aircraft Company, part No. 804033-608.

Pax Restraint System Performance. No restrain system failures were reported or found in the aircraft.

Pax Restraint System Manufacturer(s)/Model(s). Data not in available reports.

Miscellaneous Cabin Interior Performance. Occupants reported that on initial impact the forward galley contents spilled on the floor; items fell out of the coat room, and several overhead bins opened. Upon visual inspection, some overhead storage bins were found open and the ceiling access panels above rows 8-9 and 23-24 were found suspended, retained only by their safety cables. The passenger service unit (PSU) row 4, on the right side, was loose at its aft end and was hanging down. In the coach cabin, eight PSU's had failed. The forward overwing emergency exit hatches were found inside in the seats next to the exits. The rear overwing emergency exit hatches were found unlatched but in position in the exit openings. A tray table from seat 17A was deployed adjacent to the rear left overwing hatch; several other tray tables had failed also. The tray table failure next to the overwing exit in row 17 would prevent the hatch from being pulled inboard.

OCCUPANT/INJURY INFORMATION

Injuries	Crew	Passengers
Fatal	0	0
Serious	0	1
Minor/None	8	130

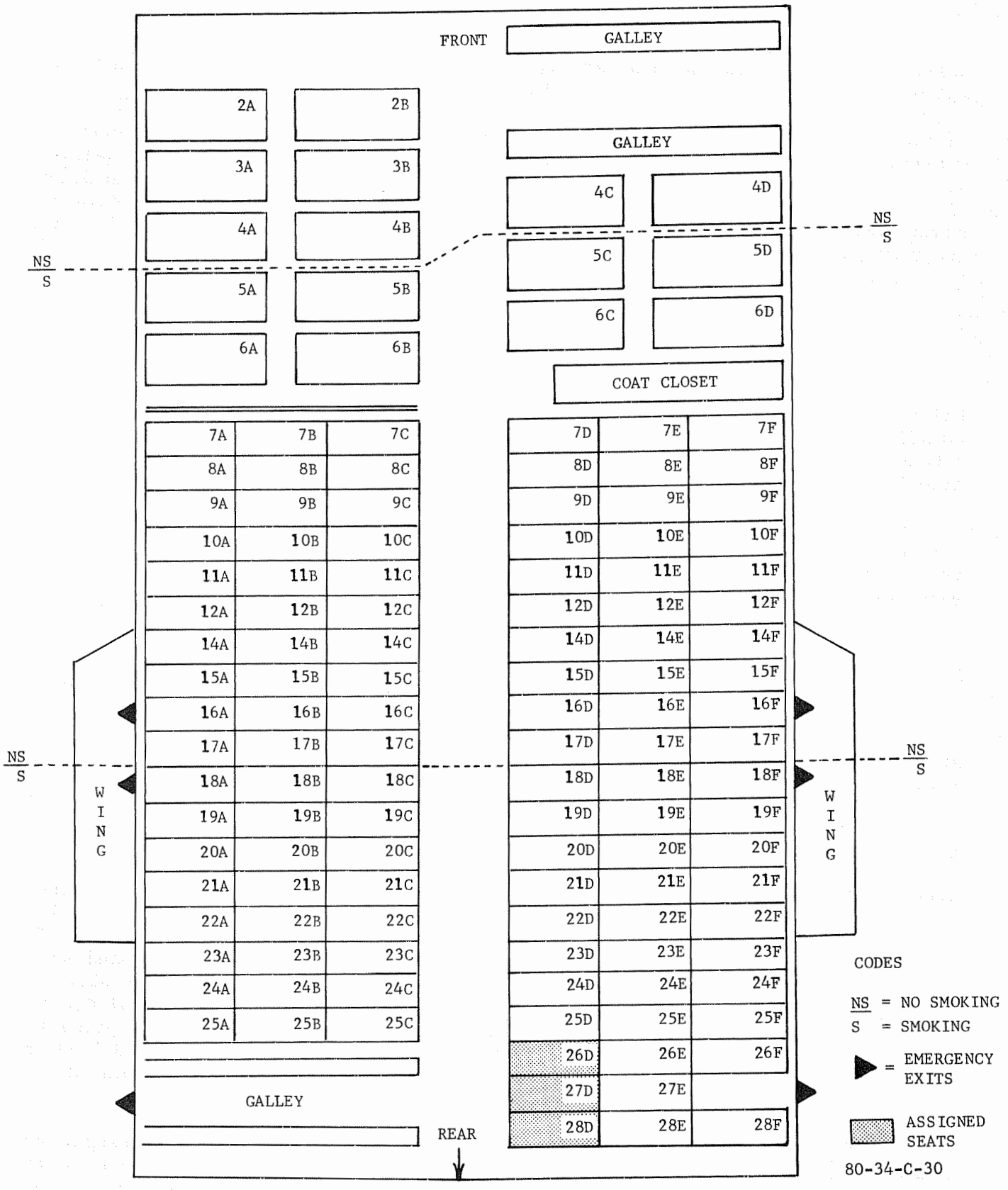


FIGURE C-32. EASTERN AIRLINES, INC., BOEING 727-200, N8838E SEATING CONFIGURATION

NOTE: In addition to the one serious injury, there were seven minor injuries. All of the injuries occurred during the evacuation.

Narrative. An Eastern Air Lines, Inc., Boeing 727-200 crashed on final approach, striking the ground short of runway 23 at the Raleigh-Durham Airport, Raleigh, North Carolina. After its first impact with the ground, the aircraft again became airborne; during its second contact with the ground the aircraft slid down the runway and off the right side. The aircraft came to rest upright on its belly with the nose gear extended. There was no postcrash fire. Of the 139 occupants aboard the aircraft, 8 were injured during the evacuation.

G-21

DATE: 04-05-76
LOCATION: Gravina Island, Kechikan, Alaska
AIRCRAFT OPERATOR: Alaska Airlines, Inc.
AIRCRAFT DATA:
Make, Model: Boeing, 727-81
Serial Number: 18821
Registration Number: N124AS
TYPE OF ACCIDENT: Overshoot, collided with ditches
PHASE OF OPERATION: Landing, level off/touchdown
AIRCRAFT DAMAGE: Destroyed

Pax Seating Configuration. The passenger cabin was configured in first class and coach sections (figure C-33). The first class section contained three rows of double seat units on both sides of the cabin aisle for a total of 12 seats. In place of row 4, a garment bag closet was located on the right side of the cabin and an auxiliary galley was located on the left side. The coach cabin began with row 5 and contained 13 rows of triple seat units on the right side and 16 similar seat units on the left side of the cabin. There were no rows 10 and 11 on either side of the center aisle; also, there were no rows 7, 8, and 9 on the right side of the cabin.

Airframe Deformation/Crash Loads. The fuselage section was broken into three sections. The forward section of the fuselage was fractured at FS 285. This entire section sustained various degrees of impact and ground fire damage. The second section of the fuselage, between FS 285 and FS 1183, was fractured at FS 1030 and received varying degrees of fire damage. The fuselage top skin and adjacent structure between FS 360 and FS 740 down to the passenger window was consumed by fire. The cabin floor between FS 740 and FS 1030 was in place but experienced ground fire damage. The third section of the fuselage from FS 1183 aft was intact but had various degrees of impact damage to the lower side of the fuselage. The central stairs were found open about 6 inches.

Pax Seat Performance. Although fire consumed most of the seats, passenger and flight attendant reports indicated that 16 seats failed, 9 of which were on the left side — rows 6 through 9 (figure C-34). Some passenger seat legs showed evidence of compressive buckling, indicating loads primarily in the downward direction with minimal forward deceleration.

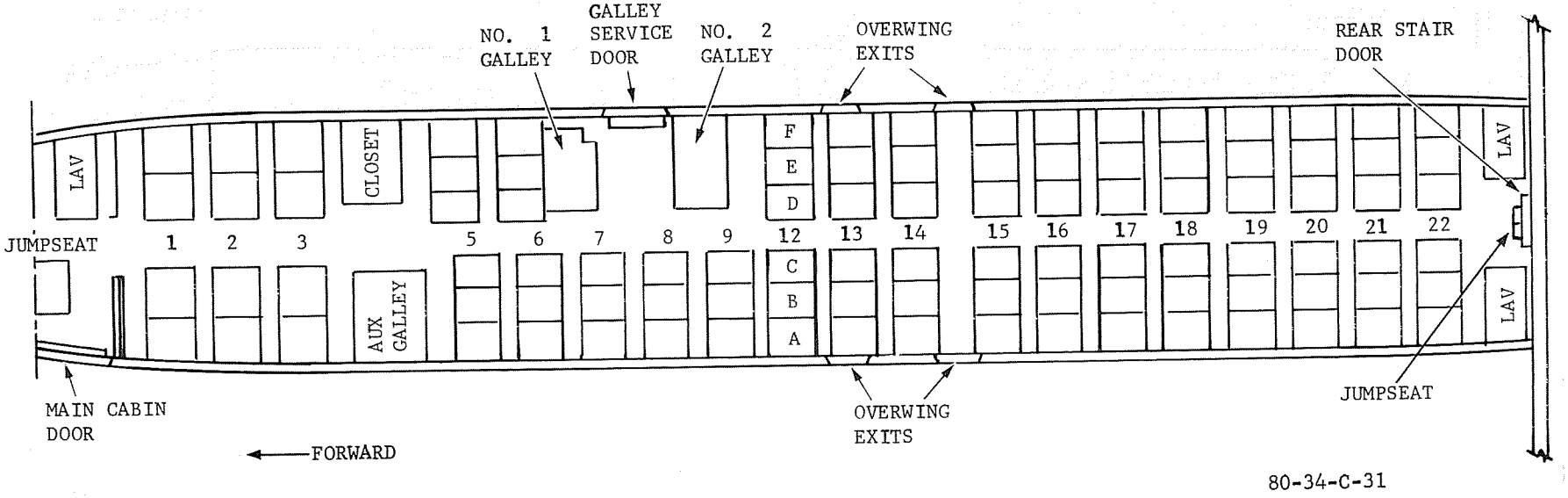
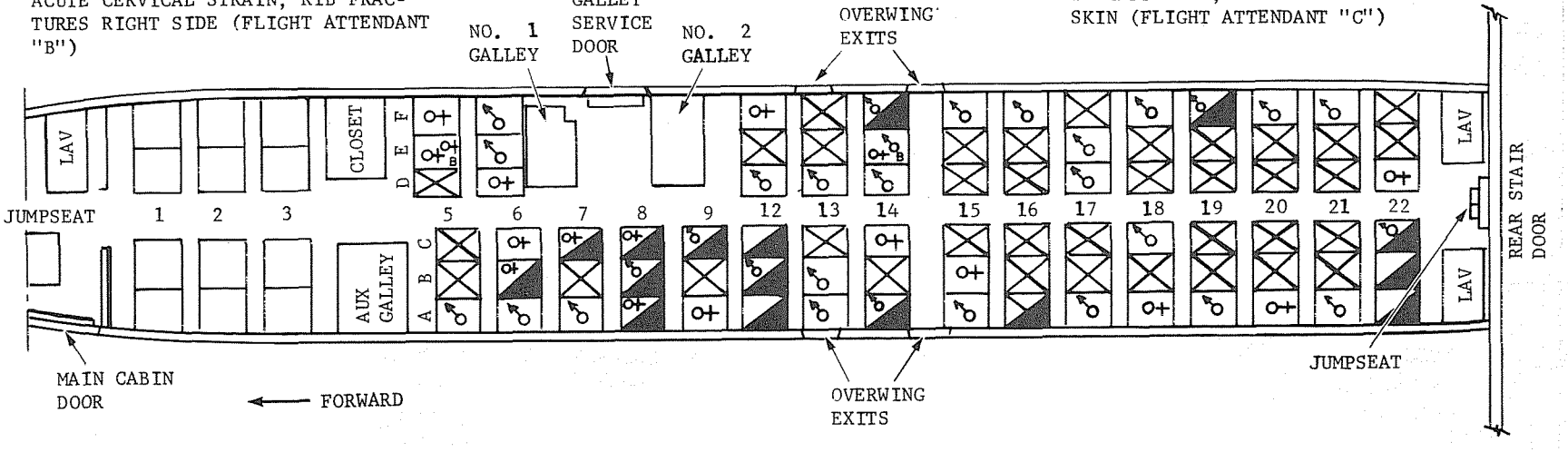


FIGURE C-33. ALASKA AIRLINES, INC., BOEING 727-81, N124AS SEATING DIAGRAM

SEAT	DESCRIPTION OF INJURY
6A	MINOR ABRASION OVER LEFT EYE
6B	FRACTURED SACRUM WITH NERVE DAMAGE
6C	MINOR LEG LACERATIONS BILATERALLY, ABDOMINAL BRUISES, SOFT TISSUE INJURY BOTH FEET (FLIGHT ATTENDANT "A")
7C	CONTUSION TO BACK OF HEAD
8A	MINOR LEG LACERATIONS BILATERALLY, SMOKE INHALATION
8B	RIB FRACTURES, LEG LACERATIONS BILATERALLY
8C	ACUTE CERVICAL STRAIN, RIB FRACTURES RIGHT SIDE (FLIGHT ATTENDANT "B")

SEAT	DESCRIPTION OF INJURY
9A	FATALITY, DEPRESSED SKULL
9C	BILATERAL CONTUSIONS TO SHINS AND CALVES, ABRASIONS TO BOTH HANDS, CONTUSIONS TO RIBS, LEFT HIP, BOTH HEELS
12F	CONTUSIONS TO BOTH ARMS, SEATBELT BRUISES
13B	FRACTURE LEFT FEMUR, FUEL BURNS
13F	LACERATION TO HEAD WHICH REQUIRED 25 SUTURES
14A	SEATBELT BRUISES

SEAT	DESCRIPTION OF INJURY
14C	CONTUSIONS TO FACE AND BACK, FACIAL LACERATIONS (FROM EYEGLASSES), ABDOMINAL BRUISES. BOARDED IN WHEELCHAIR AT JUNEAU.
16F	SEATBELT BRUISES
20A	CLOSED FRACTURE T-12
21A	SEATBELT BRUISE, HAIR SINGED
21F	LACERATED RIGHT HAND, MINOR ABRASIONS, HANDS BURNED, HAIR SINGED.
22C	CONTUSIONS TO LEFT UPPER ARM AND ABOVE RIGHT EYE, CONTUSIONS TO LEFT KNEE, FUEL CONTACT WITH SKIN (FLIGHT ATTENDANT "C")



SEAT	DESCRIPTION OF INJURY
22D	ABDOMINAL BRUISES, HAIR SINGED CONTUSIONS TO BACK OF HEAD, CONTUSIONA RIGHT HIP, CONTUSIONS LEFT ELBOW, FUEL IRRITATION RIGHT EYE (FLIGHT ATTENDANT "D")

CHILDREN

SEAT 5E	AGE	12 MOS (IN ARMS)
SEAT 5F	AGE	3 YEARS
SEAT 14D	AGE	4 WEEKS (IN ARMS)

LEGEND

X: SEAT NOT OCCUPIED
M: EXITED VIA MAIN DOOR
B: EXITED VIA A BREAK IN FUSELAGE
E: EXITED VIA AN OVERWING EXIT
◢: SEAT FAILED

80-34-C-32

FIGURE C-34. N124AS SEAT FAILURE AND INJURY DATA

Pax Seat Manufacturer(s)/Model(s). First class section: Aerotherm, model 608H-2L, -2R; coach section Aerotherm, model 830-200B-3L, -3R. The first class seats were manufactured to TSO C39 and the coach seats to TSO C39a.

Pax Restraint System Performance. No failures reported.

Pax Restraint System Manufacturer(s)/Model (s). The seatbelts were manufactured to TSO C22e.

Miscellaneous Cabin Interior Performance. Occupants reported that during the impact objects were flying overhead and that after impact debris littered the cabin floor.

OCCUPANT/INJURY INFORMATION

Injuries	Crew	Passengers
Fatal	0	1
Serious	5	6
Minor/None	2	36

One flight attendant and three passengers with no serious injuries were hospitalized for over 24 hours; but since the NTSB accident report NTSB-AAR-76-20 documents these as serious injuries, they are recorded that way in this report. Two unticketed infants were among the 36 passengers who sustained minor or no serious injury.

NOTE: Passenger injuries included spinal, leg, and rib fractures, lacerations, contusions, and abrasions. The fatally injured passenger died of impact trauma. Description of injuries are included in figure C-34.

Narrative. An Alaska Airlines, Inc., Boeing 727-81 overran the departure end of runway 11 at Ketchikan International Airport, Ketchikan, Alaska. The aircraft crashed into a ravine and was destroyed by the impact and subsequent ground fire. The fuselage was broken in three places. As a result of the crash, 1 occupant died and 32 others were injured.

G - 22

DATE: 04-27-76
LOCATION: St. Thomas, Virgin Islands
AIRCRAFT OPERATOR: American Airlines, Inc.
AIRCRAFT DATA:
Make, Model: Boeing, 727-95
Serial Number: 19837
Registration Number: N1963
TYPE OF ACCIDENT: Overshoot, collided with object
PHASE OF OPERATION: Landing, level touchdown
AIRCRAFT DAMAGE: Destroyed

Pax Seating Configuration. This aircraft was configured into two classes — first class and coach (figure C-35). The first class section consisted of six rows of double seat units on the left, numbered 2 through 7 longitudinally and A and B laterally. The right side of the aisle consisted of five rows of double seat units numbered 2 through 6, longitudinally and E and F, laterally. The coach section comprised 12 rows of triple seat units on the left, numbered rows 9 through 12 longitudinally and A, B, and C, laterally, while there were 11 rows of triple seat units on the right, numbered 10 through 20 longitudinally and D, E, and F laterally.

Airframe Deformation/Crash Loads. The fuselage broke into three major sections (figure C-36). The first section consisted of the forward portion of the fuselage from the cockpit aft to approximately FS 400 on the left side and FS 380 on the right side. This section was rolled 45° to the left resting against a block building. The second section consisted generally of the cabin from FS 700 (left side) and FS 740 (right side) aft to FS 1100. A section of the cabin between FS 400 to FS 740 was totally consumed by fire. The third section consisted of the entire tail section from FS 1100 aft. The flight data recorder traces indicated that the aircraft's airspeed increased to about 134 knots and then decreased to 127 knots between 30 seconds and 25 seconds before the recording ended. There were two significant steps in the vertical acceleration trace — one, of about 1.35 g's, 16 seconds before the end of the recording and the other, of about 1.5 g's, 3 seconds before the end of the recorded data. The final airspeed recorded was 81 knots.

Pax Seat Performance. Several passenger seats broke loose from their mounts. Some were found outside of the immediate fuselage area. Because of the extensive fire damage, the security of all seats could not be determined.

Pax Seat Manufacturer(s)/Model(s). First class section: Hardman Aerospace, model 9300; coach section: Hardman Aerospace, model 9750. All seats were manufactured against TSO C39.

Pax Restraint System Failures. No restraint system failures reported.

Pax Restraint System Manufacturer(s)/Model(s). No data or failures recorded.

Miscellaneous Cabin Interior Performance. Because fire had consumed the aircraft, it was difficult to determine the extent of cabin interior failures. Buffet A, which is part of the galley, was upright with interior items such as tray carriers, coffeemakers, and oven racks intact and in place, but buffet B had fallen on its side and slightly to the left of buffet A. In the midsection of the aircraft, all the seat track attach fitting shear lugs, not consumed by fire, were locked in the track.

OCCUPANT/INJURY INFORMATION

Injuries	Crew	Passengers
Fatal	2	35
Serious	2	17
Minor/None	3	29

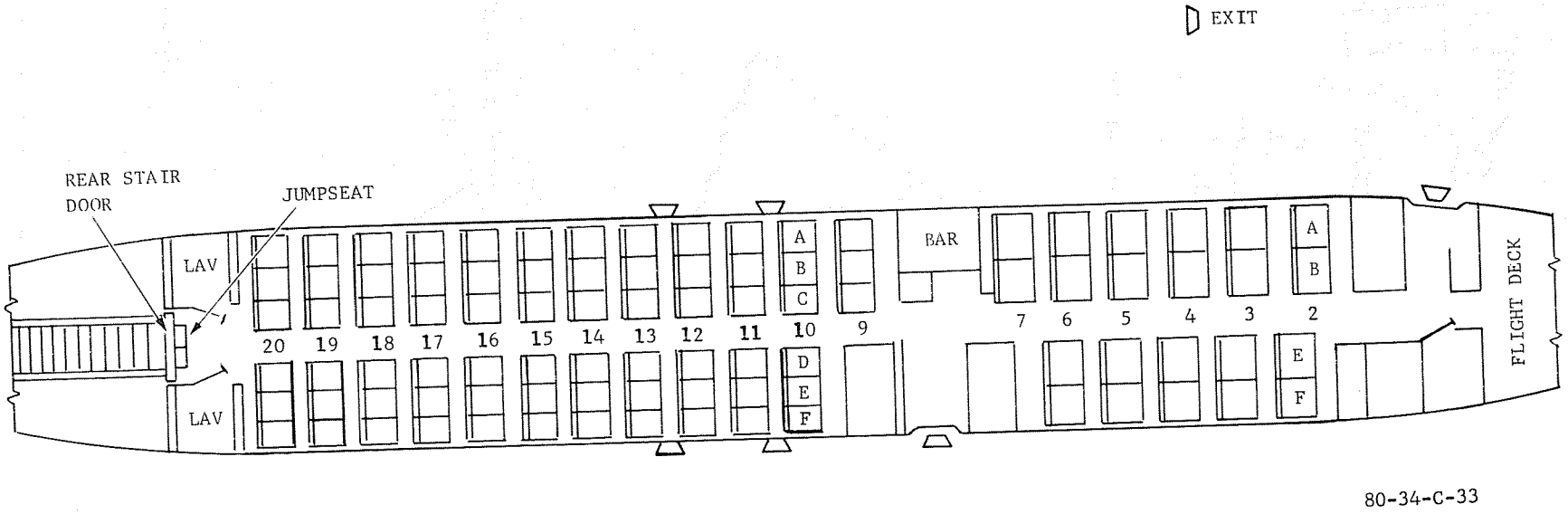


FIGURE C-35. AMERICAN AIRLINES, INC., BOEING 727-95, N1963 SEATING CONFIGURATION

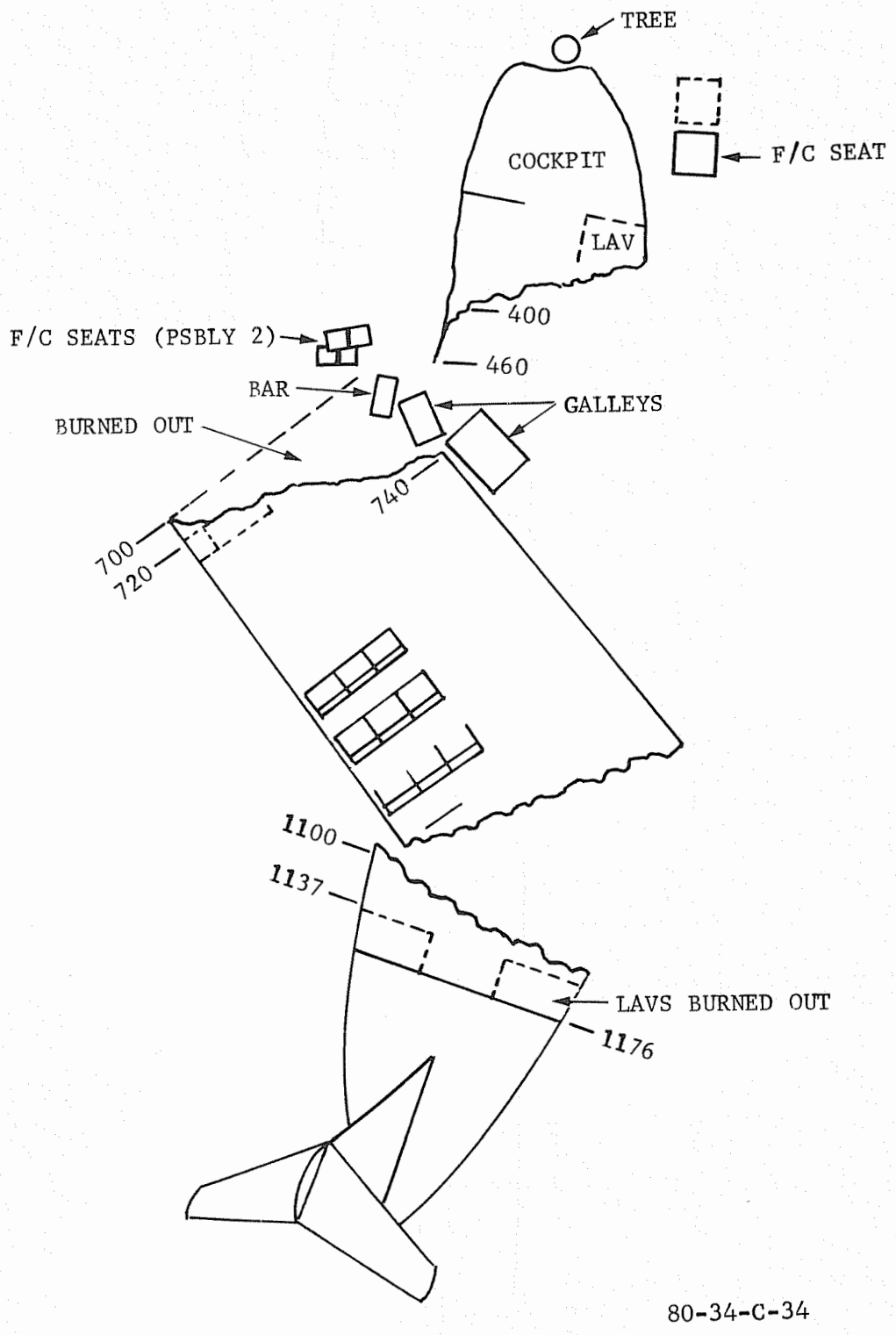


FIGURE C-36. SCHEMATIC OF N1963 AIRFRAME DEFORMATION (NOT TO SCALE)

NOTE: All but three of the surviving occupants received various bodily injuries. These injuries included abrasions, contusions, lacerations, fractures, and burns. The occupants who received fatal injuries died of a combination of impact trauma, smoke inhalation, and third degree burns.

Narrative. An American Airlines, Inc., Boeing 727-95 overran the departure end of the runway, struck the instrument landing system localizer antenna, crashed through a chain link fence, hit an embankment, became airborne, and contacted the ground on the opposite side of the airport's perimeter road. The aircraft fractured into several pieces. Of the 88 persons on board, 35 passengers and 2 flight attendants were fatally injured.

G - 23

DATE: 06-04-76
LOCATION: Guam, Marianas Islands
AIRCRAFT OPERATOR: Air Manila, Inc., Republic of Philippines Registry
AIRCRAFT DATA:
Make, Model: Lockheed, Electra 188A
Serial Number: 1007
Registration Number: RP-C1061
TYPE OF ACCIDENT: Collided with ground
PHASE OF OPERATION: Takeoff
AIRCRAFT DAMAGE: Destroyed

Pax Seating Configuration. The forward cabin section contained 15 forward-facing passenger seats. The main cabin area contained 68 passenger seats and in the extreme aft part of the aircraft there were 6 passenger seats (4 on the left and 2 on the right) in a lounge area (figure C-37). All passenger seats were forward-facing seat units with the exception of one aft-facing double seat unit on the left side (Row 18), and the six seats in the lounge area which were sideward-facing. Those seats were fitted with seatbelts and shoulder harnesses.

Airframe Deformation/Crash Loads. According to the NTSB, the decelerative forces in this accident were within human tolerance; however, the aircraft structure was damaged extensively during the ground slide. Some occupiable areas of the aircraft were crushed; numbers 1, 2, and 4 engines, the propellers, and the empennage were separated from the main fuselage.

Pax Seat Performance. NTSB reports state that seats were reported to have come loose during the accident. The seat structures which were not destroyed by the fire were severely bent and their leg and attachment fittings had failed.

Pax Seat Manufacturer(s)/Model(s). No data available.

Pax Restraint System Performance. No restraint system failure reported.

Pax Restraint System Manufacturer(s)/Model(s). No data available.

Miscellaneous Cabin Interior Performance. No data available.

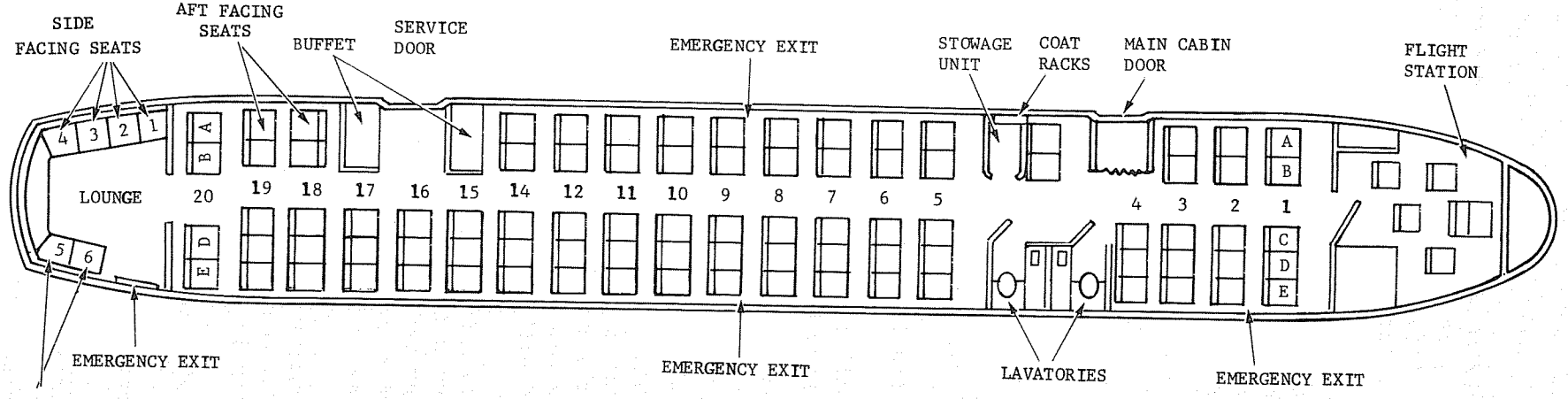


FIGURE C-37. AIR MANILA, INC., L-188A, RP-C1061 SEATING CONFIGURATION

OCCUPANT/INJURY INFORMATION

Injuries	Crew	Passengers
Fatal	12	33
Serious	0	0
Minor/None	0	0

NOTE: Twenty-three of the passengers died from suffocation by smoke inhalation and/or shock from severe burns. The other 10 passengers died from various severe impact injuries. Though one captain and first officer sustained severe traumatic injuries, their official cause of death was smoke inhalation. The flight engineer died from traumatic injuries. Six of the cabin crew members died from suffocation and the remaining three cabin crew members died from traumatic injuries.

Narrative. An Air Manila, Inc., Lockheed L-188 crashed while attempting to take off from the Aguna Naval Air Station, Guam. The aircraft climbed to between 75 and 100 feet, flew level for 1,600 feet, and then struck gradually rising terrain in a tail-low attitude 4,300 feet beyond the end of the runway. The aircraft dragged along the brow of a hill, dropped off a 13-foot embankment, crashed through a chain link fence, slid across a highway, struck a moving vehicle, and burst into flames. None of the occupants survived the impact and ground fire. Seats and occupants were found clear of the main wreckage area.

G-24

DATE: 06-23-76
LOCATION: Philadelphia, Pennsylvania
AIRCRAFT OPERATOR: Allegheny Airlines, Inc.
AIRCRAFT DATA:
Make, Model: McDonnell Douglas, DC-9-31
Serial Number: 4733
Registration Number: N994VJ
TYPE OF ACCIDENT: Collision with ground
PHASE OF OPERATION: Landing, go-around
AIRCRAFT DAMAGE: Destroyed

Pax Seating Configuration. The aircraft was configured into one class. There were 20 rows of passenger seats (figure C-38). The left side contained double occupancy seat units and the right side triple occupancy seat units. The rows were numbered 1 through 20 longitudinally and the seats were lettered laterally A, B (left side of the aisle), and C, D, and E (right side). A table was located between rows 1 and 2 on both sides of the aisle. Row 1 was rearward facing.

Airframe Deformation/Crash Loads. The major damage to the fuselage occurred below the cusp line, at the aft pressure bulkhead, and at the engine stub wing to fuselage attachments. The lower structure of the fuselage nose was severely damaged. The forward trunnion bearing supports (left and right side) were distorted, cracked, and broken from their supporting sheet metal structure. The

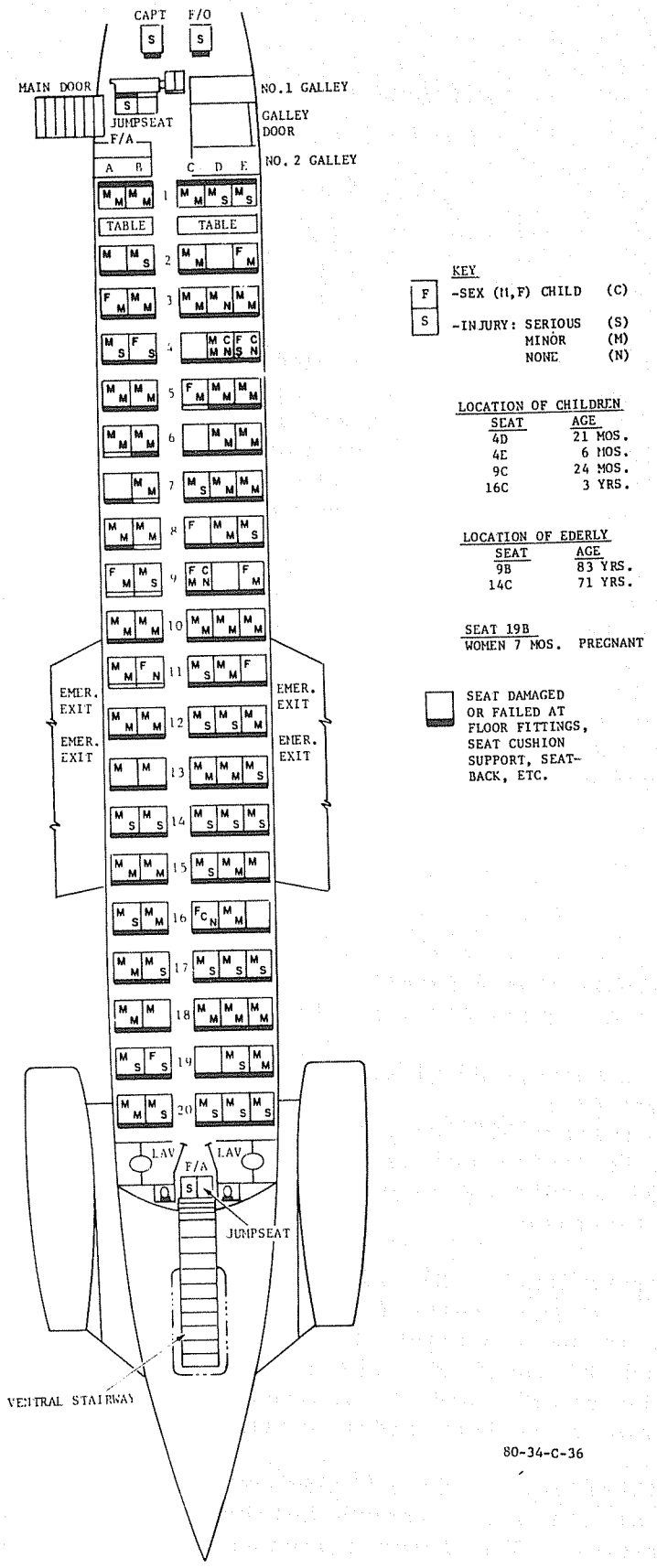


FIGURE C-38. ALLEGHENY AIRLINES, INC., DC-9-31, N994VJ SEATING DIAGRAM INCLUDING INJURIES AND SEAT FAILURES

upper attaching point had penetrated the pressure compartment. The lower skin of the fuselage was torn and abraded with crushing of the associated frames and stringer evident for the full length of the aircraft. The cabin floor was buckled upward above the main landing gears, FS 699 to FS 756. The fuselage tail section separated at FS 996 just aft of the pressure bulkhead. Tension overload failure was noted at the upper gradient. The aircraft came to rest at a heading of about 90° to the runway. According to failure analysis computation done by the NTSB, the initial impact of the rear fuselage with the ground resulted in vertical loads of at least 10 g's in the aft area of the aircraft cabin.

Pax Seat Performance. At impact most seats failed, which caused passengers to be thrown into adjacent seats and pinned some passengers between seats, between the floor and seats, and between seats and side walls. Only 8 of 100 passenger seats were undamaged. Typical damage included compression buckling of seat legs, separated floor fittings, separated lateral support tubes, and torn and separated seatbottom fabric supports. Each passenger seat was examined and the damage describe as follows:

Seat Performance Data. See Table C-3. (NTSB data)

Pax Seat Manufacturer(s)/Model(s). Burns Aero Seat Company, model unknown. The seats complied with TSO C39.

Pax Restraint System Performance. All passenger seatbelts were intact — none failed — and all were found open. All releases operated with no difficulty. However, one passenger stated that his seatbelt loosened at impact.

Pax Restraint System Manufacturer(s)/Model(s). No information available.

Miscellaneous Cabin Interior Performance. Overhead racks had failed at numerous places along the cabin area, spilling their contents. Passengers encountered baggage and garments in the aisle during evacuation. The cabin floor panel forward of the rear stair door was loose; it had moved forward 1 to 1 1/2 inches and was displaced about 2 inches upward. There were some failures reported in the galley areas and failures of overhead ceiling panels.

OCCUPANT/INJURY INFORMATION

Injuries	Crew	Passengers
Fatal	0	0
Serious	4	82
Minor/None	0	20

NOTE: Passenger injuries included cervical, thoracic, lumbar, ankle and arm fractures; cervical and lumbosacral strains; whiplash, facial lacerations, broken teeth, lacerated tongues; and multiple contusions and abrasions to the head, face, and extremities.

Narrative. An Allegheny Airlines, Inc., DC-9-31, crashed while attempting a go-around during an approach to Philadelphia International Airport, Philadelphia,

TABLE C-3. PASSENGER SEAT DATA

Row/Seat	Seat Pan Fabric	Seat Legs	Lateral Fwd Support Tube	Lateral Rear Support Tube	Miscellaneous
1A	Partially separated from rear support tube		Bent downward	Bent downward 3" at wall end	
1B	Torn about 2" at rear tube				Arm rest cover missing
1C	Separated at aft tube aisle side				Seat back displaced forward; coffee pot under seat; baggage restraint bar bent
1D	not damaged	All bent downward and toward aisle			1-D,E,F leaning 3-6" toward aisle; wire beverage cart basket in seat
1E	not damaged	Distorted downward and toward aisle		Deformed downward about 4"; fractured under 1E	
2A	not damaged	Forward leg fractured; rear leg distorted down and toward aisle	Bent downward about 6" at wall end	Bent downward about 6" at wall end	
2B	Separated at rear tube	Forward leg fractured	Bent downward and outboard		Arm rest raised;
2C	Completely detached from rear tube	Forward and rear legs between 2-C, D buckled and bent downward 2"			

TABLE C-3. PASSENGER SEAT DATA (Continued)

Row/Seat	Seat Pan Fabric	Seat Legs	Lateral Fwd Support Tube	Lateral Rear Support Tube	Miscellaneous
2D	Detached from rear tube	Forward and rear legs between 2-C, D buckled and bent downward 2"			
2E	not damaged	Rear leg buckled downward about 4"; forward legs buckled same amount; legs attached to floor track			Arm rest raised; liquor kit lid on seat
3A	not damaged			Deformed downward and separated	
3B	Detached at rear tube; rivets pulled out	Rear aisle leg bent downward and toward aisle about 1"			Tray table on 3B deployed
3 C, D, E					Underseat baggage restraint bar loose laterally only; entire row displaced downward and outboard about 1½"
3C	not damaged				Aisle baggage restraint bar under 3C bent inboard. About 2" clearance between bar and floor.
3D	Detached at rear tube				Forward edge of seat pan is about 6" above floor

TABLE C-3. PASSENGER SEAT DATA (Continued)

Row/Seat	Seat Pan Fabric	Seat Legs	Lateral Fwd Support Tube	Lateral Rear Support Tube	Miscellaneous
3E	not damaged				
4A	not damaged	Rear leg under 4A deformed downward and inboard		Tube fractured at leg	Tray table deployed; Row 4-A, B displaced downward and toward aisle about 1"
4B	not damaged				
4C	Completely separated from rear tube				Aisle baggage restraint bar bent under seat pan and about 3" from floor
4D	not damaged		Wrinkles on both sides of 4D (seats 4-C, E are cantilevered from the two legs to either side of 4D)		Floor raised about 1" under 4D and increases slightly until floor levels again at 7-C,D,E
4E	not damaged	Rear leg is fractured and separated from floor track			
4-C,D,E		All legs bent downward and inboard			Entire row is bent downward and toward aisle
5-A,B					Entire row is displaced downward and toward aisle
5A	not damaged				

TABLE C-3. PASSENGER SEAT DATA (Continued)

Row/Seat	Seat Pan Fabric	Seat Legs	Lateral Fwd Support Tube	Lateral Rear Support Tube	Miscellaneous
5B	not damaged				
5C	not damaged				Aisle baggage restraint bar bent upward and inboard (typical of many seen)
5D	Separated at rear tube	Both legs deformed downward about 1" and inboard at floor			5-D,E displaced downward; floor under 5D buckled and pushed upward about 6"
5E	not damaged				Outboard arm rest moved upward
6A	not damaged	Legs between 6-A,B displaced downward and inboard			
6B	Separated at rear tube and free end on floor	Rear aisle side leg displaced downward and toward aisle			Tray table deployed
6C	Separated at rear tube and free end on floor				Aisle baggage restraint bar bent under seat pan
6D	Separated at reat tube and free end on floor				
6E	not damaged			Cracked and displaced downward	6C and E displaced downward about 1½"

TABLE C-3. PASSENGER SEAT DATA (Continued)

Row/Seat	Seat Pan Fabric	Seat Legs	Lateral Fwd Support Tube	Lateral Rear Support Tube	Miscellaneous
5-C,D 6-C,D					Tilted toward aisle
7A	not damaged	Leg between 7-A,B deformed downward; no lateral displacement of leg			
7B	not damaged				
7-C,D,E		Leg between 7-C,D free of floor tie down; also bent downward and toward aisle with some forward displacement			Row held up by leg between 7-D,E; Row failed completely and was resting on floor
7C	not damaged				Tray table deployed; aisle baggage restraint bar bent up and snagged on bottom cushion
7D	not damaged			Bent downward outboard of leg between 7-D,E	
7E	not damaged				Arm rest stowed up
8A	Separated at inboard edge of rear tube. Rivets did not pull out				
8B	not damaged				8-C,D tilted toward aisle
8-C,D,E					

TABLE C-3. PASSENGER SEAT DATA (Continued)

Row/Seat	Seat Pan Fabric	Seat Legs	Lateral Fwd Support Tube	Lateral Rear Support Tube	Miscellaneous
8C	Separated at rear tube				
8D	Separated at rear tube				
8E	not damaged			Crack at leg between 8-D,E	Seat displaced down about 2"
9A	not damaged				
9B	not damaged				
9-C,D,E					Row displaced slightly inboard and downward
9C	Separated at rear tube				
9D	not damaged		Compression wrinkle outboard of leg between 9-D,E	Compression wrinkle outboard of leg between 9-D,E; crack located in wrinkle	Crack located near weld in outboard lateral brace at seat pan frame
9E	Torn - no rivets pulled out - at rear tube				Aisle side of seat frame bent downward
10A	Partially separated at outboard edge	Forward leg fractured and distorted downward		Cracked	
10B	not damaged			Bent downward	
10-C,D,E					Row displaced downward, forward, and toward aisle about 4"

TABLE C-3. PASSENGER SEAT DATA (Continued)

Row/Seat	Seat Pan Fabric	Seat Legs	Lateral Fwd Support Tube	Lateral Rear Support Tube	Miscellaneous
10C	not damaged	Forward and rear legs fractured and compressed downward			Aisle baggage restraint bar folded upward under seat; seat resting on floor on aisle side
10D	not damaged	Forward and rear legs fractured and compressed downward			
10E	not damaged			Cracked	
11A	not damaged				Seatback displaced forward
11B	not damaged				Seat back displaced forward
11C	Separated and fabric torn	Rear leg compressed about 1"		Fractured	11-C,D depressed about 2" downward
11D	Separated at rear tube	Forward leg compressed about 1"			
11E	Separated from rear tube			Fractured	
12A	not damaged	Rear leg compressed 1"			
12B	not damaged	Rear leg compressed			

TABLE C-3. PASSENGER SEAT DATA (Continued)

Row/Seat	Seat Pan Fabric	Seat Legs	Lateral Fwd Support Tube	Lateral Rear Support Tube	Miscellaneous
12C	not damaged	Forward and rear legs fractured and compressed about 1"			
12D	Separated from rear tube			Wrinkled	Forward edge of seat resting on floor
12E	not damaged		Wrinkled	Fractured and bent downward	Seat tie down rail fractured; seat back folded rearward
13A	not damaged	Forward and rear legs fractured and compressed about 4"			
13B	not damaged	Forward and rear legs wrinkled downward	Wrinkled	Wrinkled	Flooring between seat tracks raised; outboard seat track fractured
13-C,D,E					Row resting on floor
13C	not damaged	Rear leg fractured at top and bottom; forward leg bent forward about 6"			Aisle baggage restraint compressed; seat back displaced full forward
13D	not damaged	Rear leg fractured at floor; forward leg compressed about 4" and bent forward about 6"	Fractured	Fractured	
13E	not damaged				Cover missing from seat cushion

TABLE C-3. PASSENGER SEAT DATA (Continued)

Row/Seat	Seat Pan Fabric	Seat Legs	Lateral Fwd Support Tube	Lateral Rear Support Tube	Miscellaneous
14-A,B		All legs fractured			Seats turned about 45° in outboard direction
14A	not damaged	Forward and rear legs free of floor track			Outboard floor track fractured in three places; floor raised and buckled; Blood on wall next to seat
14B	not damaged	Rear leg attached to floor track; forward leg free from floor track			2 shelves from magazine rack under 14B
14-C,D,E					Row turned 60° to aisle and extended in to aisle about 12"
14C	not damaged	Both legs fractured at floor and bent forward about 12"			Tray table deployed; blood on tray table
14D	not damaged	Rear leg fractured; forward leg compressed and twisted			Seat back displaced forward; Side support tube on pan compressed 1"
14E	Partially separated from rear tube		Compressed	Fractured	
15A		Rear leg fractured and compressed; forward leg compressed and bent about 4" toward aisle			

TABLE C-3. PASSENGER SEAT DATA (Continued)

Row/Seat	Seat Pan Fabric	Seat Legs	Lateral Fwd Support Tube	Lateral Rear Support Tube	Miscellaneous
15B	Partially separated at rear tube	Forward and rear legs compressed			
15C	Separated from rear tube	Forward leg compressed slightly; rear leg fractured at top and at floor; also compressed about 1"			Tray table deployed; seat pan side tube fractured at forward end; baggage aisle restraint bar folded under seat
15-D,E					Seat backs displaced rearward 8-10"
15D	Separated at rear tube	Forward leg compressed slightly; rear leg fractured at floor and compressed about 1"	Buckled		Tray table deployed; seat pan side tube fractured at rear
15E		Rear leg fractured and compressed about 4"			Seat pan side tube fractured at forward end
16A	not damaged	Forward leg compressed about 2" and fractured; rear leg compressed about 3" and fractured at floor end.			Wallet with identification of R. Berryman found at seat. Tray table down and its latch was missing
16B	Separated from rear tube	Forward leg compressed about 1". Rear leg compressed about 3" and fractured at floor end			Tray table down
16C	Separated from rear tube	Forward leg compressed about 2". Rear leg compressed about 1"			Tray table down; aisle baggage restraint bar folded upward

TABLE C-3. PASSENGER SEAT DATA (Continued)

Row/Seat	Seat Pan Fabric	Seat Legs	Lateral Fwd Support Tube	Lateral Rear Support Tube	Miscellaneous
16D	not damaged		Buckled	Buckled	
16E	not damaged			Fractured and outboard portion bent down about 2"	Side support fractured at forward end allowing seat back to be displaced rearward about 6"
17A	not damaged			Fractured and compressed at outboard end	
17B	Separated at rear tube				The contoured back of the magazine rack was found in front of seat
17-C,D,E					Entire row compressed downward and about 4" above floor
17C	Partially separated in center of tube				Seat back displaced forward; Coupon for C.R. Cowan found under seat
17D	Partially separated	Forward leg fractured at floor	Buckled		Seat back displaced forward; seat displaced downward about 6-8"
17E	not damaged			Buckled and compressed at side outboard	Seat back displaced forward; seat cushion on floor

TABLE C-3. PASSENGER SEAT DATA (Continued)

Row/Seat	Seat Pan Fabric	Seat Legs	Lateral Fwd Support Tube	Lateral Rear Support Tube	Miscellaneous
18A	not damaged	Forward leg fractured at floor; rear leg fractured at floor; both legs compressed about 4"	Buckled near outboard end about 2"	Buckled and end penetrated wall about 2"	
18B	Separated at rear tube	Forward leg compressed about 1" at top of leg; rear leg compressed about 2" at floor end of leg			Plastic bag containing hand soap on seat; blood like stain on rear tube under bottom cushion; no stain on cushion or elsewhere on seat or on floor
18-C,D,E					All seat backs displaced forward. All legs collapsed and resting on floor
18C	Partially separated				
18D	not damaged				Bottom cushion on floor
18E	not damaged				
19A	not damaged	Forward leg fractured at floor end and compressed; rear leg compressed			Tray table deployed
19B	not damaged	Both legs compressed			Tray table deployed
19-C,D,E		Rear legs fractured and compressed down; legs attached to floor			Row resting on floor
19C	not damaged				Small portable radio in seat

TABLE C-3. PASSENGER SEAT DATA (Continued)

Row/Seat	Seat Pan Fabric	Seat Legs	Lateral Fwd Support Tube	Lateral Rear Support Tube	Miscellaneous
19D	not damaged				
19E	not damaged			Fractured at outboard side and compressed about 2"	
20-A,B					Row moved outboard about 2"
20A	not damaged	Forward leg fractured at floor; rear leg fractured at floor			Seat compressed about 6"
20B	Separated at rear tube	Forward leg compressed about 6" down and about 2" toward aisle; rear leg compressed about 2" down and about 2" toward aisle			
20-C,D,E		Forward legs free of floor tracks; rear legs compressed downward			All legs fractured;rear portion of seat row resting on floor and displaced rearward about 45°; row moved into aisle about 8-10"; baggage restraint bar loose
20C					
20D					Seat pan side tube compressed
20E		Forward leg fittings pulled out of track		Fractured	Seat pan side tube fractured
20D					Blood like stain on aft bottom edge of trim below seat back

Pennsylvania. The wreckage came to rest about 6,000 feet beyond the threshold and about 350 feet to the right of the centerline of runway 27R. Of the 106 persons on board, 86 persons were injured. There were no fatalities. The survival of all occupants was the result of a combination of several factors. The aircraft hit the ground in a tail-low, wings-level attitude with the landing gear retracted and slid along level terrain. Consequently, the fuel tanks did not rupture and there was no fire. According to the NTSB injuries resulted from vertical loads of at least 10 g's caused by the initial impact of the rear fuselage with the ground, followed by the nose impact. Approximately 12 passengers were immobilized by injuries or trapped by failed seats and were still in the cabin when the crash-fire-rescue personnel arrived.

G-25

DATE: 04-04-77
LOCATION: New Hope, Georgia
AIRCRAFT OPERATOR: Southern Airways, Inc.
AIRCRAFT DATA:
Make, Model: McDonnell Douglas, DC-9-31
Serial Number: 47393
Registration Number: N1335U
TYPE OF ACCIDENT: Engine failure, collision with ground
PHASE OF OPERATION: Landing, level-off touchdown
AIRCRAFT DAMAGE: Destroyed

Pax Seating Configuration. The passenger cabin consisted of a single class configuration (figure C-39). There were 20 rows of seats. Double unit seats were on the left side of the aisle with triple unit seats on the right side of the aisle. The rows were numbered 1 through 20, longitudinally, while the seats were lettered A through E, laterally (from left to right).

Airframe Deformation/Crash Loads. The aircraft fuselage broke into five major sections (figure 40): (1) the nose section rearward to FS 148; (2) FS 148 to FS 275, which contained the cockpit bulkhead forward passenger door, service door, and four cabin windows; (3) FS 275 to FS 579, which contained 12 cabin windows; (4) FS 579 to FS 870, which contained the wing center section; and (5) FS 870 to FS 1090, which included the engine pylons, APU, and the aft pressure bulkhead. Additionally, the empennage section had separated at FS 1090.

The first section came to rest inverted; fire did not damage this section. The third section also came to rest inverted with no fire damage. The fourth and fifth sections were substantially damaged by fire.

As the aircraft crashed into the trees, the forward cabin (3) rolled to its left 180° and split open. Sections 4 and 5 collided with at least two large pine trees and experienced decelerative forces along their lateral axis when the trees were struck and uprooted. The structure of these sections experienced high lateral and other multidirectional forces.

Pax Seat Performance. Several passenger seats from section 2 were found outside the section. All seats showed evidence of compressive buckling to the right.

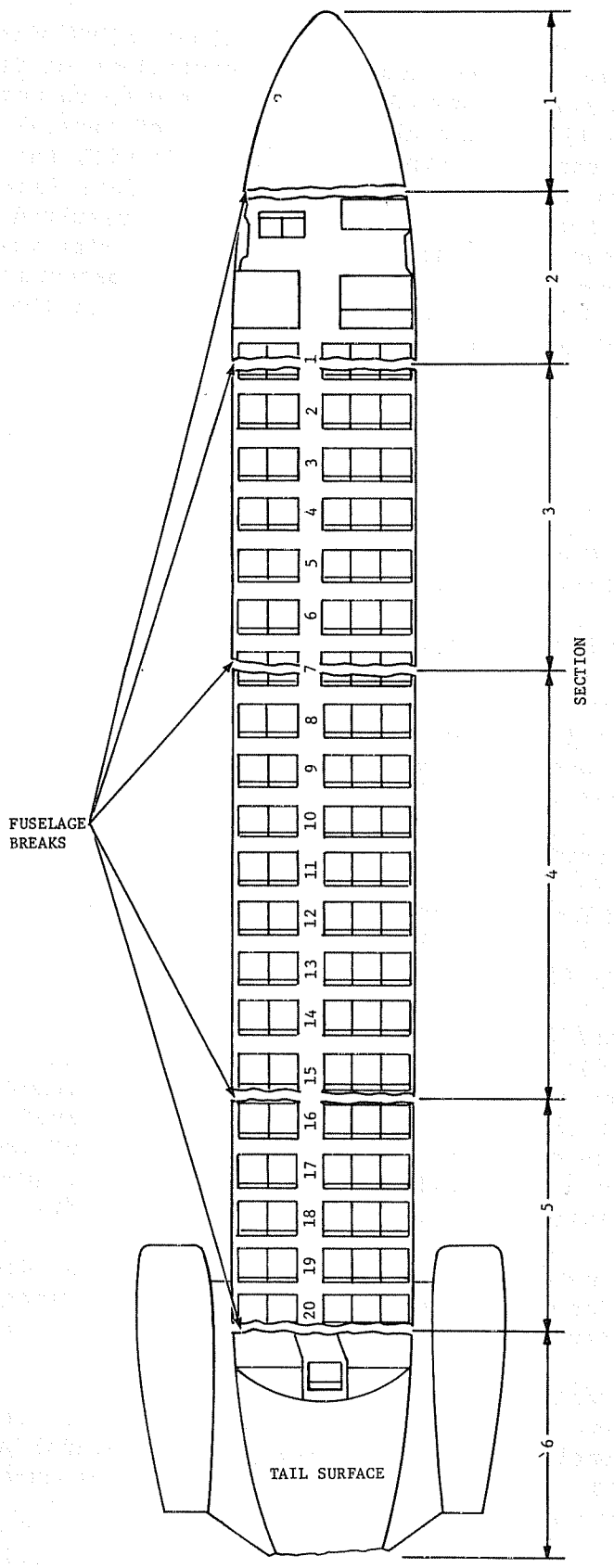


FIGURE C-39. SOUTHERN AIRWAYS, INC., DC-9-31, N1335U SEATING CONFIGURATION

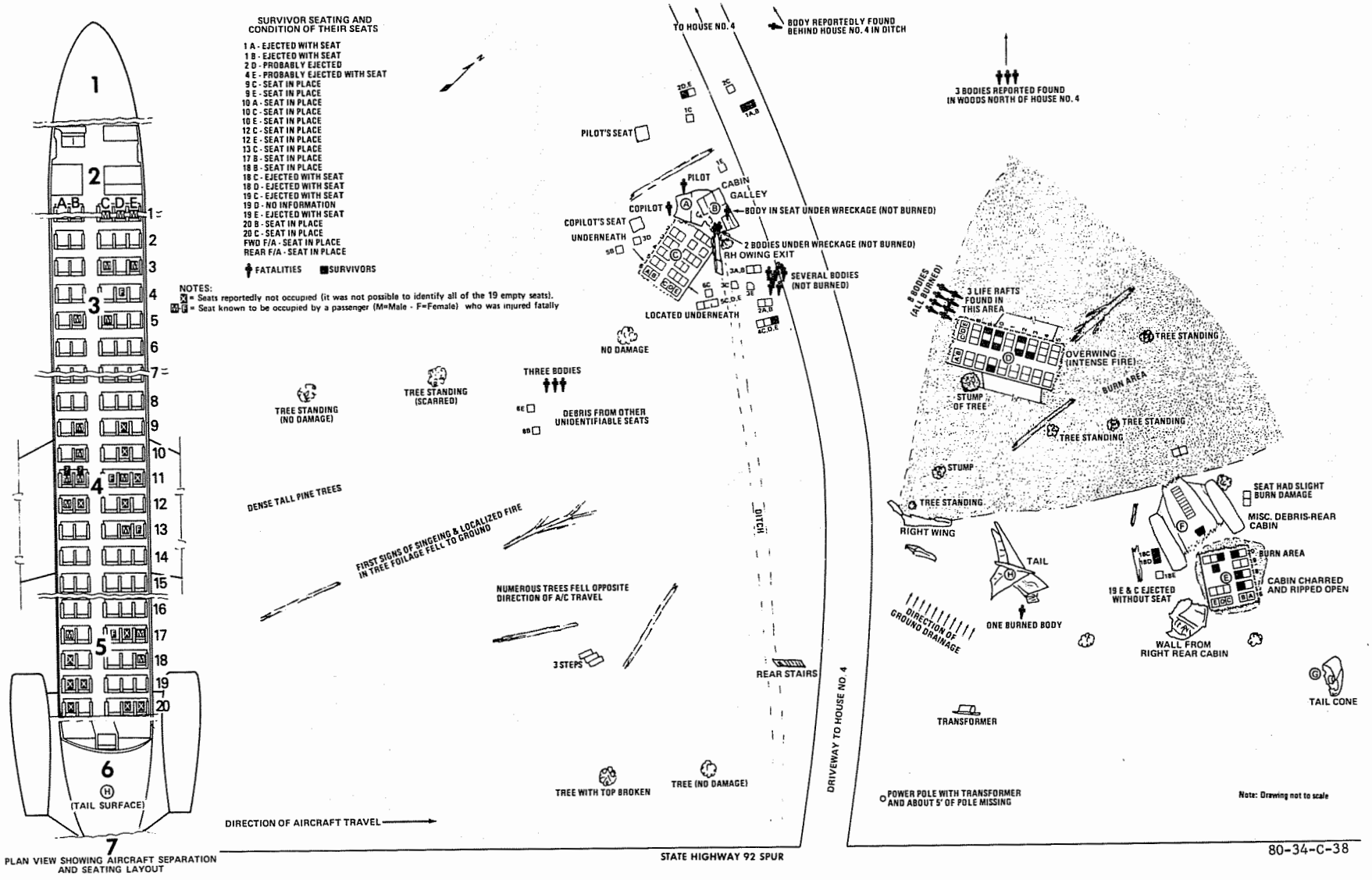


FIGURE C-40. SCHEMATIC DIAGRAM OF N1335U ACCIDENT SITE INCLUDING PASSENGER LOCATIONS

Section 3 was inverted and most of the passenger seats separated from their tracks. Many seats were scattered around the section. In section 4 all the cabin seats and floor were consumed by fire. Most of the seats located in section 5 had separated from their tracks and were scattered around the section (figure C-41). Some of them were substantially damaged by fire.

Pax Seat Manufacturer(s)/Model(s). According to Southern Airways, the passenger seats could have been manufactured by Burns Aero Seat Company or by Aerosmith, Inc., and a mix of these seats might have been on board.

Pax Restraint System Performance. No passenger restraint system failures were reported.

Pax Restraint System Manufacturer(s)/Model(s). The passenger seatbelts were of the metal-to-metal type and manufactured by American Safety, part No. 500524, TSO-C22e, NAS 802, rated at 1,500 pounds.

Miscellaneous Cabin Interior Performance. The passenger and service doors were jammed. The forward galleys and closets were damaged, but were generally in place; their contents, however, were scattered about the area.

OCCUPANT/INJURY INFORMATION

Injuries	Crew	Passengrs
Fatal	2	60
Serious	1	21*
Minor/None	1	0

*Two persons died 1 month after the accident.

NOTE: All the survivors received injuries, either musculoskeletal trauma, burns, or a combination of trauma and burns. Both the flight deck crewmembers and 31 passengers died of extensive trauma. Twenty passengers died of burns and smoke inhalation while nine deaths were attributed to a combination of trauma and burning and/or smoke inhalation.

Narrative. A Southern Airways, Inc., McDonnell Douglas DC-9-31 crashed while attempting an emergency landing on a highway after losing both engines in flight. The aircraft struck road signs, utility poles, fences, trees, shrubs, gasoline pumps at a gas station, five automobiles, and a truck. It broke into five major pieces before coming to rest. Fire erupted in the wing and rear cabin areas. Twenty-three occupants survived the accident.

G-26

DATE: 05-08-78
LOCATION: Escambia Bay, off Pensacola, Florida
AIRCRAFT OPERATOR: National Airlines, Inc.
AIRCRAFT DATA:
Make, Model: Boeing, 727-235

FIGURE C-41. N1335U CABIN WRECKAGE

Serial Number: 19464
Registration Number: N4744NA
TYPE OF ACCIDENT: Collision with water
PHASE OF OPERATION: Approach, landing
AIRCRAFT DAMAGE: Substantial

Pax Seating Configuration. The aircraft seating was a standard 727-235 configuration (figure C-42). The first class cabin consisted of seven double seat units, four on the left side of the center aisle and three on the right side (rows 2, 3, and 4). There were 40 triple seat units on either side of a center aisle and one double seat unit (row 26) in the coach section of the aircraft.

Airframe Deformation/Crash Loads. The underside of the fuselage was buckled, compressed, and crushed. It was buckled from FS 178 to FS 196 and showed minor damage from FS 360 aft to about FS 700. Compression wrinkles were noted in the left hand lower fuselage skin about FS 680. The wrinkles extended from an area 30 inches above the upper wing skin down to the keel beam area. The keel beam structure in the area of FS 740 was displaced upward about 30 inches. The associated structure on each side of the beam was compressed upward.

The underside of the fuselage from FS 950 E aft including the two aft cargo doors and the aft airstairs had separated from the aircraft as had the nose and main landing gears. The bulkhead assemby at FS 1342 had separated from the right fuselage structure; however, it was still attached to the left fuselage structure.

Pax Seat Performance. Seat damage was observed at rows 26, 27, and 28 where the seats and seat row units had either canted, pivoted, or separated. Seat row unit at row 26 was canted to the right; both outboard seat track fittings had separated. The seat unit at row 27 exhibited separation of all four legs. Portions of the outboard legs were still attached to the floor tracks. Seat row 28 was separated with portions of the outboard track still attached to legs which were extensively distorted.

Pax Seat Manufacturer(s)/Model(s). No data in available reports.

Pax Restraint System Performance. No seatbelt failures were reported.

Pax Restraint System Manufacturer(s)/Model(s). No data in available reports.

Miscellaneous Cabin Interior Performance. The cockpit entry door separated inward but did not impede egress from the cabin. The left forward clothes closet in the passenger cabin became dislodged, shifted forward, and according to the crew, delayed the opening of the forward passenger door. A floor access panel (about 33 by 15 inches) in the first class cabin aisle between the forward passenger and galley door came loose on impact. All galleys remained secured. Except for several lightweight trim panels and a ceiling panel in the rear of the cabin, all overhead storage racks and ceiling panels remained secured (figure C-43).

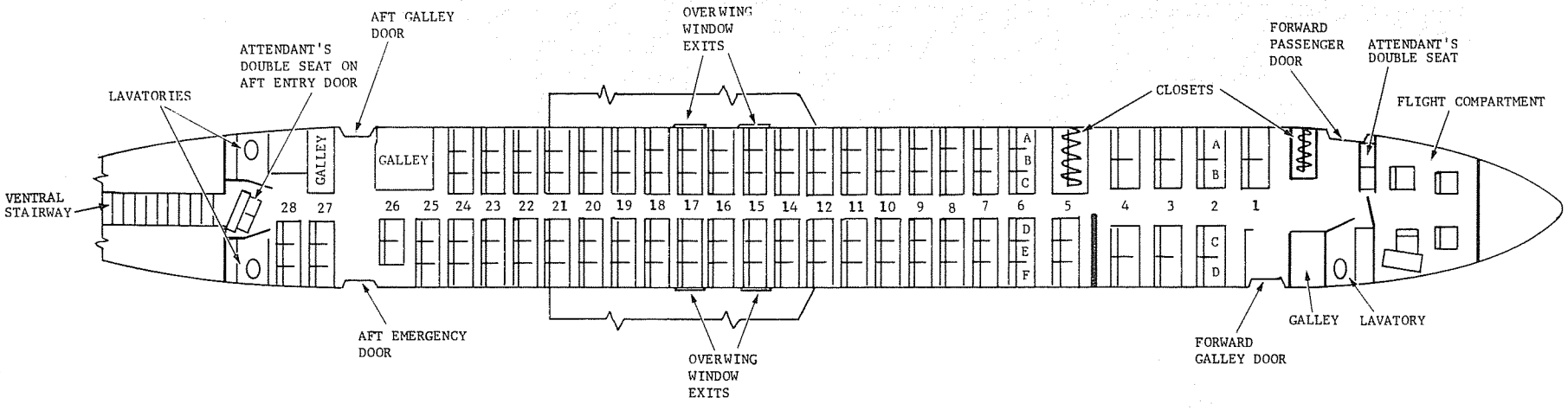


FIGURE C-42. NATIONAL AIRLINES, INC., BOEING 727-235, N4744NA SEATING CONFIGURATION

FIGURE C-43. N4744NA INTERIOR CABIN VIEW AFTER ACCIDENT

OCCUPANT/INJURY INFORMATION

Injuries	Crew	Passengers
Fatal	0	3
Serious	2	9
Minor/None	4	40

NOTE: The three fatalities were caused by drowning. The serious injuries appeared to be impact injuries.

Narrative. A National Airlines, Inc., Boeing 727-235 was inbound on an airport surveillance radar approach to the Pensacola Regional Airport. The aircraft struck water in Escambia Bay approximately 3 miles short of the east end of runway 25 and came to rest in about 12 feet of water. Water and fuel quickly entered the cabin through the dislodged aft bulkhead door and a large hole torn in the floor under the two aft most seat rows. The passengers evacuated the cabin as the aircraft settled, tail first. There were 52 passengers and a crew of 6 on board; 3 passengers drowned. A large barge in the vicinity of the accident site rescued most of the survivors within approximately 30 minutes of impact; others were rescued simultaneously by a motor boat.

G-27

DATE: 12-28-78
LOCATION: Portland, Oregon
AIRCRAFT OPERATOR: United Air Lines, Inc.
AIRCRAFT DATA:
Make, Model: McDonnell Douglas, DC-8-61
Serial Number: 45972
Registration Number: N8082U
TYPE OF ACCIDENT: Collision with ground/water, controlled
PHASE OF OPERATION: Approach, landing
AIRCRAFT DAMAGE: Destroyed

Pax Seating Configuration. The aircraft was configured in a two-class (first and coach) arrangement (figure C-44). The first class cabin contained 12 seats, and the coach section contained 177 seats. There were 35 rows of seats in the aircraft, numbered 1 through 35. Seat designations are illustrated in the figure C-44.

Airframe Deformation/Crash Loads. The fuselage from FS 200 forward received severe and extensive impact damage in a generally rearward direction. Fuselage skin and associated stringers from a point just below the cabin window on the left side of the fuselage at FS 280 forward to FS 200 had been torn away. Also, on the left side of the fuselage, the window at FS 250 was in position but was smashed; the fuselage skin and associated support structure on the lower and underside of the aircraft from FS 200 aft to about FS 300 was torn and crushed. There was also a 2- by 2-foot depression between the cabin windows (at FS 834 and FS 879) and extensive tearing and crushing type damage (from FS 960 aft to FS 1040). The structure was

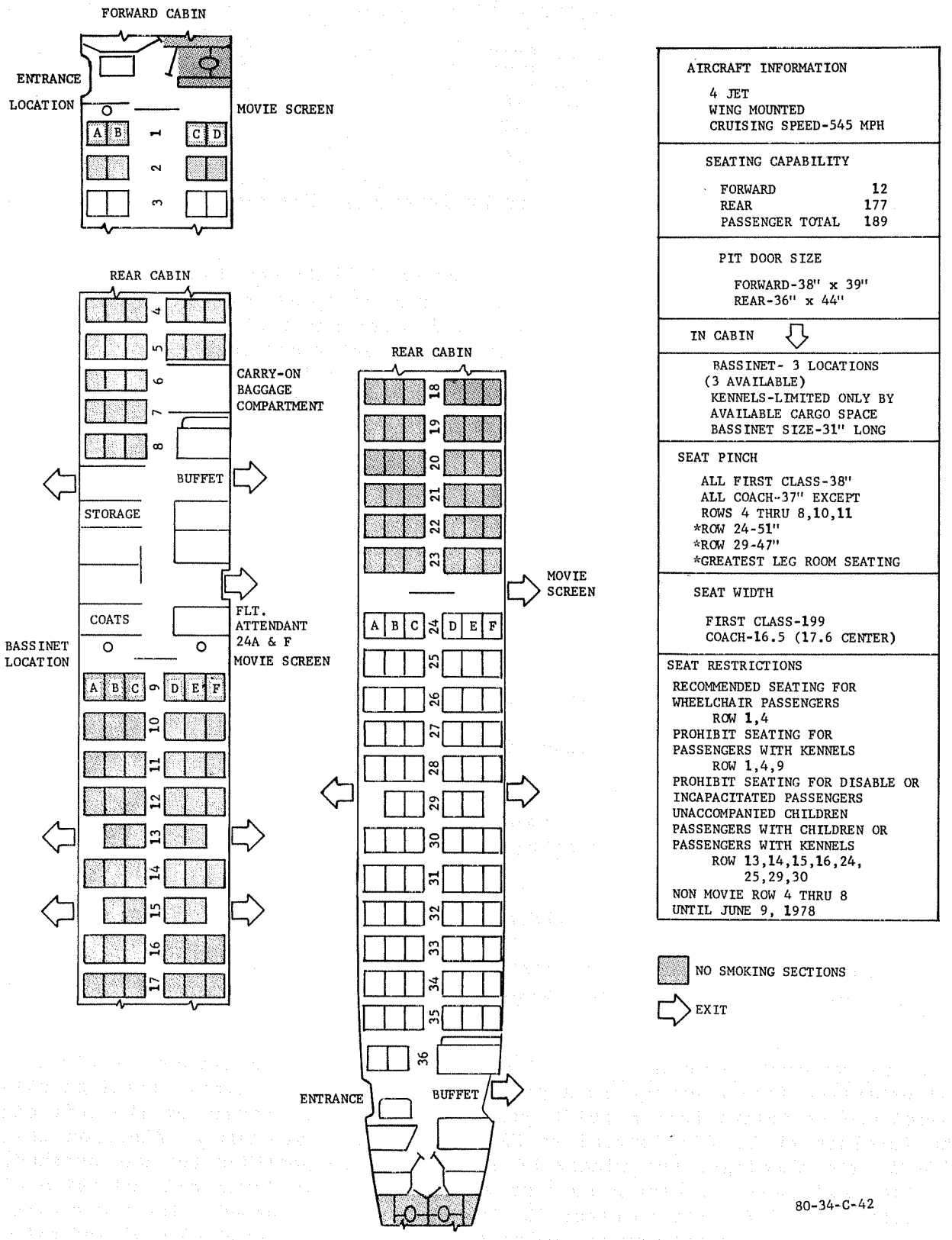


FIGURE C-44. UNITED AIRLINES, INC., DC-8-61, N8082U PASSENGER SEATING ARRANGEMENT

split open and crushed inward from a point above the windows down to below the cabin floor structure.

On the right side of the fuselage, the following damage was noted: the cabin window at FS 650 had been smashed; the forward cargo compartment door at FS 540 was missing and the fuselage structure forward of the door was severely damaged; the underside of the fuselage from FS 560 aft to approximately FS 980 showed extensive damage; and the fuselage from the wing to the fuselage faring at FS 1040 had been split open on a somewhat vertical plane up to a point just above the cabin windows at FS 1010 and FS 1050. The window at FS 1050 had been smashed and the structure above the window was torn and crushed inward. A large tree was positioned under the fuselage at FS 700 while a large tree stump was imbedded in the fuselage at the right wing trailing edge area FS 1000, figure C-45.

Pax Seat Performance. Six double occupancy seat assemblies from first-class section and the first two rows of triple occupancy seats from the coach section were found outside and generally forward of the break at FS 200. These seats had all separated from the floor attachments. Seats at rows 20, 21, and 22 (D,E,F) were located in the area where the floor was displaced upward and where the fuselage skin was displaced inward. The rear outboard leg attachment buttons of row 34 seat assembly (D,E,F) were not engaged in the floor track. The bottoms and floor track were not damaged; the seat assembly's horizontal support frame was bent slightly upward. Figure C-46 shows the interior cabin damage.

Pax Seat Manufacturer(s)/Model(s). Not given in available reports.

Pax Restraint System Performance. No restraint failures were reported.

Pax Restraint System Manufacutrer(s)/Model(s). Not given in available reports.

Miscellaneous Cabin Interior Failures. Overhead storage bins on the left side (above rows 4, 5, and 6) were sprung open; the bins on the right side (above rows 4, and 5) were free of their supports and found resting on top of the carry-on baggage compartment. Bin assemblies from row 9 (left and right) to row 11 (left and right) were loose from the supporting structure. The forward ends of both assemblies were 4 inches lower than the rear ends. Numerous oxygen masks were deployed.

OCCUPANT/INJURY INFORMATION

Injuries	Crew	Passengers
Fatal	2	8
Serious	2	21
Minor/None	4	152

NOTE: Fatal injuries were sustained by persons who were located in the right forward portion of the aircraft; i.e., flight engineer's station, three right rows of first-class seats, and the first two rows of coach seats. Occupants received severe blunt and penetrating head impacts and varying degrees of multiple musculoskeletal trauma to spine, torso, and extremities.

FIGURE C-45. N8082U FUSELAGE DAMAGE

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FIGURE C-46. N8082U INTERIOR CABIN DAMAGE

Narrative. A United Air Lines, Inc., Douglas DC-8-61 crashed on approach to Portland International Airport. The aircraft struck numerous trees and destroyed two frame dwellings before coming to rest in a wooded area. There was no fire. Of the 189 people on board the aircraft, 10 occupants (2 crewmembers, and eight passengers) received fatal injuries at impact.