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**A CRASHWORTHINESS ANALYSIS WITH EMPHASIS  
ON THE FIRE HAZARD:  
U.S. AND SELECTED FOREIGN TURBINE  
AIRCRAFT ACCIDENTS 1964-1974**

**Thomas G. Horeff**



**JULY 1976**

**FINAL REPORT**

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16. Abstract An analysis of 382 impact-survivable/substantial damage turbine aircraft accidents and incidents which occurred during the 11-year period from 1964 through 1974 was performed as part of an overall study of the interrelationship of aircraft crashworthiness and airport crash fire-rescue services. The analysis included 343 accidents and incidents which occurred in the U.S. and 39 outside the U.S. Crashworthiness data were obtained from accidents both in and outside the U.S. The U. S. accidents also provided data for an airport crash fire-rescue service analysis.  The crashworthiness analysis indicated that 94.9 percent of the fatalities in world-wide U. S. air carrier impact-survivable accidents resulted from accidents where fire occurred. Fire and its effects were estimated to be the cause of: (1) forty percent of the fatalities; (2) fatal injuries to 23.3 percent of the occupants in survivable/fatal accidents; and (3) a reduction in survivability, from 65.2 percent to 41.9 percent; of the occupants in survivable/fatal accidents. The status of FAA crashworthiness R&D programs directed toward the development of aircraft fire protective measures is described to focus on efforts being taken to reduce the fire hazard.					
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## METRIC CONVERSION FACTORS

### Approximate Conversions to Metric Measures

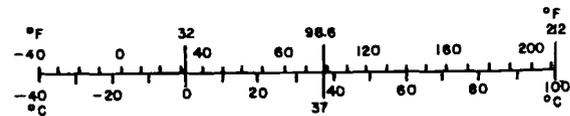
Symbol	When You Know	Multiply by	To Find	Symbol
<b>LENGTH</b>				
in	inches	2.5	centimeters	cm
ft	feet	30	centimeters	cm
yd	yards	0.9	meters	m
mi	miles	1.6	kilometers	km
<b>AREA</b>				
in <sup>2</sup>	square inches	6.5	square centimeters	cm <sup>2</sup>
ft <sup>2</sup>	square feet	0.09	square meters	m <sup>2</sup>
yd <sup>2</sup>	square yards	0.8	square meters	m <sup>2</sup>
mi <sup>2</sup>	square miles	2.6	square kilometers	km <sup>2</sup>
	acres	0.4	hectares	ha
<b>MASS (weight)</b>				
oz	ounces	28	grams	g
lb	pounds	0.45	kilograms	kg
	short tons (2000 lb)	0.9	tonnes	t
<b>VOLUME</b>				
tsap	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 <sup>3</sup>	cubic feet	0.03	cubic meters	m <sup>3</sup>
yd <sup>3</sup>	cubic yards	0.76	cubic meters	m <sup>3</sup>
<b>TEMPERATURE (exact)</b>				
°F	Fahrenheit temperature	5/9 (after subtracting 32)	Celsius temperature	°C

\* 1 in = 2.54 (exact). 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
<b>LENGTH</b>				
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
<b>AREA</b>				
cm <sup>2</sup>	square centimeters	0.16	square inches	in <sup>2</sup>
m <sup>2</sup>	square meters	1.2	square yards	yd <sup>2</sup>
km <sup>2</sup>	square kilometers	0.4	square miles	mi <sup>2</sup>
ha	hectares (10,000 m <sup>2</sup> )	2.5	acres	
<b>MASS (weight)</b>				
g	grams	0.035	ounces	oz
kg	kilograms	2.2	pounds	lb
t	tonnes (1000 kg)	1.1	short tons	
<b>VOLUME</b>				
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 <sup>3</sup>	cubic meters	35	cubic feet	ft <sup>3</sup>
m <sup>3</sup>	cubic meters	1.3	cubic yards	yd <sup>3</sup>
<b>TEMPERATURE (exact)</b>				
°C	Celsius temperature	9/5 (then add 32)	Fahrenheit temperature	°F



## PREFACE

Data on the nature of aircraft fuel system damage and modes of fuel release were developed in conjunction with the participation of the author on the Field Data Panel of the Coordinating Research Council (CRC) Aviation Fuel Safety Report Task Force. Much of the damage and fuel release data used in this crashworthiness analysis were developed by the Field Data Panel for publication in CRC Report No. 482 entitled, "Aviation Fuel Safety - 1975." This assistance by the members of the Field Data Panel and the CRC is gratefully acknowledged.

The cooperation of personnel of the Accident Inquiries and Records Section, National Transportation Safety Board, in providing accident case files for review and of the Flight Standards Service Air Safety Analysis Group in providing accident summaries is very much appreciated. The assistance of several members of the Aircraft Design Criteria Branch, Aircraft Safety and Noise Abatement Division, in reviewing the accident files is also appreciated.

## TABLE OF CONTENTS

	<u>Page</u>
INTRODUCTION	1
ACCIDENT STATISTICS	3
Approach Accidents	3
Landing Accidents	5
Takeoff Accidents	7
Inflight Accidents	8
Taxiing Accidents and Incidents	9
Parked Accidents and Incidents	10
CRASHWORTHINESS ANALYSIS	11
Aircraft Fires	11
U.S. and Foreign Turbine Aircraft Fire Hazard in the U.S.	11
U.S. and Selected Foreign Turbine Aircraft Fires Outside the U.S.	13
U.S. Air Carrier Aircraft Fire Hazard World-Wide	13
Wing Separation Fire Accidents	15
Tank Damage Fire Accidents	17
Fuel Line/Engine Component Damage Fire Accidents	19
Summary of U.S. Air Carrier Survivable/Fatal Accident Fatality Causes	20
Relationship of Survivable and Non-Survivable/Fatal Accidents	20
U.S. and Foreign Air Carrier Aircraft Fuel Tank Explosion and Cabin Fire Hazards	21
Fuel Tank Explosion Hazard	21
Cabin Fire Hazard	21
Emergency Evacuation	24
AIRPORT CRASH FIRE-RESCUE SERVICE ANALYSIS	25
U.S. Air Carrier Survivable/Fatal Fire Accidents in the U.S.	25
U.S. Operators Non-Fatal Fire Accidents World-Wide	26
STATUS OF FAA CRASHWORTHINESS R&D	27
Modified Fuel	27
Fuel Tank Inerting	28
Crash-Resistant Fuel Tanks	30
Cabin Interior Materials	31
Cabin Compartmentation	32
Cabin Fire Suppression	32
Emergency Evacuation	32

TABLE OF CONTENTS (Continued)

	<u>Page</u>
SUMMARY	34
CONCLUSIONS	38
REFERENCES	40
APPENDICES	
A - Survivable/Substantial Damage Approach Accident Summaries	A-1
B - Survivable/Substantial Damage Landing Accident Summaries	B-1
C - Survivable/Substantial Damage Takeoff Accident Summaries	C-1
D - Survivable/Substantial Damage Inflight Accident Summaries	D-1
E - Taxiing Accident and Incident Summaries	E-1
F - Parked Accident and Incident Summaries	F-1

LIST OF TABLES

<u>TABLE</u>		<u>Page</u>
1	Approach Accidents	3
2	Landing Accidents	5
3	Landing Accidents Due to Adverse Runway Conditions	6
4	Landing Gear Failure Accidents	7
5	Takeoff Accidents	7
6	Takeoff Accidents Due to Adverse Runway Conditions	8
7	Inflight Accidents	9
8	Taxiing Accidents and Incidents	10
9	Parked Accidents and Incidents	10
10	U.S. Survivable/Substantial Damage Fire/No Fire Accidents, U.S. and Foreign Turbine Aircraft	12
11	U.S. Fire/No Fire Accident Fatalities, U.S. and Foreign Turbine Aircraft	12
12	U.S. Fatal and Non-Fatal Fire Accidents, U.S. and Foreign Turbine Aircraft	12
13	Outside U.S. Survivable/Substantial Damage Fire/No Fire Accidents, U.S. and Selected Foreign Turbine Aircraft	13
14	Outside U.S. Fatal and Non-Fatal Fire Accidents, U.S. and Selected Foreign Turbine Aircraft	13
15	Survivable/Substantial Damage Fire/No Fire Fatal Accidents, U.S. Air Carrier Turbine Aircraft World-Wide	14
16	Fire/No Fire Accident Fatalities, U. S. Air Carrier Turbine Aircraft World-Wide	14
17	U. S. Operators World-Wide Wing Separation/Fire Accidents	16
18	Survivable Wing Separation/Fire Accident Fatalities, U.S. Air Carriers	16
19	Survivable Wing Separation/Fire Accident Fatality Causes, U. S. Air Carriers	17
20	U. S. Operators World-Wide Tank Damage Fire Accidents	17

LIST OF TABLES (Continued)

<u>TABLE</u>		<u>PAGE</u>
21	Survivable Tank Damage/Fire Accident Fatalities, U. S. Air Carriers	18
22	Survivable Tank Damage/Fire Accident Fatality Causes, U. S. Air Carriers	18
23	U. S. Operators World-Wide Tank Damage/No Fire Accidents	19
24	U. S. Operators World-Wide Fuel Line/Component Damage Fire Accidents	19
25	U. S. Air Carrier Survivable/Fatal Accident Fatality Causes	20
26	U. S. and Foreign Survivable Aircraft Fuel Tank Explosion Accidents and Incidents	22
27	U. S. and Foreign Survivable Aircraft Cabin Fire Accidents and Incidents	23
28	Emergency Evacuation Injuries, U. S. and Foreign Operators World-Wide	24
29	U. S. Air Carrier Survivable/Fatal Fire Accident Locations in the U.S.	25
30	U. S. Operators World-Wide Non-Fatal Fire Accidents	26
A-1	Survivable/Substantial Damage Approach Accidents	A-i
B-2	Survivable/Substantial Damage Landing Accidents	B-i
C-3	Survivable/Substantial Damage Takeoff Accidents	C-i
D-4	Survivable/Substantial Damage Inflight Accidents	D-i
E-5	Substantial Damage Taxiing Accidents and Incidents	E-i
F-6	Substantial Damage Parked Accidents and Incidents	F-i

## INTRODUCTION

An analysis of impact-survivable/substantial damage turbine aircraft accidents which occurred to U.S. and selected foreign air carrier, commuter, and business aircraft operators during the 11-year period from 1964 through 1974 was performed as part of an overall study of the inter-relationship of aircraft crashworthiness and the requirements for airport crash fire-rescue services. The study was conducted in response to a request from the Airports Service Operations Division.

An impact-survivable accident in this analysis is defined as an accident in which all occupants did not receive fatal injuries as a result of impact forces imposed during the crash sequence. An accident is classified as a fatal accident if one or more occupants received fatal injuries. Substantial damage is damage which adversely affects the structural strength, performance, or flight characteristics of the aircraft and which would normally require replacement or major repair unless the accident results in destruction of the aircraft. Several fatal accidents involving an initial non-fatal occurrence resulting in substantial damage and a subsequent non-survivable impact or fatal event are included in the survivable or non-fatal categories because the damage resulting from the initial impact was of interest from a crashworthiness viewpoint and also because the subsequent impact or event might have been prevented had the effect of the initial damage been minimized. Non-impact-survivable and minor or no damage accidents and incidents were not considered in the crashworthiness analysis.

A total of 382 substantial damage accidents and incidents was included in the analysis. This total consists of 334 accidents and incidents experienced by U.S. operators on or near U.S. airports; 31 by U.S. operators at airports outside the U.S.; nine by foreign operators at U.S. airports, and eight by foreign operators at airports outside the U.S. This data base was derived from the National Transportation Safety Board (NTSB) accident reports and case files, the World Airline Accident Summary published by

the British Air Registration Board (now the Civil Aviation Authority),  
Summaries of U.S. Certificated Air Carrier and Commercial Operator  
Accidents prepared by the Flight Standards Service Air Safety Analysis  
Group (AFS-54), and various miscellaneous reports.

Fatalities resulted from 28 accidents in the U.S. to U.S. operators,  
one accident in the U.S. to a foreign operator, four accidents outside  
the U.S. to U.S. operators, and four accidents outside the U.S. to  
foreign operators. These 37 survivable/fatal accidents together with  
several non-fatal U.S. and foreign accidents and incidents of interest  
from a crashworthiness viewpoint formed the basis for the crashworthiness  
analysis. The remainder of the 382 accidents and incidents was included  
to indicate those which occurred on or near U.S. airports for review of  
airport crash fire-rescue requirements and also the substantial damage  
accidents which occurred to U.S. operators outside the U.S.

The total of 382 accidents and incidents does not include 11 U.S. air  
carrier and 14 business operator cases which were identified on an NTSB  
computer run of substantial damage accidents. NTSB files on these cases  
were unavailable for review, but it is assumed that they are insignificant  
from a crashworthiness viewpoint since they were not listed in the other  
data sources. Nine of the air carrier and 13 business operator accidents  
occurred at U.S. airports, resulting in a total of 365 substantial damage  
accidents and incidents which actually occurred on or near U.S. airports  
from 1964 through 1974. The 343 U.S. accidents included in this analysis  
represent 94% of the total which actually occurred. The two U.S. air  
carrier accidents and one business operator accident which occurred out-  
side the U.S. and are not included in this analysis result in a total of  
34 substantial damage accidents and incidents which actually occurred to  
U.S. operators at airports outside the U.S. in the same 11-year period.

ACCIDENT STATISTICS

Approach Accidents

Accidents which were considered to occur in the Approach phase of flight were those which happened when the aircraft crashed while descending on approach before reaching the airport or when the aircraft collided with obstructions before landing or crashing on the airport. There were 42 approach accidents included in the analysis, of which 22 resulted in fatalities, as shown below in Table 1.

TABLE 1 - APPROACH ACCIDENTS

	<u>Total</u>	<u>Fatal</u>	<u>Fatalities</u>	<u>TOB*</u>	<u>FAT/TOB*</u>
U.S. Air Carriers-U.S.	28	18	731	938	74.4%
Commuter Aircraft - U.S.	2	1	4	8	50.0%
Business Aircraft-U.S.	8	1	1	8	12.5%
Foreign Air Carriers-U.S.	1	0	0	0	0
U.S. Air Carriers-Outside U.S.	<u>3</u>	<u>2</u>	<u>103</u>	<u>164</u>	<u>62.8%</u>
	<u>42</u>	<u>22</u>	<u>839</u>	<u>1114</u>	<u>72.1%</u>

\*NOTE: Fatal Accidents Only - Total on Board (TOB)

Tabulations and narrative summaries of these approach accidents including the names of the operators and accident locations are presented in Appendix A. The following accident information is listed in Table 1 of Appendix A:

1. Date of accident
2. Airplane model
3. Post-crash fire-yes or no
4. Mode of fuel release - E, T, W (Engine, Tank, Wing)

- a. E-Fuel released from damaged engine fuel lines or components downstream of a shut-off valve.
  - b. T-Fuel released from damaged fuel tanks.
  - c. W-Fuel released during separation of a wing or a portion of a wing from the aircraft.
5. Crew and passenger data
- a. T-Total on board
  - b. N/M-No injuries or minor injuries
  - c. S-Serious injuries
  - d. F-Fatal injuries
6. Evacuation data
- a. N-No injuries
  - b. M-Minor injuries
  - c. S-Serious injuries
  - d. P-Problems with evacuation system
7. Type of flight
- a. P-Passenger
  - b. C-Cargo
  - c. T-Training
  - d. B-Business

Post-crash fires occurred in 16 of the 22 fatal approach accidents, of which 14 were passenger flights; one was a cargo flight; and one was a commuter flight. Four of the non-fire fatal approach accidents were passenger flights; one was a cargo flight; and one was a private business flight. Post-crash fires also occurred in four of the 20 non-fatal approach accidents, of which two were passenger flights; one was a cargo flight; and one was a business flight. Of the 16 non-fatal/non-

fire approach accidents, six were passenger flights; six were business flights; two were training flights; one was a cargo flight; and one was a commuter flight. A detailed analysis of approach accident post-crash fires experience is presented on pages 11-20 and 25-27.

Landing Accidents

Accidents which were considered to occur in the Landing phase of flight were those which happened when the aircraft touched down on or near the runway or overran or veered off the runway after touchdown. There were 179 landing accidents included in the analysis of which four resulted in fatalities, as shown below in Table 2.

TABLE 2 - LANDING ACCIDENTS

	<u>Total</u>	<u>Fatal</u>	<u>Fatalities</u>
U.S. Air Carriers-U.S.	107	1	43
Commuter Aircraft-U.S.	1	0	0
Business Aircraft-U.S.	51	2	4
Foreign Air Carriers-U.S.	4	0	0
U.S. Air Carriers-Outside U.S.	14	1	2
Foreign Air Carriers-Outside U.S.	1	1*	0*
Foreign Business Aircraft-Outside U.S.	<u>1</u>	<u>0</u>	<u>0</u>
	<u>179</u>	<u>4</u>	<u>49</u>

\*NOTE: This fatal accident was a non-survivable accident during go-around following a hard landing which resulted in damage of crashworthiness interest and is therefore not included in the landing fatality statistics.

Tabulations and narrative summaries of these landing accidents are presented in Appendix B. The same information for landing accidents is listed in Table 2 of Appendix B as is shown in Table 1 of Appendix A for approach accidents except that runway conditions are identified as "S" for slippery and "H" for hydroplaning. Engine fires are identified as "E" under the "Fire-Yes" column.

Post-crash fires occurred in both fatal U.S. air carrier landing accidents where all 45 fatalities were attributed to fire or its effects and in one of the two fatal business aircraft accidents. Fires also occurred in 35 of the 175 non-fatal landing accidents, of which four were engine fires that were extinguished by the engine fire extinguishing system and one was a small fire in the cabin aft section that was extinguished by the crew with hand-fire extinguishers. The 30 other fires included eight engine fires and were not extinguished with equipment provided in the aircraft. Of these 30 non-fatal/fire landing accidents, 15 were passenger flights; nine were cargo flights; three were training flights; and three were business flights. A detailed analysis of landing accident fire experience is presented on pages 11-20 and 25-27.

Landing on slippery runways resulted in seven accidents, while landing on wet runways which caused hydroplaning resulted in 25 accidents as shown below in Table 3. None of these accidents was fatal. Three of the hydroplaning accidents resulted in aircraft fires, one of which was an engine fire.

TABLE 3 - LANDING ACCIDENTS DUE TO ADVERSE RUNWAY CONDITIONS

	<u>Runway Conditions</u>		<u>Total</u>
	<u>Slippery</u>	<u>Hydroplaning</u>	
U.S. Air Carriers-U.S.	4	15	19
Business Aircraft-U.S.	3	8	11
U.S. Air Carriers-Outside U.S.	<u>0</u>	<u>2</u>	<u>2</u>
	7	25	32

Failures of one or more of the main landing gears in flight or on the runway and pilot errors in landing gear operation caused 82 substantial damage landing accidents; while landing short, landing overruns, and veering off the runway caused 35 substantial damage accidents with landing gear failures as shown below in Table 4.

TABLE 4- LANDING GEAR FAILURE ACCIDENTS

	<u>Gear-Up Landings</u>	<u>Landing Gear Failures</u>		<u>Total</u>
		<u>On Runway</u>	<u>Off Runway</u>	
U.S. Air Carriers-U.S.	14	40	24	78
Commuter Aircraft-U.S.	1	0	0	1
Business Aircraft-U.S.	6	15	11	32
Foreign Air Carriers- U.S.	1	1	0	2
U.S. Air Carriers- Outside U.S.	0	3	0	3
Foreign Business Air- craft-Outside U.S.	0	1	0	1
	<u>22</u>	<u>60</u>	<u>35</u>	<u>117</u>

Takeoff Accidents

Accidents which were considered to occur in the Takeoff phase of flight were those which happened while the aircraft was moving on the runway for takeoff and after liftoff prior to retracting the landing gear and/or flaps. There were 56 takeoff accidents included in the analysis, of which seven resulted in fatalities, as shown below in Table 5.

TABLE 5- TAKEOFF ACCIDENTS

	<u>Total</u>	<u>Fatal</u>	<u>Fatalities</u>
U.S. Air Carriers-U.S.	32	3	58
Commuter Aircraft-U.S.	1	1	3
Business Aircraft-U.S.	9	0	0
Foreign Air Carriers-U.S.	3	1	3
U.S. Air Carriers-Outside U.S.	8	1	48
Foreign Air Carriers-Outside U.S.	<u>3</u>	<u>2*</u>	<u>59*</u>
	<u>56</u>	<u>7</u>	<u>171</u>

\*NOTE: One of these two fatal accidents involved an engine failure and fire on takeoff and is classified as a takeoff accident but is not included in the takeoff fatality statistics, since the five fatalities were a result of fuel tank explosions after the aircraft had returned to the airport.

Tabulations and narrative summaries of these takeoff accidents are presented in Appendix C. The same information for takeoff accidents is listed in Table 3 of Appendix C as is shown in Table 2 of Appendix B for landing accidents.

Post-crash fires occurred in all seven fatal takeoff accidents including two U.S. air carrier accidents, one in the U.S. and one outside the U.S., where all 95 fatalities were attributed to fire and its effects or explosions. Fires also occurred in 29 of the 49 non-fatal takeoff accidents, of which three were engine fires that were extinguished by the engine fire extinguishing system; one also included a small fire in the cabin aft section that was extinguished by the crew with hand-fire extinguishers. The 26 other fires included one engine fire and were not extinguished with equipment provided in the aircraft. Of these 26 non-fatal/fire takeoff accidents, 16 were passenger flights, four were cargo flights; three were training flights; and three were business flights. A detailed analysis of takeoff accident fire experience is presented on pages 11-20 and 25-27.

Takeoff on slippery runways resulted in two accidents, while takeoff on a wet runway which caused hydroplaning resulted in one accident as shown below in Table 6. None of these accidents was fatal. One of the slippery runway accidents resulted in an aircraft fire.

TABLE 6- TAKEOFF ACCIDENTS DUE TO ADVERSE RUNWAY CONDITIONS

	<u>Runway Conditions</u>		<u>Total</u>
	<u>Slippery</u>	<u>Hydroplaning</u>	
U.S. Air Carriers-U.S.	2	1	3

Inflight Accidents

Accidents which were considered to occur Inflight were those which resulted in substantial damage and/or injuries or fatalities while the aircraft was in climb, cruise, or descent configuration. There were 37 inflight accidents included in the analysis, of which two resulted in fatalities, as shown below in Table 7.

TABLE 7--INFLIGHT ACCIDENTS

	<u>Total</u>	<u>Fatal</u>	<u>Fatalities</u>
U.S. Air Carriers-U.S.	28	1	1
Business Aircraft-U.S.	6	0	0
Foreign Air Carriers-U.S.	1	0	0
U.S. Air Carriers-Outside U.S.	1	0	0
Foreign Air Carriers-Outside U.S.	<u>1</u>	<u>1</u>	<u>123</u>
	<u>37</u>	<u>2</u>	<u>124</u>

Tabulations and narrative summaries of these inflight accidents are presented in Appendix D. The same information for inflight accidents is listed in Table 4 of Appendix D as is shown in Table 1 of Appendix A for approach accidents.

Fire occurred in the fatal foreign air carrier inflight accident where all 123 fatalities were caused by fire and its effects. Fires also occurred in 15 of the 35 non-fatal inflight accidents, of which five were engine fires that were extinguished by the engine fire extinguishing system and two were cabin fires that were extinguished by the crew. The eight other fires included three engine fires and were not extinguished with equipment provided in the aircraft. Of these 15 non-fatal/fire inflight accidents, 11 were passenger flights, and four were business flights. A detailed analysis of inflight accident fire experience is presented on pages 11-13, 21-23, and 26-27.

Taxiing Accidents and Incidents

Accidents and incidents resulting in substantial damage which occurred while the aircraft was taxiing on the airport under its own power were included to supply additional data for a study of the evacuation aspects of crashworthiness and review of airport crash fire-rescue requirements. There were 38 taxiing accidents and incidents included in the analysis as shown below in Table 8.

TABLE 8-TAXIING ACCIDENTS AND INCIDENTS

	<u>Total</u>
U.S. Air Carriers-U.S.	32
Business Aircraft-U.S.	5
U.S. Air Carriers-Outside U.S.	<u>1</u>
	38

Tabulations and narrative summaries of these taxiing accidents and incidents are presented in Appendix E.

Fire occurred in eight of these taxiing accidents and incidents, of which two were engine fires that were extinguished by the engine fire extinguishing system. The six other fires included one engine fire and were not extinguished with equipment provided in the aircraft. Of these eight taxiing fire accidents, seven were passenger flights and one was a cargo flight.

Parked Accidents and Incidents

Accidents and incidents resulting in substantial damage and/or injuries while the aircraft was stationary on the airport were also included to supply additional data for a study of the evacuation aspects of crash-worthiness and review of airport crash-fire rescue requirements. There were 30 parked accidents and incidents included in the analysis as shown below in Table 9.

TABLE 9- PARKED ACCIDENTS AND INCIDENTS

	<u>Total</u>
U.S. Air Carriers-U.S.	24
U.S. Air Carriers-Outside U.S.	4
Foreign Air Carriers-Outside U.S.	<u>2</u>
	30

Tabulations and narrative summaries of these parked accidents and incidents are presented in Appendix F.

Fire occurred in 16 of these parked accidents and incidents, of which one was an engine fire that was extinguished by the engine fire extinguishing system and two were fires that were extinguished by the crew. The 13 other fires included two engine fires and were not extinguished with equipment provided in the aircraft. Of these 16 parked fire accidents, four were passenger flights; one was a cargo flight; six occurred while the aircraft was being serviced or refueled; two prior to boarding passengers; and three while the aircraft was unattended.

## CRASHWORTHINESS ANALYSIS

### Aircraft Fires

The most relevant aspect of aircraft crashworthiness which bears on requirements for airport crash fire-rescue services is that which involves the fire hazard; i.e., the potential for fire injury to occupants in an impact-survivable accident.

#### U.S. and Foreign Turbine Aircraft Fire Hazard in the U.S.

The crash fire hazard in the U.S. is reflected in the accident statistics summarized in Tables 10, 11, and 12. Table 10 presents the number of impact-survivable/substantial damage accidents to U.S. and foreign turbine aircraft which occurred with and without fire on or near U.S. airports. The fires enumerated in Table 10 are those which were not extinguished with equipment provided in the aircraft and include fuel fires, cabin and cargo compartment fires, engine fires, and brake fires. Fatalities in these accidents are presented in Table 11. Table 12 presents the numbers of fatal and non-fatal fire accidents to U.S. and foreign turbine aircraft which occurred on or near U.S. airports.

The accident statistics indicate that 794 of 848 fatalities (93.6%) in survivable/substantial damage accidents in the U.S. were in accidents where fire occurred. The post-crash fire hazard was greatest in approach accidents where 14 of 17 fire accidents (82.4%) were fatal resulting in 685 fatalities or 80.8% of the total fatalities in the U.S. survivable/substantial damage accidents. Five of the 26 takeoff/fire accidents

TABLE 10-U.S. SURVIVABLE/SUBSTANTIAL DAMAGE FIRE/NO FIRE ACCIDENTS  
U.S. AND FOREIGN TURBINE AIRCRAFT, 1964-1974

YEAR	<u>APPROACH</u>		<u>LANDING</u>		<u>TAKEOFF</u>		<u>INFLIGHT</u>		<u>TAXIING</u>		<u>PARKED</u>		<u>TOTAL</u>	
	No		No		No		No		No		No		No	
	Fire	Fire	Fire	Fire	Fire	Fire	Fire	Fire	Fire	Fire	Fire	Fire	Fire	Fire
1964	0	1	1	11	1	1	0	0	0	3	0	0	2	16
1965	1	0	3	7	1	2	2	2	0	2	0	0	7	13
1966	1	2	1	24	0	2	0	0	0	3	0	1	2	32
1967	1	1	1	17	3	1	1	1	0	1	0	0	6	21
1968	3	9	4	12	1	4	0	4	1	2	0	2	9	33
1969	0	4	3	8	4	3	0	1	1	8	1	1	9	25
1970	1	2	2	19	3	1	0	2	1	5	6	1	13	30
1971	2	2	2	7	2	2	3	3	2	0	0	2	11	16
1972	3	1	4	15	2	1	1	2	1	3	2	1	13	23
1973	4	0	3	9	5	0	0	4	0	2	1	1	13	16
1974	1	0	3	3	4	0	0	2	0	0	1	1	9	6
	<u>17</u>	<u>22</u>	<u>27</u>	<u>132</u>	<u>26</u>	<u>17</u>	<u>7</u>	<u>21</u>	<u>6</u>	<u>29</u>	<u>11</u>	<u>10</u>	<u>94</u>	<u>231</u>

TABLE 11-U.S. FIRE/NO FIRE ACCIDENT FATALITIES  
U.S. AND FOREIGN TURBINE AIRCRAFT, 1964-1974

YEAR	<u>APPROACH</u>		<u>LANDING</u>		<u>TAKEOFF</u>		<u>INFLIGHT</u>		<u>TAXIING</u>		<u>PARKED</u>		<u>TOTAL</u>	
	No		No		No		No		No		No		No	
	Fire	Fire	Fire	Fire	Fire	Fire	Fire	Fire	Fire	Fire	Fire	Fire	Fire	Fire
1964	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1965	58	0	43	0	0	0	0	0	0	0	0	0	101	0
1966	84	0	0	0	0	0	0	0	0	0	0	0	84	0
1967	70	0	0	0	1	0	0	0	0	0	0	0	71	0
1968	94	23	2	0	0	0	0	0	0	0	0	0	96	23
1969	0	12	0	0	6	0	0	0	0	0	0	0	6	12
1970	3	0	0	0	47	0	0	0	0	0	0	0	59	0
1971	32	0	0	0	0	0	0	0	0	0	0	0	32	0
1972	147	16	0	0	10	0	0	0	0	0	0	0	157	16
1973	126	0	0	2	0	0	0	1	0	0	0	0	126	3
1974	71	0	0	0	0	0	0	0	0	0	0	0	71	0
	<u>685</u>	<u>51</u>	<u>45</u>	<u>2</u>	<u>64</u>	<u>0</u>	<u>0</u>	<u>1</u>	<u>0</u>	<u>0</u>	<u>0</u>	<u>0</u>	<u>794</u>	<u>54</u>

TABLE 12 - U.S. FATAL AND NON-FATAL FIRE ACCIDENTS  
U.S. AND FOREIGN TURBINE AIRCRAFT, 1964-1974

<u>APPROACH</u>	<u>LANDING</u>	<u>TAKEOFF</u>	<u>FATAL</u>		<u>TAXIING</u>	<u>PARKED</u>	<u>TOTAL</u>
			<u>INFLIGHT</u>	<u>TOTAL</u>			
14	2	5	0	0	0	0	21
<u>3</u>	<u>25</u>	<u>21</u>	<u>7</u>	<u>6</u>	<u>11</u>	<u>11</u>	<u>73</u>
<u>17</u>	<u>27</u>	<u>26</u>	<u>7</u>	<u>6</u>	<u>11</u>	<u>11</u>	<u>94</u>

(19.2%) were fatal resulting in 64 fatalities (7.5% of the total) while two of 27 landing/fire accidents (7.4%) were fatal resulting in 45 fatalities (5.3% of the total).

U.S. and Selected Foreign Turbine Aircraft Fires Outside the U.S.

The numbers of outside U.S. impact-survivable/substantial damage fire and no fire accidents to U.S. and selected foreign turbine aircraft that were included in this analysis are presented in Table 13. The outside U.S. fatal and non-fatal fire accidents are enumerated in Table 14.

TABLE 13 - OUTSIDE U.S. SURVIVABLE/SUBSTANTIAL DAMAGE FIRE/NO FIRE ACCIDENTS

U.S. AND SELECTED FOREIGN TURBINE AIRCRAFT, 1964-1974

<u>APPROACH</u>		<u>LANDING</u>		<u>TAKEOFF</u>		<u>INFLIGHT</u>		<u>TAXIING</u>		<u>PARKED</u>		<u>TOTAL</u>	
<u>Fire</u>	<u>No Fire</u>	<u>Fire</u>	<u>No Fire</u>	<u>Fire</u>	<u>No Fire</u>	<u>Fire</u>	<u>No Fire</u>	<u>Fire</u>	<u>No Fire</u>	<u>Fire</u>	<u>No Fire</u>	<u>Fire</u>	<u>No Fire</u>
3	0	6	9	7	3	2	3	0	0	2	4	20	17

TABLE 14 - OUTSIDE U.S. FATAL AND NON-FATAL FIRE ACCIDENTS

U.S. AND SELECTED FOREIGN TURBINE AIRCRAFT, 1964-1974

<u>APPROACH</u>	<u>LANDING</u>	<u>TAKEOFF</u>	<u>FATAL INFLIGHT</u>	<u>TAXIING</u>	<u>PARKED</u>	<u>TOTAL</u>
2	1	2	1	0	0	6
<u>NON-FATAL</u>						
$\frac{1}{3}$	$\frac{5}{6}$	$\frac{5}{7}$	$\frac{1}{2}$	$\frac{0}{0}$	$\frac{2}{2}$	$\frac{14}{20}$

Tables 10 and 13 indicate that 114 survivable/substantial damage fire accidents and 248 no fire accidents were included in this analysis. Tables 12 and 14 indicate that 27 of the fire accidents were fatal and 87 were non-fatal. These accidents will be considered in subsequent sections on the fire hazards to U.S. and foreign air carriers world-wide.

U.S. Air Carrier Aircraft Fire Hazard World-Wide

The world-wide crash fire hazard of U.S. Air Carriers is reflected in the accident and fatality statistics summarized in Tables 15 and 16.

Table 15 presents the numbers of impact-survivable/substantial damage fatal accidents to U.S. air carrier turbine aircraft which occurred with and without fire in and outside the U.S. Fatalities in these accidents are presented in Table 16.

TABLE 15 - SURVIVABLE/SUBSTANTIAL DAMAGE FIRE/NO FIRE FATAL ACCIDENTS  
U.S. AIR CARRIER TURBINE AIRCRAFT WORLD-WIDE

<u>YEAR</u>	<u>APPROACH</u>		<u>LANDING</u>		<u>TAKEOFF</u>		<u>TOTAL</u>	
	<u>Fire</u>	<u>No Fire</u>	<u>Fire</u>	<u>No Fire</u>	<u>Fire</u>	<u>No Fire</u>	<u>Fire</u>	<u>No Fire</u>
1964	0	0	0	0	1	0	1	0
1965	1	0	1	0	0	0	2	0
1966	1	0	0	0	0	0	1	0
1967	1	0	0	0	1	0	2	0
1968	4	2	0	0	0	0	4	2
1969	0	2	0	0	1	0	1	2
1970	1	0	1	0	1	0	3	0
1971	2	0	0	0	0	0	2	0
1972	2	1	0	0	1	0	3	1
1973	2	0	0	0	0	0	2	0
1974	2	0	0	0	0	0	2	0
	<u>16</u>	<u>5</u>	<u>2</u>	<u>0</u>	<u>5</u>	<u>0</u>	<u>23</u>	<u>5</u>

TABLE 16 - FIRE/NO FIRE ACCIDENT FATALITIES  
U.S. AIR CARRIER TURBINE AIRCRAFT WORLD-WIDE

<u>YEAR</u>	<u>APPROACH</u>		<u>LANDING</u>		<u>TAKEOFF</u>		<u>TOTAL</u>	
	<u>Fire</u>	<u>No Fire</u>	<u>Fire</u>	<u>No Fire</u>	<u>Fire</u>	<u>No Fire</u>	<u>Fire</u>	<u>No Fire</u>
1964	0	0	0	0	48	0	48	0
1965	58	0	43	0	0	0	101	0
1966	84	0	0	0	0	0	84	0
1967	70	0	0	0	1	0	71	0
1968	100	22	0	0	0	0	100	22
1969	0	12	0	0	3	0	3	12
1970	3	0	2	0	47	0	52	0
1971	32	0	0	0	0	0	32	0
1972	142	16	0	0	10	0	152	16
1973	126	0	0	0	0	0	126	0
1974	168	0	0	0	0	0	168	0
	<u>783</u>	<u>50</u>	<u>45</u>	<u>0</u>	<u>109</u>	<u>0</u>	<u>937</u>	<u>50</u>

These accident statistics indicate that 937 of 987 fatalities (94.9%) in world-wide survivable/substantial damage fatal accidents to U.S. air carrier turbine aircraft were in accidents where fire occurred. The post-crash fire hazard was greatest in approach accidents where 16 of the 21 fatal accidents were fire accidents which resulted in 783 fatalities or 79.3% of the total fatalities in the U.S. air carrier world-wide survivable/substantial damage fatal accidents. The five fatal takeoff fire accidents resulted in 109 fatalities (11.0% of the total) while the two fatal landing fire accidents resulted in 45 fatalities (4.6% of the total).

The accident statistics clearly point to the approach accidents followed by takeoff accidents as being the most severe in terms of fire development and impact forces imposed during the crash sequence and landing accidents as being the least severe. The degree of fire severity is influenced by the nature of aircraft fuel system damage which allows the release of fuel to come in contact with ignition sources, usually either by wing separation, tank damage, or engine fuel line damage.

#### Wing Separation Fire Accidents

The U.S. operator survivable/fire accidents involving fuel release through wing or partial wing separation are tabulated in Table 17. Fourteen of the 19 U.S. wing separation/fire accidents were fatal and were air carriers, of which 12 occurred during approach and two during takeoff as summarized in Table 18.

The National Transportation Safety Board (NTSB) has reported that all 47 fatalities in the 11/27/70 DC-8 takeoff accident at Anchorage and 28 fatalities in the 6/7/71 CV-580 approach accident at New Haven were caused as a direct result of fire and its effects. The NTSB has also reported that 96 of the 97 fatalities in the 1/30/74 B-707 approach accident at Pago Pago and 33 of the 71 fatalities in the 9/11/74 DC-9 approach accident at Charlotte were caused by fire and its effects. The number of fatalities caused by fire in the other wing separation accidents has not been specified, but based on the accident characteristics, it is assumed that all fatalities in the B-707 Erlanger takeoff

TABLE 17-U.S. OPERATORS WORLD-WIDE WING SEPARATION/FIRE ACCIDENTS,  
1964-1974

	<u>DATE</u>	<u>AIRPLANE</u>	<u>LOCATION</u>	<u>TOB</u>	<u>FATALITIES</u>	<u>OPER. MODE</u>
1.	11/8/65	B-727	Constance, KY	62	58	Approach
2.	3/21/66	CL-44D4	Norfolk, VA	6	0	Landing
3.	11/6/67	B-707	Erlanger, KY	36	1	Takeoff
4.	11/20/67	CV-880	Constance, KY	82	70	Approach
5.	8/10/68	FH-227B	Charleston, WV	37	35	Approach
6.	10/25/68	FH-227C	Hanover, NH	42	32	Approach
7.	12/27/68	CV-580	Chicago, IL	45	27	Approach
8.	5/1/69	CL-44D4	Anchorage, AK	4	0	Landing
9.	8/8/70	CV-990	Acapulco, MEX	8	0	Approach
10.	11/27/70	DC-6-63F	Anchorage, AK	229	47	Takeoff
11.	3/18/71	L-382	McConnell AFB, KA	4	0	Landing
12.	6/7/61	CV-580	New Haven, CT	31	28	Approach
13.	10/24/71	B-99	Allentown, PA	8	4	Approach
14.	12/12/72	DH-125	Findlay, OH	7	0	Approach
15.	12/29/72	L-1011	Everglades, FL	175	99	Approach
16.	7/23/73	FH-227B	St. Louis, MO	44	38	Approach
17.	7/31/73	DC-9-31	Boston, MA	89	88	Approach
18.	1/30/74	B-707-321B	Pago Pago, SAMOA	101	97	Approach
19.	9/11/74	DC-9-31	Charlotte, NC	82	71	Approach
				<u>1092</u>	<u>695</u>	

TABLE 18-SURVIVABLE WING SEPARATION/FIRE ACCIDENT FATALITIES  
U.S. AIR CARRIERS, 1964-1974

<u>ACCIDENTS</u>	<u>MODE</u>	<u>TOTAL ON BOARD</u>	<u>FATALITIES</u>	<u>FAT./TOB</u>
2	Takeoff	265	48	18.1%
<u>12</u>	Approach	<u>798</u>	<u>647</u>	81.1%
<u>14</u>		<u>1063</u>	<u>695</u>	65.4%

accident and the B-99 Allentown, FH-227 St. Louis, L-1011, and DC-9 Boston approach accidents were due to impact and that fire caused one-fourth of the fatalities in the remaining accidents. On this basis, it is estimated that there is a total of 259 fatalities due to fire as shown in Table 19, or 37.3 percent of the total fatalities in the 14 survivable/wing separation/fire accidents.

As shown in Tables 15 and 16, there were 28 survivable and fatal U.S. air carrier turbine aircraft accidents during 1964-1974 with a total of 987 fatalities. Therefore, the 14 wing separation/fire accidents represent 50 percent of the total survivable/fatal accidents and the estimated 259 fatalities due to fire in these 14 accidents represent 26.2 percent of the total survivable accident fatalities.

TABLE 19-SURVIVABLE WING SEPARATION/FIRE ACCIDENT FATALITY CAUSES

U.S. AIR CARRIERS, 1964-1974

	<u>DATE</u>	<u>AIRPLANE</u>	<u>LOCATION</u>	<u>FIRE</u>	<u>IMPACT</u>	<u>TOTAL FATALITIES</u>
1.	11/8/65	B-727	Constance, KY	14*	44*	58
2.	11/6/67	B-707	Erlanger, KY	0*	1*	1
3.	11/20/67	CV-880	Constance, KY	17*	53*	70
4.	8/10/68	FH-227B	Charleston, WV	9*	26*	35
5.	10/25/68	FH-227C	Hanover, NH	8*	24*	32
6.	12/27/68	CV-580	Chicago, IL	7*	20*	27
7.	11/27/70	DC-8-63F	Anchorage, AK	47	0	47
8.	6/7/71	CV-580	New Haven, CT	28	0	28
9.	10/24/71	B-99	Allentown, PA	0*	4*	4
10.	12/29/72	L-1011	Everglades, FL	0*	99*	99
11.	7/23/73	FH-227B	St. Louis, MO	0*	38*	38
12.	7/31/73	DC-9-31	Boston, MA	0*	88*	88
13.	1/30/74	B-707-321B	Pago Pago, Samoa	96	1	97
14.	9/11/74	DC-9-31	Charlotte, NC	33	38	71
				<u>259</u>	<u>436</u>	<u>695</u>

\*NOTE: Estimated

Tank Damage Fire Accidents

The U.S. operator survivable/fire accidents involving fuel release from damaged fuel tanks are tabulated in Table 20.

TABLE 20-U.S. OPERATORS WORLD-WIDE TANK DAMAGE/FIRE ACCIDENTS, 1964-1974

	<u>DATE</u>	<u>AIRPLANE</u>	<u>LOCATION</u>	<u>TOB</u>	<u>FAT.</u>	<u>OPER. MODE</u>
1.	4/22/66	L-188C	Ardmore, OK	98	84	Approach
2.	9/8/67	B-707	Frankfurt, Germany	174	0	Takeoff
3.	3/21/68	B-727	Chicago, IL	3	0	Takeoff
4.	4/28/68	DC-8	Atlantic City, NJ	4	0	Landing
5.	6/13/68	B-707	Calcutta, India	63	6	Approach
6.	7/15/69	DHC-6	Jamaica, NY	14	3	Takeoff
7.	12/13/69	B-747	Renton, WA	11	0	Landing
8.	10/10/70	L-382B	Wrightstown, NJ	3	3	Approach
9.	12/28/70	B-727	St. Thomas, VI	55	2	Landing
10.	3/19/72	L-188C	Hill AFB, UT	3	0	Landing
11.	12/8/72	B-737-222	Chicago, IL	61	43	Approach
12.	12/20/72	DC-9-31	Chicago, IL	45	10	Takeoff
13.	4/24/73	DC-8	Jamaica, NY	3	0	Takeoff
14.	10/28/73	B-737-222	Greensboro, NC	95	0	Landing
15.	12/17/73	DC-9	Greensboro, NC	89	0	Takeoff
				<u>721</u>	<u>151</u>	

Seven of the 15 U.S. operator tank damage/fire accidents were fatal and were air carriers, of which four occurred during approach, two during takeoff, and one on landing as summarized in Table 21.

TABLE 21-SURVIVABLE TANK DAMAGE/FIRE ACCIDENT FATALITIES

U.S. AIR CARRIERS, 1964-1974

<u>ACCIDENTS</u>	<u>MODE</u>	<u>TOTAL ON BOARD</u>	<u>FATALITIES</u>	<u>FAT./TOB</u>
1	Landing	55	2	3.6%
2	Takeoff	59	13	22.0%
$\frac{4}{7}$	Approach	$\frac{225}{339}$	$\frac{136}{151}$	$\frac{60.4\%}{44.5\%}$

The NTSB has reported that the two fatalities in the 12/28/70 B-727 landing accident at St. Thomas and nine of the 10 fatalities in the 12/20/72 DC-9 takeoff accident at Chicago were caused as a direct result of fire and its effects. It is assumed that all three fatalities in the 7/15/69 DHC-6 takeoff accident at Jamaica, NY, were due to impact. Again assuming that fire caused one-fourth of the fatalities in the remaining accidents, it is estimated that there is a total of 45 fatalities due to fire as shown in Table 22, or 29.8% of the total fatalities in the seven survivable/tank damage/fire accidents. These seven tank damage/fire accidents represent 25% of the total survivable/fatal accidents and the estimated 45 fatalities due to fire in these seven accidents represent 4.6% of the total survivable accident fatalities.

TABLE 22-SURVIVABLE TANK DAMAGE/FIRE ACCIDENT FATALITY CAUSES

U.S. AIR CARRIERS, 1964-1974

	<u>DATE</u>	<u>AIRPLANE</u>	<u>LOCATION</u>	<u>FIRE</u>	<u>IMPACT</u>	<u>TOTAL FATALITIES</u>
1.	4/22/66	L-188C	Ardmore, OK	21*	63*	84
2.	6/13/68	B-707	Calcutta, India	1*	5*	6
3.	7/15/69	DHC-6	Jamaica, NY	0*	3*	3
4.	10/10/70	L-382B	Wrightstown, NJ	1*	2*	3
5.	12/28/70	B-727	St. Thomas, VI	2	0	2
6.	12/8/72	B-737-222	Chicago, IL	11*	32*	43
7.	12/20/72	DC-9-31	Chicago, IL	$\frac{9}{45}$	$\frac{1}{106}$	$\frac{10}{151}$

\*NOTE: Estimated

Fuel was released from damaged fuel tanks without resulting in fire in 22 substantial damage/non-fatal accidents to U.S. operators as summarized in Table 23.

TABLE 23-U.S. OPERATORS WORLD-WIDE TANK DAMAGE/NO FIRE ACCIDENTS, 1964-74

	<u>APPROACH</u>	<u>LANDING</u>	<u>TAKEOFF</u>	<u>INFLIGHT</u>	<u>TAXIING</u>	<u>PARKED</u>	<u>TOTAL</u>
Air Carriers	0	5	2	5	2	0	14
Bus. Aircraft	<u>0</u>	<u>6</u>	<u>0</u>	<u>0</u>	<u>2</u>	<u>0</u>	<u>8</u>
	0	11	2	5	4	0	22

Foreign air carriers experienced the non-fatal 12/17/73 DC-10 approach accident and the 8/13/72 B-707 takeoff accident on U.S. airports and the non-fatal 4/19/70 DC-8 and fatal 11/20/74 B-747 takeoff accidents at foreign airports which involved fire due to fuel release from damaged fuel tanks. There were 59 fatalities in the B-747 takeoff accident.

Fuel Line/Engine Component Damage Fire Accidents

The U.S. operator survivable/fire accidents involving fuel release from damaged fuel lines or engine components are tabulated in Table 24.

TABLE 24-U.S. OPERATORS WORLD-WIDE FUEL LINE/COMPONENT DAMAGE/FIRE ACCIDENTS, 1964-1974

	<u>DATE</u>	<u>AIRPLANE</u>	<u>LOCATION</u>	<u>TOB</u>	<u>FAT.</u>	<u>OPER. MODE</u>
1.	11/23/64	B-707-331	Rome, Italy	73	48	Takeoff
2.	9/13/65	CV-880	Kansas City, MO	4	0	Takeoff
3.	11/11/65	B-727	Salt Lake City, UT	91	43	Landing
4.	10/16/69	DC-8-63F	Stockton, CA	5	0	Takeoff
5.	5/18/72	DC-9-31	Ft. Lauderdale, FL	10	0	Landing
6.	3/5/73	B-707	Denver, CO	3	0	Takeoff
7.	11/27/73	DC-9	Chattanooga, TN	<u>77</u>	<u>0</u>	Approach
				263	91	

Two of the seven U.S. air carrier fuel line or engine component damage/fire accidents were fatal of which one occurred during takeoff and one on landing. All 91 fatalities in these two accidents were caused by fire and its effects. These two fuel line/engine component damage/fire accidents represent 7.1% of the total survivable/fatal accidents and the fatalities due to fire in these accidents represent 9.2% of the total survivable accident fatalities.

Summary of U.S. Air Carrier Survivable/Fatal Accident Fatality Causes

The causes of the fatalities in the 28 survivable and fatal U.S. air carrier turbine aircraft accidents during 1964-1974 are summarized in Table 25.

TABLE 25-U.S. AIR CARRIER SURVIVABLE/FATAL ACCIDENT FATALITY CAUSES

<u>ACCIDENTS</u>	<u>TOB</u>	<u>FIRE FATALITIES</u>	<u>IMPACT FATALITIES</u>	<u>TOTAL FATALITIES</u>
14 Wing Separation	1063	259	436	694
7 Tank Damage	339	45	106	151
2 Fuel Line/Comp. Damage	164	91	0	91
23 Fire Accidents	<u>1566</u>	<u>395</u>	<u>542</u>	<u>937</u>
5 No Fire Accidents	132	0	50	50
28	<u>1698</u>	<u>395</u>	<u>592</u>	<u>987</u>

The estimated 395 fatalities due to fire in the 23 world-wide U.S. air carrier survivable/fatal fire accidents represent 42.2 percent of the 937 fatalities in these accidents and 40.0 percent of the 987 total survivable accident fatalities. The fire fatalities also represent 25.2 percent of the 1566 occupants in the 23 fire accidents and 23.3 percent of the 1698 occupants in all the survivable/fatal accidents. The estimated 592 fatalities due to impact forces represent 34.9 percent of the total occupants in these accidents.

A total of 987 or 58.1 percent of the 1698 occupants received fatal injuries and 711 or 41.9 percent survived the accidents. If the fire hazard had not existed in 23 of these accidents, an additional 23.3 percent of the occupants may have survived, increasing the survivability from 41.9 percent to 65.2 percent. The fire hazard may then be expressed as the cause of: (1) 40.0 percent of the total survivable accident fatalities; (2) fatalities to 23.3 percent of the occupants in survivable/fatal accidents; and (3) a reduction in survivability of occupants in survivable accidents from 65.2 percent to 41.9 percent.

Relationship of Survivable and Non-Survivable/Fatal Accidents

U. S. air carriers experienced a total of 71 turbine aircraft fatal accidents world-wide during 1964 - 1974 with 2455 fatalities. As

summarized above, 28 of these accidents (39.4 percent of the total) were impact-survivable accidents with 987 fatalities (40.2 percent of the total). Forty-three accidents were non-impact-survivable (60.6 percent of the total) and caused 1468 fatalities (59.8 percent of the total). The estimated 395 fatalities due to fire and 592 fatalities due to impact forces in the impact-survivable air carrier accidents represent 16.1 percent and 24.1 percent of the total fatal accident fatalities respectively. On the basis of these estimates, 2060 fatalities (83.9 percent of the total) in the survivable and non-survivable accidents were probably caused by impact forces.

#### U.S. and Foreign Air Carrier Aircraft Fuel Tank Explosion and Cabin Fire Hazards

In addition to the 26 U.S. air carrier survivable/fatal accidents and other substantial damage accidents and incidents which occurred in the U.S., four fatal and four non-fatal accidents experienced by foreign operators outside the U.S. were included in the analysis to depict the total fuel tank explosion and cabin fire hazards.

##### Fuel Tank Explosion Hazard

The U.S. and foreign survivable aircraft accidents and incidents involving fuel tank explosions are tabulated in Table 26.

Four of the fuel tank explosions were due to heating of the fuel tank by external fires fed by fuel released from damaged fuel lines or engine components. Five explosions were caused by external fires fed by fuel released from damaged tanks, one by a fire fed by fuel released from a damaged fuel line and tank, and two by fires from fuel released due to separated wings. Four explosions were caused by electrostatic discharge during refueling.

##### Cabin Fire Hazard

The U.S. and foreign survivable aircraft accidents and incidents involving non-fuel related interior fuselage and cabin fires are tabulated in Table 27.

TABLE 26-U.S. AND FOREIGN SURVIVABLE AIRCRAFT FUEL TANK EXPLOSION  
ACCIDENTS AND INCIDENTS, 1964-1974

<u>DATE</u>	<u>AIRPLANE</u>	<u>LOCATION</u>	<u>TOB</u>	<u>FATALITIES</u>	<u>CAUSE</u>
1. 11/23/64	B-707-331	Rome, Italy	73	48	Engine component damage
2. 6/28/65	B-707-321B	Travis AFB, CA	153	0	Fuel line damage
3. 8/30/66	Britannia	London, Eng.	0	0	Electrostatic discharge
4. 4/8/68	B-707-465	London, Eng.	127	5	Fuel line damage
5. 10/16/69	DC-8-63F	Stockton, CA	5	0	Fuel line damage
6. 4/19/70	DC-8	Rome, Italy	65	0	Tank damage
7. 4/25/70	NA-265	Hannover, Ger.	2	0	Tank damage
8. 5/3/70	B-727-100	Minneapolis, MN	0	0	Electrostatic discharge
9. 7/5/70	DC-8-63	Toronto, Can.	109	109*	Fuel line and tank damage
10. 10/10/70	L-382B	Wrightstown, NJ	3	3	Tank damage
11. 11/27/70	DC-8-63F	Anchorage, AK	229	47	Wing separation
12. 12/23/70	B-727-100	Minneapolis, MN	0	0	Electrostatic discharge
13. 6/7/71	CV-580	New Haven, CT	31	28	Wing separation
14. 3/19/72	L-188C	Hill AFB, UT	3	0	Fuel tank damage
15. 6/21/73	DC-8-53	Toronto, Canada	0	0	Electrostatic discharge
16. 7/11/73	B-707	Paris, France	<u>134</u> 934	<u>123</u> 363	Tank damage

\*NOTE: This accident is included because it involved an initial survivable hard landing which resulted in fuel line and tank damage of crashworthiness interest.

TABLE 27-U.S. AND FOREIGN SURVIVABLE AIRCRAFT CABIN FIRE ACCIDENTS  
AND INCIDENTS, 1964-1974

	<u>DATE</u>	<u>AIRPLANE</u>	<u>LOCATION</u>	<u>TOB</u>	<u>FAT.</u>	<u>OPER. MODE</u>
1.	7/31/67	V-745D	Honolulu, HI	33	0	Inflight
2.	11/19/68	B-707	Denver, CO	70	0	Inflight
3.	8/7/69	B-720	Philadelphia, PA	0	0	Parked
4.	4/22/70	B-707	Indianapolis, IN	0	0	Parked
5.	12/31/70	B-737	Washington, DC	0	0	Parked
6.	4/10/71	LJ-23	Danville, IL	6	0	Inflight
7.	4/11/71	LJ-25	Lake Charles, LA	2	0	Inflight
8.	5/9/71	F-27F	McAlester, OK	23	0	Inflight
9.	5/10/72	DC-9	Atlanta, GA	4	0	Parked
10.	5/23/72	B-707	Jamaica, NY	0	0	Parked
11.	6/10/72	B-727	New York, NY	77	0	Parked
12.	6/28/72	G-1159	Jamaica, NY	7	0	Inflight
13.	7/11/73	B-707	Paris, France	134	123	Inflight
14.	1/16/74	B-707-131B	Los Angeles, CA	55	0	Landing
15.	4/20/74	L-1011	Boston, MA	0	0	Parked
				<u>411</u>	<u>123</u>	

Seven interior fire accidents occurred inflight, one occurred as the aircraft stopped on the runway following a hard landing, and seven occurred when the aircraft were parked. Three inflight fire accidents involved battery compartment fires; two involved malfunctioning equipment fires (one under the cabin floor, the other behind the instrument panel); and two involved lavatory fires, one of which spread through the cabin and caused 123 fatalities in the only fatal cabin fire accident. Two parked fire accidents involved oxygen fed fires, one while the oxygen system was being serviced and the other while a portable oxygen unit was being used. Four parked fire accidents were due to electrical ignition sources, three of which occurred while the aircraft were unattended. One parked fire accident occurred during cargo loading as a result of leaking chemicals.

Emergency Evacuation

The reference data base provided emergency evacuation information on 119 accidents and incidents experienced by U.S. and foreign operators in and outside the U.S. These include 65 evacuations with 2853 occupants on board during which no injuries were incurred, and 54 evacuations with 5136 occupants on board which resulted in minor and serious injuries as shown in Table 28.

TABLE 28-EMERGENCY EVACUATION INJURIES, U.S. AND FOREIGN OPERATORS WORLD WIDE, 1964-1974

	<u>EVACUATIONS</u>	<u>INJURIES</u>		<u>TOB</u>
		<u>Minor</u>	<u>Serious</u>	
Approach	1	13	3	167
Landing	18	39*	11	1172
Takeoff	14	85*	23	1652
Inflight	4	10	5	253
Taxiing	6	79*	11	729
Parked	<u>11</u>	<u>42</u>	<u>21</u>	<u>1163</u>
	54	268*	74	5163

\*NOTE: Total minor injuries were not reported for two landing, one takeoff, and one taxiing evacuation incidents.

Air carrier passenger operations were involved in 53 evacuation injury incidents and air carrier cargo operations in one incident. The reported 268 occupants who received minor injuries represent 5.2 percent of the total on board in the 54 accidents and incidents and the 74 who received serious injuries represent 1.4 percent of the total. The total of 342 occupants who received either minor or serious injuries in the 54 evacuation incidents represents 6.7 percent of the total on board.

No injuries were reported during emergency evacuation in 47 air carrier passenger, six air carrier cargo, five air carrier pilot training, and seven business aircraft operations.

Various problems with the emergency evacuation system were reported in 12 evacuation incidents where injuries were incurred during evacuation and 12 incidents where there were no injuries. These problems included

escape slides which did not inflate or reach the ground, were installed inverted, were punctured, were pushed under the aircraft by the wind, and were slick due to rain. A detailed discussion of factors affecting 10 emergency evacuations is presented in NTSB Report No. NTSB-AAS-74-3, "Safety Aspects of Emergency Evacuations from Air Carrier Aircraft," dated November 13, 1974.<sup>1</sup>

AIRPORT CRASH FIRE-RESCUE SERVICE ANALYSIS

U.S. Air Carrier Survivable/Fatal Fire Accidents in the U.S.

Nineteen of the 23 fatal U.S. air carrier turbine aircraft fire accidents occurred in the U.S., of which six occurred on the airport and 13 at distances from the airport ranging from 3000 ft. to 18 miles as shown in Table 29.

TABLE 29-U.S. AIR CARRIER SURVIVABLE/FATAL FIRE ACCIDENT LOCATIONS IN THE U.S.

	<u>DATE</u>	<u>AIRPLANE</u>	<u>OPER. MODE</u>	<u>LOCATION*</u>	<u>CFRS</u>
1.	11/8/65	B-727	Approach	2 miles	No
2.	11/11/65	B-727	Landing	On airport	Yes**
3.	4/22/66	L-188C	Approach	1.5 miles	No
4.	11/6/67	B-707	Takeoff	On airport	Yes
5.	11/20/67	CV-880	Approach	6,878 ft.	No
6.	8/10/68	FH-227B	Approach	On airport	Yes
7.	10/25/68	FH-227C	Approach	4 miles	No
8.	12/27/68	CV-580	Approach	On airport	Yes
9.	7/15/69	DHC-6	Takeoff	On airport	Yes
10.	10/10/70	L-382B	Approach	5,470 ft.	Yes
11.	11/27/70	DC-8-63F	Takeoff	3,400 ft.	Yes
12.	6/7/71	OV-580	Approach	4,620 ft.	Yes
13.	10/24/71	B-99	Approach	11 miles	No
14.	12/8/72	B-737-222	Approach	1.5 miles	No
15.	12/20/72	DC-9-31	Takeoff	On airport	Yes
16.	12/29/72	L-1011	Approach	18 miles	No
17.	7/23/73	FH-227B	Approach	2.3 miles	No
18.	7/31/73	DC-9-31	Approach	3,000 ft.	Yes
19.	9/11/74	DC-9-31	Approach	3 miles	Yes

NOTE: \*Distance from the airport (or runway).

\*\*CFRS rescued three survivors about 25 minutes after impact.

There was a total of 21 turbine aircraft survivable/fatal fire accidents in the U.S. including a foreign air carrier CV-880 accident on 6/24/69 about 2,600 ft. from the airport and a U.S. F-27J business aircraft accident on 5/4/68 following overrun into heavy terrain on landing. Airport crash fire rescue service (CFRS) reached the scene of the foreign air carrier accident about four minutes after the accident, while CFRS was not available at the airport where the business aircraft accident occurred.

In addition to the foreign air carrier accident, CFRS was provided at the scene of 11 fatal U. S. air carrier fire accidents in the U.S.; six on the airport and five at distances from the airport ranging from 3000 ft. to three miles. CFRS was not provided at nine accidents (including the F-27J accident) which occurred within 18 miles from the airport. CFRS rescued three survivors in one accident about 25 minutes after impact and either was not available, could not respond, or arrived too late in the other 20 U. S. survivable/fatal fire accidents to affect rescue.

U. S. Operators Non-Fatal Fire Accidents World-Wide

The numbers of non-fatal turbine engine and aircraft fire accidents experienced by U. S. operators on or near U. S. and outside U. S. airports which were or were not extinguished with equipment provided in the aircraft are listed in Table 30. The fire accidents which were extinguished with equipment provided in the aircraft are enumerated under the columns labeled "A"; those which were not are enumerated under "B".

TABLE 30-U.S. OPERATORS WORLD-WIDE NON-FATAL FIRE ACCIDENTS, 1964-1974

<u>In U.S.</u>	<u>APPROACH</u>		<u>LANDING</u>		<u>TAKEOFF</u>		<u>INFLIGHT</u>		<u>TAXILING</u>		<u>PARKED</u>		<u>TOTAL</u>	
	<u>A</u>	<u>B</u>	<u>A</u>	<u>B</u>	<u>A</u>	<u>B</u>	<u>A</u>	<u>B</u>	<u>A</u>	<u>B</u>	<u>A</u>	<u>B</u>	<u>A</u>	<u>B</u>
Engine	0	0	3	7	1	1	4	3	2	1	1	2	11	14
Aircraft	0	2	1	19	1	18	2	4	0	5	2	9	6	57
	<u>0</u>	<u>2</u>	<u>4</u>	<u>26</u>	<u>2</u>	<u>19</u>	<u>6</u>	<u>7</u>	<u>2</u>	<u>6</u>	<u>3</u>	<u>11</u>	<u>17</u>	<u>71</u>
<u>Outside U.S.</u>														
Engine	0	0	1	1	1	0	0	0	0	0	0	0	2	1
Aircraft	0	1	0	3	0	2	0	1	0	0	0	0	0	7
	<u>0</u>	<u>3</u>	<u>5</u>	<u>30</u>	<u>3</u>	<u>21</u>	<u>6</u>	<u>8</u>	<u>2</u>	<u>6</u>	<u>3</u>	<u>11</u>	<u>19</u>	<u>79</u>

Four non-fatal aircraft fire accidents which were not extinguished with aircraft equipment were experienced in the U.S. by foreign operators, in addition to the 57 aircraft fire accidents experienced by U.S. operators. These 61 non-fatal aircraft fire accidents in the U.S. include four wing separation accidents ( one approach, three landing), nine tank damage accidents (one approach, four landing, four takeoff) and six fuel line damage accidents (one approach, two landing, three takeoff). The other 42 aircraft accidents include brake fires, hydraulic fluid fires, battery compartment fires, fuel tank explosions, etc. These 61 U.S. non-fatal aircraft fires and the 14 engine fires in addition to the eight non-fatal fire accidents experienced by U.S. operators outside the U.S. either resulted in destruction of the aircraft or required the services provided by ground fire fighting equipment for extinguishment.

#### STATUS OF FAA CRASHWORTHINESS R&D

##### Modified Fuel

Fuel was released from severed or partially severed wings in 14 impact-survivable U.S. air carrier turbine aircraft fatal accidents from 1964 through 1974 and from damaged tanks in seven fatal accidents, resulting in external fires and estimated 304 fatalities due to fire or its effects. These 21 accidents represent 75 percent of the total survivable/fatal accidents (29.6 percent of the total fatal accidents) and the estimated 304 fatalities due to fire in these accidents represent 30.8 percent of the total survivable accident fatalities (12.4 percent of the total fatal accident fatalities). The fire fatalities also represent 21.7 percent of the 1402 occupants in the 21 accidents and 17.9 percent of the 1698 occupants in all 28 survivable/fatal accidents. If the fire hazard due to fuel released from severed wings or damaged fuel tanks had not existed, an additional 17.9 percent of the occupants in survivable/fatal accidents may have survived, increasing the survivability from 41.9 percent to 59.8 percent.

The fuel released from severed wings or damaged fuel tanks during approach, landing, and takeoff accidents forms a fine mist of combustible

vapor which is readily ignited, resulting in a fire which serves as an ignition source for continuing fuel spillage as the aircraft comes to rest. "Anti-misting" modified fuel is being developed to inhibit the formation of fuel mists by creating a coarse spray of large droplets which reduces the probability of flame propagation, thereby decreasing the fire hazard following a survivable accident and improving conditions for safe occupant evacuation.

The FAA Modified Fuel Program is directed toward demonstrating the safety benefits of modified fuel under realistic crash conditions and developing a modified fuel specification which is required for approval of modified fuel candidates and qualification of engine and aircraft to use modified fuel. Engine and aircraft fuel system compatibility problems exist and efforts are underway to identify and resolve the problems. The process for restoring modified fuel to a usable form for unrestricted engine operation is the major compatibility factor which must be resolved. The FAA program plans call for development of any required system design changes to follow the safety demonstration and consideration of engine and aircraft ground and flight tests to assure that the use of modified fuel will not reduce the operational reliability and performance of conventional fuel.

A cost analysis in 1970 indicated that the use of a thicker-gelled fuel would result in a 4.5 percent increase in airline total operating costs for the first 10-year period of use.<sup>2</sup> Preliminary indications are that the use of lower viscosity "anti-misting" modified fuel would result in considerably reduced costs. These costs will be estimated following development of any required system design changes. It is possible, based upon accident experience, that an average of up to 30.8 percent of the fatalities in future impact-survivable accidents might be prevented by the use of modified fuel if it is eventually found to be practical. This might result in survival of an additional 17.9 percent of the occupants in survivable/fatal accidents.

#### Fuel Tank Inerting

Fuel tank explosions occurred in 16 U. S. and foreign survivable aircraft accidents and incidents (one of the foreign accidents involved an initial survivable hard landing which caused fuel line and tank damage resulting

in inflight fuel tank explosions, loss of control, and a non-survivable impact). The explosions in eight of the 16 survivable accidents and incidents occurred in non-damaged fuel tanks. Two of these accidents resulted in 53 fatalities; the explosions in one accident were due to the ignition of vapors in a fuel tank vent by fire fed by fuel from a damaged engine fuel system component and in the other to heating of the fuel tank by an external fire. Two accidents were non-fatal; one involved inflight explosions in an outer wing fuel tank and the other a post-crash explosion, both caused by heating of the fuel tank by an external fire. Fuel tank explosions in four incidents were caused by electrostatic discharge during refueling. The explosions in the other eight survivable accidents were caused by fires fed by fuel released from severed wings or damaged tanks or damaged lines. The explosions contributed toward the cause of 78 fatalities in three of these accidents and were the indirect cause of 109 fatalities in the foreign accident where the explosions caused loss of control and a non-survivable impact. Three tank damage/explosion accidents were non-fatal while the explosions in a foreign cabin fire accident near Paris were not a causal factor of the fatalities.

These data indicate that fuel tank explosions were the indirect cause of 109 fatalities in one initially survivable accident and contributed toward the cause of 131 fatalities in five survivable accidents by expanding and intensifying the post-crash fires so as to prevent further safe evacuation. Statistics on fuel tank explosions which resulted in non-survivable accidents are not included since such accidents are beyond the scope of this report.

The FAA recently completed a series of small-scale and full-scale tests using a 50-gallon capacity test article and C-133 outer wing panels to determine the effect of inerted fuel tanks in prevention of fuel tank explosions due to external fires.<sup>3</sup> The test results indicated that inerting a fuel tank to a reduced oxygen concentration of nine percent will prevent an explosion such as that which occurred under similar external fire test conditions in an uninerted fuel tank. These results suggest that the eight explosions in non-damaged fuel tanks would

probably have been prevented had the tanks been inerted and also that the remaining eight explosions due to fires fed by fuel released from severed or damaged tanks or damaged lines would at least have been delayed until the inert concentration in the tanks was lost, providing more time for safe evacuation.

Liquid nitrogen fuel tank inerting technology is presently available as evidenced by the installation and certification of the first fully qualified inerting system in the FAA DC-9 and by the installation of inerting systems in the Air Force C-5A fleet. A joint FAA-Air Force effort is currently in progress to develop a method to generate nitrogen on-board the aircraft for fuel tank inerting in order to eliminate the logistics and reduce the weight associated with the use of liquid nitrogen. This effort involves the use of hollow-fiber permeable membranes for separating the oxygen from engine bleed air.<sup>4</sup> A full-scale "breadboard" generating system to supply nitrogen enriched air will be built and tested. This contractual effort is scheduled for completion in early 1977.

#### Crash-Resistant Fuel Tanks

Local damage to wing fuel tanks was the cause of fuel release in 15 survivable/fire accidents to U.S. operators, seven of which were fatal with an estimated 45 fatalities due to fire. These seven tank damage/fire accidents represent 25 percent of the total survivable/fatal accidents and the estimated 45 fatalities due to fire represent 4.6 percent of the total survivable accident fatalities. Fuel was released from damaged fuel tanks without resulting in fire in 22 substantial damage/non-fatal accidents to U.S. operators.

A cost/benefit analysis of incorporating crash-resistant fuel tanks in a civil jet transport was conducted in 1970.<sup>5</sup> This analysis considered incorporation of a level of crash resistance represented by structural reinforcement in the front spar area plus a foam layer on the rear surface of the front spar and a highly elastic film attached to the foam.

If it is assumed that the load factor is 60 percent and that 50 percent of the occupants would survive an accident and resultant fire even if the airplane did not have crash-resistant tanks and that the other 50 percent would survive due to prevention of fire with crash-resistant tanks, the analysis determined that post-crash fires would have to be prevented in seven survivable crashes of contemporary transports or three of wide-body transports over a 10-year period for the crash-resistant tanks to be cost/beneficial. If maximum potential benefits are considered at a load factor of 100 percent where complete credit is given to crash resistant tanks for saving all occupants, the benefits would exceed the costs if post-crash fires were prevented in three contemporary transport crashes or one wide-body transport crash over a 10-year period.

On the basis of these cost/benefit criteria, incorporation of crash-resistant integral fuel tanks in U.S. air carrier aircraft from 1964 through 1974 would not have been cost/beneficial. Several aircraft incorporate auxiliary bladder fuel cells in the fuselage below the wing box structure. It would appear that the weight and volume penalties would not be as high for crashworthy fuselage tanks as they are for integral tanks.

#### Cabin Interior Materials

Smoke and toxic gases from burning interior materials were largely responsible for the fatalities in the inflight fire accident which occurred to a foreign air carrier while approaching Paris and some of the fatalities in approach, landing, and takeoff accidents which occurred to U.S. air carriers.

The FAA program to develop toxic gas emissions criteria for cabin interior materials includes the burning of 75 representative cabin interior materials under controlled conditions to obtain gas yield data of nine toxic gases. Tests are also being conducted to relate the material gas yield data and time-to-incapacitation of animals when exposed to the combustion products of the same materials. These tests are expected to be completed by December 1976.

### Cabin Compartmentation

Accident investigations have indicated that existing cabin class dividers tend to confine and inhibit fire spread to adjacent compartments. The FAA conducted 37 tests on various compartmentation configurations to determine their effectiveness in controlling the spread of cabin fires. A report on these test results will be published in late 1976.

### Cabin Fire Suppression

The first phase of an FAA program investigating the application of cabin fire suppression systems to reduce fatalities in survivable fire accidents was recently concluded by the completion of fire suppressant distribution tests in a DC-7 cabin.<sup>6</sup> The next phase involved 22 tests which were conducted from late 1975 through early 1976 to evaluate the effectiveness of these systems in controlling cabin interior fires. Tests were also conducted to investigate system effectiveness in inhibiting entry of external fires into a cabin opening. The concentration of hydrogen fluoride resulting from the pyrolysis of Halon 1301 suppressing agent was measured in these tests to establish whether human mobility may be affected by such a system. The reports on these latter phases will be published in mid-1976.

### Emergency Evacuation

Injuries were reported to 6.7 percent of the total occupants on board during emergency evacuations in 54 accidents and incidents. In order to improve emergency evacuation following survivable accidents, the FAA sponsored a contractual effort in 1967 to identify and establish the feasibility of new emergency evacuation concepts. The final report on this effort was published in January 1968<sup>7</sup> and recommended the following aircraft concepts for experimental evaluation:

1. Application of automatic voice instructions and audio signal devices.
2. Active, better distributed lighting mix for interiors and exteriors.
3. Use of tactual sense displays.

4. Situation displays for the crew.
5. Improved interpersonal communication devices.
6. Wide-spectrum passenger and crew education program and displays.
7. Personal protective devices.
8. On-board fire suppressant and prevention systems.
9. Automatically and manually controlled cabin venting systems.
10. Better slide entry and egress devices.
11. Better passenger containment and more versatile egress devices.
12. Power assistance for doors and egress device deployment.
13. Automatic passenger egress devices.
14. Application of cargo handling concepts.

Several of these concepts have been incorporated in air carrier aircraft or are under current evaluation.

## SUMMARY

An analysis of 382 impact-survivable/substantial damage turbine aircraft accidents and incidents which occurred during the 11-year period from 1964 through 1974 was performed to study the interrelationship of airport crash fire-rescue service requirements and aircraft crashworthiness. The analysis included 343 accidents which were estimated to represent 94% of the substantial damage accidents which occurred in the U.S. to all U.S. and foreign turbine aircraft operators and 39 accidents which occurred outside the U.S. Crashworthiness data were obtained from accidents both in and outside the U.S. The outside U.S. accidents were included to complete the consideration of all substantial damage accidents to U.S. operators and to cover several accidents to foreign operators which were of interest from a crashworthiness viewpoint. The U.S. accidents also provided data for an airport crash fire-rescue service analysis.

The analysis of accidents world-wide to U.S. operators and selected accidents outside the U.S. to foreign operators indicated the following of interest from a crashworthiness viewpoint:

1. There were 28 survivable/substantial damage fatal accidents world-wide to U.S. air carrier turbine aircraft. Fire occurred in 19 of these accidents in the U.S. and four outside the U.S. These fire accidents accounted for 94.9% of the fatalities from world-wide survivable accidents to U.S. air carriers. The fire hazard was greatest in approach accidents where 16 fatal approach fire accidents resulted in 79.3% of the total fatalities. Five fatal takeoff fire accidents accounted for 11.0% of the total fatalities. The fire hazard was least in landing accidents where two fatal landing fire accidents resulted in 4.6% of the total fatalities. The remaining 5.1% of the fatalities resulted from five approach accidents where fire did not occur.

2. Two fatal takeoff and 12 fatal U. S. air carrier approach fire accidents involved fuel release from wing or partial wing separation. Fatalities due to fire and its effects in these 14 accidents were estimated to be 37.3 percent of the total fatalities in these accidents. The 14 U.S. air carrier wing separation/fire accidents represent 50 percent of the total survivable fatal accidents and the fatalities due to fire in these accidents represent 26.2 percent of the total survivable accident fatalities.
3. One fatal landing, two fatal takeoff, and four fatal U.S. air carrier approach fire accidents involved fuel release from damaged fuel tanks. Fatalities due to fire and its effects in these seven accidents were estimated to be 29.8 percent of the total fatalities in these accidents. The seven tank damage/fire accidents represent 25 percent of the total survivable/fatal accidents and the fatalities due to fire in these accidents represent 4.6 percent of the total survivable accident fatalities.
4. One fatal takeoff and one fatal U.S. air carrier landing accident involved fuel release from damaged fuel lines or engine components. All fatalities in these two accidents were due to fire and its effects. The two fuel line/component damage/fire accidents represent 7.1 percent of the total survivable/fatal accidents and the fatalities due to fire in these accidents represent 9.2 percent of the total survivable accident fatalities.
5. The estimated 395 fatalities due to fire in the 28 U.S. air carrier world-wide survivable/fatal accidents represent 40.0 percent of the fatalities in these accidents and 16.1 percent of the fatalities in the total of 71 U.S. air carrier turbine aircraft fatal accidents.
6. Fire and its effects were estimated to be the cause of fatalities to 23.3 percent of the occupants in U.S. air carrier survivable/fatal accidents and reduced survivability from 65.2 percent to 41.9 percent of those on board.

7. Fuel tank explosions were the indirect cause of all 109 fatalities in one fatal foreign accident and contributory causal factors of 131 fatalities in five U.S. and foreign fatal accidents by expanding and intensifying post-crash fires so as to prevent further safe evacuation. Fuel tank explosions also occurred in 10 other U.S. and foreign non-fatal aircraft accidents and incidents.
8. Non-fuel related interior fuselage and cabin fires occurred in 14 U.S. non-fatal accidents and incidents and one foreign survivable aircraft accident which was fatal as a result of a cabin fire which spread and caused 123 fatalities.
9. Landing and taking off on slippery runways resulted in nine accidents, one of which resulted in an aircraft fire. Landing and taking off on wet runways which caused hydroplaning resulted in 26 accidents, two of which resulted in aircraft fires and one an engine fire. None of the accidents was fatal.
10. Injuries were reported during emergency evacuations in 54 accidents and incidents. The number of occupants who received either minor or serious injuries in these evacuation incidents represents 6.7% of the total on board. No injuries were reported in 65 evacuations.

The analysis of accidents in the U.S. to U.S. and foreign turbine aircraft operators indicated the following relative to consideration of airport crash fire-rescue service requirements:

1. There were 29 impact-survivable/substantial damage fatal accidents to U.S. and foreign turbine aircraft operators in the U.S. Fire occurred in 21 of these accidents; 19 to U.S. air carriers, one to a foreign air carrier, and one to a U.S. business aircraft operator. These fire accidents accounted for 93.6% of the fatalities from survivable accidents in the U.S. The fire hazard was greatest in approach accidents where 82.4% of approach fire accidents were fatal resulting in 80.8% of the total fatalities. In takeoff fire accidents, 15.4% were fatal accounting for 7.5% of the total

fatalities. The fire hazard was least in landing accidents where 7.4% of landing fire accidents were fatal resulting in 5.3% of the total fatalities.

2. Six of the 19 fatal U.S. air carrier fire accidents in the U.S. occurred on the airport and 13 at distances from the airport ranging from 3000 ft. to 18 miles. The foreign air carrier fatal fire accident occurred 2600 ft. from the airport, while the U.S. business aircraft accident occurred following overrun into heavy terrain on landing. Airport crash fire-rescue service (CFRS) was provided at the scene of 12 accidents; six on the airport and six at distances from the airport ranging from 2600 ft. to three miles. CFRS was not provided at nine accidents which occurred within 18 miles from the airport. CFRS rescued three survivors in one landing accident on the airport about 25 minutes after impact and either was not available, could not respond, or arrived too late in the other 20 fatal U.S. accidents to affect rescue.
3. A total of 75 non-fatal substantial damage accidents occurred in the U.S. where fire resulted in either destruction of the aircraft or required extinguishment by CFRS. Four accidents were experienced by foreign operators and 71 by U.S. operators. These 75 accidents included 14 engine fires and 61 aircraft fires. Four aircraft fires were the result of wing separation accidents, nine of tank damage accidents, and six of fuel line damage accidents. The other 42 aircraft fire accidents included brake fires, hydraulic fluid fires, battery compartment fires, and fuel tank explosions and cabin fires while the aircraft were parked.

## CONCLUSIONS

The following conclusions are based on analysis of 343 impact-survivable/substantial damage turbine aircraft accidents which occurred in the U.S. during the 11-year period from 1964 through 1974 and 39 selected accidents which occurred outside the U.S. and the current status of FAA crashworthiness R&D:

1. A significant majority (94.9 percent) of the total fatalities in survivable/substantial damage accidents world-wide to U.S. air carrier turbine aircraft resulted from accidents where fire occurred. Approach accidents with post-crash fire caused the most fatalities (79.3 percent of the total) and were the most severe in terms of fire development and impact forces; followed by takeoff accidents (11.0 percent of the total fatalities) and landing accidents (4.6 percent of the total). The remaining 5.1 percent of the fatalities resulted from approach accidents where fire did not occur.
2. Fire and its effects were estimated to be the cause of a high percentage (40.0 percent) of the fatalities corresponding to 23.3 percent of the occupants in the world-wide U.S. air carrier impact-survivable/turbine aircraft fatal accidents. If the fire hazard had not existed, an additional 23.3 percent of the occupants may have survived.
3. The estimated fatalities due to fire and its effects in the impact-survivable accidents represent 16.1 percent of the fatalities in all the fatal turbine aircraft accidents of which 60.6 percent were non-impact survivable and 39.4 percent were impact-survivable to some degree.
4. Crashworthiness is the first line of defense for survival after an accident. Action taken in the design of an aircraft to minimize the fire hazard and to retain adequate structural integrity is the most effective technique for accident survival.

5. If "anti-misting" modified fuel is found to be practical, its use might prevent an average of up to 30.8 percent of the fatalities in future impact-survivable accidents. This may result in survival of an additional 17.9 percent of the occupants in survivable/fatal accidents.
6. Fuel tank inerting is capable of preventing explosions in undamaged fuel tanks which are exposed to external fires and might delay explosions in damaged tanks, thereby providing more time for safe evacuation.
7. Incorporation of crash-resistant technology in auxiliary fuel cells located in the lower fuselage of some air carrier aircraft would probably create lower weight and volume penalties than those associated with crash-resistant integral wing fuel tanks.

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APPENDIX A

Survivable/Substantial Damage Approach Accident Summaries

Turbine-Powered Aircraft

1964-1974

1. 11/29/64, B-720, FAA, Oklahoma City, OK

The aircraft touched down 114 feet short of the runway threshold. The aircraft hit boundary approach lights and their concrete foundation. Impact with these objects and the ground caused substantial damage to the landing gear and other areas of the aircraft. Just before the aircraft reached the end of the runway it became airborne and, after a go-around, it was landed without further damage or incident.

Ref. ARB Summary, Pg. 30/64

2. 11/8/65, B-727, American, Constance, KY

The flight was conducting a visual landing approach when it crashed into a wooded hillside approximately two miles north of the runway. Initial impact occurred at an altitude 225 feet below the published airport elevation of 890 feet m.s.l. The right wing tore off and there was a post-impact fire.

Ref. ARB Summary, Pg. 27/65, and AFS-54 1965 Summary, Pg. 23

3. 4/22/66, L-188C, American Flyers, Ardmore, OK

The aircraft struck a hill at an elevation of 963 ft. about 1-1/2 miles from the airport while making an approach at night. The aircraft was destroyed by the impact and subsequent fire.

Ref. ARB Summary, Pg. 14/66, and AFS-54 1966 Summary, Pg. 8

4. 6/29/66, B-720B, American, Mojave, CA

The aircraft touched down 4,074 ft. short of the runway while executing an approach to landing. The aircraft suffered substantial damage. There was no fire.

Ref. AFS-54 1966 Summary, Pg. 14

5. 8/15/66, HS-125, Pennsalt Chemical Co., Paducah, KY

During the approach to land, the aircraft struck the ground 2,500 ft. short of the runway. The aircraft suffered substantial damage.

Ref. ARB Summary, Pg. 23/66

6. 11/1/67, CV-580, Frontier, Great Falls, MT

The aircraft struck the ground 2.3 miles short of the runway, damaging the nose gear and hydraulic system, and a missed approach was initiated during which 5 powerline cables were severed by the vertical tail. The aircraft continued to Billings, MT, where the nose gear collapsed during the landing roll on a foamed runway, damaging both propellers and engines. The passenger and stewardess exited through the left rear emergency door and slid by rope to the ground. The copilot used the right cockpit window and the Captain used the forward cargo door. There was no fire. Emergency units were standing by.

Ref. NTSB File No. 1-0061

7. 11/20/67, CV-880, Trans World, Constance, KY

During approach, the aircraft first struck trees 9,357 ft. short of the runway and came to rest 6,878 ft. from the runway and 442 ft. to the right of the extended runway centerline. The right wing was broken off and the fuselage was broken up. The aircraft was destroyed by fire.

Ref. ARB Summary, Pg. 23/67

8. 6/3/68, B-727, Trans World, New York, NY

The aircraft initially struck several approach lights about 700 ft. short of the threshold during an ILS approach in fog. Initial impact took off the left main landing gear, and damage to the aft fuselage and possibly the No. 2 engine occurred as the aircraft rotated to a climbout attitude. Several minutes later, the Captain landed the aircraft at Kennedy International, where the weather was better. During this landing, the right main and nose gear, which would not retract, failed and the left wing and under-fuselage were damaged. There was no fire. The aircraft came to rest about two-thirds down the runway and 480 ft. to the left. Passengers evacuated using overwing exits and slides at forward main and auxiliary doors. Emergency equipment arrived too late if there had been a fire, according to some passengers.

Ref. ARB Summary, Pg. 10/68, and NTSB File No. 1-0057

9. 6/6/68, Mystere 20, Business Jets, Reading, PA

The aircraft undershot on approach and contacted the ground just prior to the threshold, collapsing the landing gear. The aircraft skidded off the right side of the runway and stopped about 2,000 ft. from the threshold. There was no fire.

Ref. ARB Summary, Pg. 10/68, and NTSB File No. 3-2046

10. 6/13/68, B-707, Pan American, Calcutta, India

During a night approach in rain, the aircraft struck a tree and crashed 900 ft. short of the runway. The ground slide tore off all 4 engines. There was severe fire damage.

Ref. ARB Summary, Pg. 10/68, and AFS-54 1968 Summary, Pg. 13

11. 6/24/68, CV-580, North Central, Sioux Falls, SD

On approach, the aircraft struck a TV tower and the left propeller and engine reduction gear box were torn from the aircraft. A successful landing was made. There was no fire.

Ref. AFS-54 1968 Summary, Pg. 13

12. 7/1/68, AC-1121, N.C. Life Insurance Co., Fayetteville, AR

On approach without power, a wing contacted the ground and the aircraft crashed short of the runway. There was no fire.

Ref. ARB Summary, Page 11/68, and NTSB File No. 3-2243

13. 7/23/68, Lear Jet 24A, Denny's Restaurants, Little Rock, CA

The aircraft undershot the runway, collided with a tree about 100 yards short of the runway during the final approach, and came to rest to the right of the runway. There was no fire.

Ref. ARB Summary, Page 12/68, and NTSB File No. 3-2434

14. 8/10/68, FH-227B, Piedmont, Charleston, WV

The aircraft undershot the runway and crashed into a steep hillside 33 ft. below the runway elevation and 250 ft. short of the threshold. The aircraft bounced up onto the airport while it disintegrated. An extensive ground fire followed.

Ref. ARB Summary, Page 14/68, and AFS-54 1968 Summary, Page 21

15. 10/6/68, Lear Jet 23, \_\_\_\_\_, Chantilly, VA

During the final approach, the aircraft descended below the glide path and struck the middle marker causing substantial damage.

Ref. ARB Summary, Page 17/68

16. 10/25/68, FH-227C, Northeast, Hanover, NH

The aircraft was making a VOR approach and crashed into a mountain about 4 miles from the VOR station. There was fire after impact.

Ref. ARB Summary, Page 18/68, and AFS-54 1968 Summary, Page 26

17. 11/3/68, L-382E, Interior Airways, Prudhoe Bay, AK

During approach, the aircraft struck the ground, but the pilot recovered control and remained airborne. The No. 1 engine flamed out and a successful landing was made. There was substantial damage to the underside of the fuselage. There was no fire.

Ref. AFS-54 1968 Summary, Page 27, and NTSB File No. 3-4840

18. 12/24/68, L-382B, Airlift International, Brit Put, AK

During approach, the aircraft struck the ground about 3/4 mi. from the end of the runway. There was no fire and the aircraft was destroyed. The captain and load-master walked to the station for assistance. There was no emergency equipment.

Ref. AFS-54 1968 Summary, Pg. 30, and NTSB File No. 3-4907

19. 12/24/68, CV-580, Allegheny, Bradford, PA

During approach, the aircraft made initial contact with trees 66 ft. above ground level about 3 miles from the runway, struck another tree 33 ft. above ground level, and rolled to an inverted position before striking the ground. There was no sustained fire.

Ref. ARB Summary, Pg. 20/68, and AFS-54 1968 Summary, Pg. 30

20. 12/27/68, CV-580, North Central, Chicago, IL

During approach, the aircraft started a climb about 4,500 ft. from the threshold and stalled at 925 ft. above ground level, turned to the left, and struck the side of a hangar in a near-inverted attitude. The aircraft was destroyed by impact and resultant ground fire.

Ref. ARB Summary, Pg. 21/68, and AFS-54 1968 Summary, Pg. 31

21. 1/6/69, CV-580, Allegheny, Bradford, PA

During a VOR approach, the aircraft initially struck the top of a tree, cut a swath through further trees in a descending flight path, and struck the ground about 1,000 ft. beyond the tree of initial contact and about 6 miles short of the airport. The aircraft came to rest inverted about 400 ft. beyond the point of initial ground impact. There was no fire.

Ref. ARB Summary, Pg. 1/69, and AFS-54 1969 Summary, Pg. 1

22. 2/6/69, DC-9, Trans Texas, Harlingen, TX

While on final approach, the DC-9 collided with a Piper PA-28 at 150 ft. altitude near the end of the runway. The PA-28 crashed on the runway and the DC-9 landed without further incident. There was no fire.

Ref. AFS-54 1969 Summary, Pg. 4

23. 3/13/69, DHC-6, Wein-Consolidated, Lake Minchumina, AK

During approach, the aircraft struck a frozen lake and one passenger was thrown through an emergency exit door. The aircraft was destroyed.

Ref. AFS-54 1969 Summary Pg. 5

24. 7/20/69, DC-8-63F, Capitol, New Castle, DE

The aircraft struck an ILS antenna during approach and continued to Baltimore where a safe landing was made. Emergency air pressure was used to stop after turn off on the taxiway. There was extensive damage to underside of fuselage, right flap, left main gear door, and hydraulic lines on right main gear strut. There was no fire.

Ref. ARB Summary, Pg. 13/69, and NTSB File No. 1-0025

25. 1/11/70, DC-9, Texas International, Harlingen, TX

The aircraft struck a tree and two power poles 12,000 ft. short of the runway. Following a missed approach, the aircraft continued to Houston where a safe landing was made. There were no injuries or fire. Aircraft damage consisted of tears, holes, and buckling in the wings, underside of fuselage, and No. 1 engine nacelle.

Ref. ARB Summary, Pg. 1/70, and NTSB File No. 1-0002

26. 8/8/70, CV-990, Modern Air Transport, Acapulco, Mexico

During approach, the aircraft struck trees, approach lights and a small masonry building, and came to rest 600 ft. short of the runway and 100 ft. to the left of the centerline. The aircraft was destroyed by impact and fire. Rain and airport fire equipment extinguished the fire.

Ref. AFS-54 1970 Summary, Pg. 10, and NTSB File No. 1-0051

27. 10/10/70, L-382B, Saturn, McGuire AFB, Wrightstown, NJ

During approach, the aircraft struck trees and descended into the ground 5,470 ft. short of the runway. Fire and explosion followed impact. Several witnesses saw a crew member attempting to get out of the wreckage. Fire trucks arrived after the rescue attempt.

Ref. NTSB File No. 1-0028

28. 11/9/70, DHC-6, Mississippi Valley Airways, LaCrosse, WI

The aircraft struck trees about 4,000 ft. short of the runway on the approach centerline. Both wings, the wing-mounted engines, the left main landing gear, and the left horizontal stabilizer separated from the aircraft when it struck the trees. There was no post-crash fire.

Ref. NTSB File No. 3-1452

29. 2/17/71, DC-9, Southern, Gulfport, MS

During approach, the aircraft struck a power line and tower 8,700 ft. short of the runway, made a go-around, and landed without further incident. The aircraft received substantial damage to the left main landing gear, left wing leading edge, and left side of the fuselage. There was no fire.

Ref. ARB Summary, Pg. 5/71, and NTSB File No. 1-0003

30. 6/7/71, CV-580, Allegheny, New Haven, CT

The aircraft undershot on approach and struck three cottages at an altitude of 29 ft., 4,890 ft. short of the threshold and 510 ft. to the right of the extended centerline. The aircraft caught fire in flight following impact with the cottages, struck the ground, and came to rest 270 ft. beyond the cottages. The bulk of the fuselage remained intact, but sections of the left and right wings were separated with both engines. There was extensive fuel spillage. A series of explosions occurred shortly after impact, expanding the fire so that further evacuation was impossible. The fatalities occurred as a direct result of fire and its effects. Two fire fighting units arrived at the crash site about 5 minutes after the accident occurred.

Ref. ARB Summary, Pg. 11/71, and NTSB File No. 1-0006

31. 7/5/71, Falcon 60, General Transport, Boca Raton, FL

The aircraft touched down 900 ft. short of the runway and collided with a 3-4 ft. high sand bank about 850 ft. from the runway threshold, collapsing the left and right main landing gears. The fuselage broke into three major sections when it separated at the wing leading and trailing edges. There was no fire.

Ref. ARB Summary, Pg. 13/71, and NTSB File No. 3-1996

32. 10/24/71, B-99, Monmouth, Allentown, PA

The aircraft crashed during approach at about the 1,540 ft. level of a mountain about 11 miles from the airport. The aircraft caught fire shortly after coming to rest and several explosions occurred during the ensuing fire which destroyed the cockpit and cabin area. The surviving passengers were still strapped in their seats after the fuselage came to rest. They were able to evacuate the aircraft before the fire reached the cabin area. Various aircraft components, including the outboard sections of both wings, portions of the horizontal tail surfaces, and right engine, were distributed along a 370 ft. path.

Ref. NTSB File No. 3-2307

33. 3/3/72, FH-227B, Mohawk, Albany, NY

During approach, the aircraft crashed into a house about 3.5 miles from the airport. The aircraft struck the house near ground level and came to rest with the passenger section almost completely buried under the collapsed wreckage of the house. There was no fire or explosion. Rescue operations began about 10 minutes after impact and were completed about 3 hours later.

Ref. ARB Summary, Pg. 8/72

34. 12/8/72, B-737-222, United, Chicago, IL

The aircraft crashed during approach into a number of houses about 1.5 miles from the approach end of the runway. The aircraft was destroyed by impact and subsequent fire.

Ref. ARB Summary, Pg. 35/72, and AFS-54 1972 Summary, Pg. 24

35. 12/12/72, DH-125, Marathon Oil, Findlay, OH

The aircraft collided with trees on approach, crashed short of the runway, and immediately burst into flames. All occupants evacuated via the main door with minor injuries. The aircraft was completely destroyed by fire.

Ref. ARB Summary, Pg. 36/72, and NTSB File No. 3-3744

36. 12/29/72, L-1011, Eastern, Everglades, FL

The aircraft crashed about 18 miles from the airport following a missed approach due to an unsafe nose gear indication. The terrain in the impact area was flat marshland, covered with soft mud under 6-12 inches of water. The left outer wing impacted first, followed by No. 1 engine, and then the left main landing gear. The aircraft disintegrated, scattering wreckage over an area about 1,600 ft. long and 300 ft. wide. The fuselage was broken into four main sections. The No. 1 and No. 3 engines separated from the aircraft. After impact, a flash fire developed from sprayed fuel. Some of the burning fuel penetrated the cabin area, causing 14 passengers to suffer various degrees of burns.

Ref. NTSB Report No. NTSB-AAR-73-14

37. 7/23/73, FH-227B, Ozark, St. Louis, MO

The aircraft struck trees in a heavily wooded residential area during approach and crashed 2.3 miles short of the airport. On impact, both wings separated from the center wing section just outboard of the engine nacelles and the center wing section separated from the aircraft. Both main landing gears broke off. Several small fires broke out in various portions of the wreckage after final impact. Municipal fire department arrived on the scene about 3 minutes after the alarm and extinguished the fires. All passenger seats but one broke loose from the fuselage floor structure. Three seatbelts failed.

Ref. NTSB Report No. NTSB-AAR-74-5

38. 7/31/73, DC-9-31, Delta, Boston, MA

The aircraft struck a sea wall during approach about 165 ft. to the right of the extended runway centerline and 3,000 ft. short of the runway threshold. The aircraft wreckage was scattered in an area about 250 ft. wide and 790 ft. long. Portions of wing and fuselage structure were found between the edge of the water and the base of the wall. The largest part of the fuselage was found on the runway, fragmented, and almost consumed by fire. The wings separated from the center wing section. Both were extensively damaged by ground fire. Both engines and portions of the pylons separated from the fuselage. Airport firefighting equipment arrived at the scene in about 3 minutes and extinguished the cabin fire with

foam in less than 1 minute.

Ref. NTSB Report No. NTSB-AAR-74-3

39. 11/27/73, DC-9, Delta, Chattanooga, TN

The aircraft struck the approach lights 1,600 ft. short of the runway, then struck a dike, careened and slid to the left of the runway and came to rest on the grass. The left main landing gear and left engine separated following impact. The tail section and left side of the fuselage were damaged by fire. The passengers and crew evacuated rapidly.

Ref. AFS-54 1973 Summary, Pg. 15

40. 12/17/73, DC-10-30, Iberian, Boston, MA

The aircraft struck approach light piers about 500 ft. short of the threshold, then struck an embankment and sheared its right main landing gear, and skidded to a stop on the airport about 3,000 ft. beyond the threshold and 280 ft. to the right of the runway. The No. 1 and No. 3 engines and pylons separated from the wings. A fire erupted on the left side of the aircraft as it skidded along the runway. Fuel from a ruptured left wing fuel tank was feeding the fire. Airport fire equipment arrived within 3 minutes of the alarm and extinguished the fire and spread a protective foam cover on the leaking fuel. The right forward, right aft, and left aft doors could not be opened. Four passengers escaped through a break in the top of the fuselage and the remaining occupants through four open exits. Two passengers and one flight attendant were injured seriously during evacuation, 13 passengers were injured slightly. Evacuation was completed in about 2 minutes.

Ref. NTSB Report No. NTSB-AAR-74-14

41. 1/30/74, B-707-321B, Pan American, Pago Pago, Samoa

During approach, the aircraft struck trees about 3,865 short of the threshold, impacted the ground 236 ft. farther along the crash path, continued through jungle vegetation, struck a 3 ft. high lava rock wall, and stopped 3,090 ft. from the threshold as the right wing hit and destroyed the MM transmitter. There was progressive destruction of the aircraft during its travel through the vegetation and as it slid over the ground. The landing gear, the outer panels, the outboard ailerons, parts of the main and fillet wing flaps, all four engines, and the No. 3 pylon separated from the aircraft. The lower fuselage structure from the nose to just forward of the rear pressure bulkhead was severely damaged. Fire was evident during the last 350 ft. of the wreckage pattern. The aircraft fuselage was gutted by fire. Both wings and all fuel tanks which remained with the aircraft were burned and melted. The upper skin was melted on Nos. 1, 2, and 3 main fuel tanks and both stub sections of the center wing tanks. The No. 4 main wing tank

had ruptured and was damaged extensively by fire. The reserve tanks separated from the wings and were not damaged by fire. Only the copilot sustained traumatic injuries in the accident. All other fatalities were a direct result of the post-crash fire. Fire and rescue personnel took 14 minutes to reach the crash site.

Ref. NTSB Report No. NTSB-AAR-74-15

42. 9/11/74, DC-9-31, Eastern, Charlotte, NC

During approach, the right wingtip struck and broke tree limbs about 25 ft. above the ground, then the left wing struck and sheared a cluster of pine trees about 16 ft. above the ground. The aircraft struck the ground in an open field 110 ft. past the initial impact point. After the aircraft traveled a further 440 ft., the left wing contacted other trees and the wing broke in sections; at this point, the fuel ignited and moved along the ground with the aircraft. The right wing and right stabilizer were sheared off. The remainder of the aircraft, the fuselage and part of the empennage section, continued through a wooded area and came to rest about 3.3 miles short of the runway. The fuselage breakup was more severe in this area. There was fire inside the cabin during the crash sequence. The effects of the fire were fatal to the passengers before the cabin interior materials had a chance to burn and generate a significant amount of cyanide gas. Of the 71 persons who died as a result of the accident, 31 passengers and 1 crew member died of impact injuries. Thirty-three passengers died of burns and/or smoke inhalation. The remaining five passengers and a flight attendant died because of a combination of factors. First fire vehicle arrived on the scene 5 minutes after the alert. The fire was under control within minutes after the arrival of the first vehicle.

Ref. NTSB Report No. NTSB-AAR-75-9

## APPENDIX A

TABLE I

SURVIVABLE/SUBSTANTIAL DAMAGE APPROACH ACCIDENTSTURBINE-POWERED AIRCRAFT

1964-1974

No.	Date	Airplane	Fire		Mode of Fuel Release			Crew				Passengers				Evac.				Type of Flight			
			Yes	No	E	T	W	T	N/M	S	F	T	N/M	S	F	N	M	S	P	P	C	T	B
1	11/29/64	B-720		X				4	4	0	0	0	0	0	0	0	0	X				X	X
2	11/ 8/65	B-727	X				X	6	0	1	5	56	0	3	53					X			
3	4/22/66	L-188C	X			X		5	0	0	5	93	0	14	79					X			
A-12 4	6/29/66	B-720B		X				6	6	0	0	0	0	0	0							X	
5	8/15/66	HS-125		X				2	2	0	0	4	4	0	0								X
6	11/ 1/67	CV-580		X				3	3	0	0	1	1	0	0	X				X			
7	11/20/67	CV-880	X				X	7	0	2	5	75	0	10	65					X			
8	6/ 3/68	B-727		X				7	6	1	0	95	95	0	0	X				X			
9	6/ 6/68	M-20		X				2	2	0	0	0	0	0	0								X
10	6/13/68	B-707	X		X	X		10	8	1	1	53	41	7	5					X			
11	6/24/68	CV-580		X				3	3	0	0	19	19	0	0					X			



TABLE I CON'T

SURVIVABLE/SUBSTANTIAL DAMAGE APPROACH ACCIDENTS

No.	Date	Airplane	Fire		Mode of Fuel Release			Crew				Passengers				Evac.					Type of Flight			
			Yes	No	E	T	W	T	N/M	S	F	T	N/M	S	F	N	M	S	P	P	C	T	B	
26	8/ 8/70	CV-990	X				X	8	0	8	0	0	0	0							X			
27	10/10/70	L-382B	X			X		3	0	0	3	0	0	0							X			
28	11/9/70	DHC-6		X			X	2	0	2	0	4	1	3	0						X			
29	2/17/71	DC-9-15		X				4	4	0	0	7	7	0	0						X			
30	6/ 7/71	CV-580	X				X	3	0	1	2	28	0	2	26						X			
31	7/ 5/71	Falcon 60		X				2	0	2	0	0	0	0	0								X	
32	10/24/71	B-99	X		X	X	X	2	0	0	2	6	0	4	2						X			
33	3/ 3/72	FH-227B		X		X	X	3	0	1	2	45	1	30	14						X			
34	12/ 8/72	B-737-222	X			X		6	2	1	3	55	5	10	40			X			X			
35	12/12/72	DH-125	X			X	X	2	2	0	0	5	5	0	0								X	
36	12/29/72	L-1011	X			X	X	11	0	6	5	164	17	53	99						X			
37	7/23/73	FH-227B	X				X	3	0	2	1	41	0	4	37						X			
38	7/31/73	DC-9-31	X		X	X	X	6	0	0	6	83	0	1	82						X			
39	11/27/73	DC-9	X		X			5	4	1	0	72	72	0	0	X					X			

TABLE 1 CON'T

SURVIVABLE/SUBSTANTIAL DAMAGE APPROACH ACCIDENTS

No.	Date	Airplane	Fire		Mode of Fuel Release			Crew				Passengers				Evac.				Type of Flight							
			Yes	No	E	T	W	T	N/M	S	F	T	N/M	S	F	N	M	S	P	P	C	T	B				
40	12/17/73	DC-10-30	X			X			14	13	1	0	153	138	15	0		13	3	X			X				
41	1/30/74	B-707	X				X		10	0	0	10	91	0	4	87							X				
42	9/11/74	DC-9-31	X				X		4	1	1	2	78	0	9	69							X				
			<hr/>					<hr/>				<hr/>				<hr/>											
			20	22				193	35	66			1518	218		773					.13	3					

A-15/A-16

\*\* Note: Fire not sustained



APPENDIX B

Survivable/Substantial Damage Landing Accident Summaries

Turbine-Powered Aircraft

1964-1974

1. 1/1/64, CV-880, Trans World, Boston, MA

During a night landing roll on runway 4R following an ILS approach, the aircraft veered and slid off the left side of the runway. Side forces off the runway failed the main landing gears and the aircraft slid to a stop 191 ft. short of the upwind end of the runway and 135 feet off the left side. During the landing approach the pilot was advised that all landing surfaces were covered with one-fourth to three-eighths of an inch of slush and although runway 4R had been sanded braking action was reported fair to poor. The crew indicated that spoilers and reverse thrust were used for initial deceleration. Thereafter as braking was applied and increased it became evident that braking was ineffective. The Captain said, when it became doubtful the aircraft could be stopped on the runway and might roll into Boston Harbor, he intentionally turned the aircraft off the runway. Aircraft received substantial damage. Some passengers deplaned through aft main loading door which was close to the ground. Others used chutes at port and starboard galley hatches. Crash trucks arrived 10 minutes after accident.

Ref. ARB Summary, Pg. 1/64, and NTSB File No. 1-0014

2. 1/12/64, F-27, Ozark, St. Louis, MO

Following takeoff, the landing gear control was placed in the up position; however, the gear failed to retract. The gear position warning devices showed a down and locked indication at this time and thereafter during unsuccessful attempts to cycle the gear. The plane was then returned and landed with gear down and locked position indications but the gear control inadvertently left in the up position. When the nose-wheel touched down the gear retracted and the aircraft slid off the runway. Crew executed an emergency evacuation without incident.

Ref. ARB Summary, Pg. 2/64, and AFS-54 1964 Summary, Pg. 1

3. 2/12/64, F-27A, Bonanza, Las Vegas, NV

The aircraft landed 2,300 ft. from the approach end of a 4,400 ft. runway and overran the end of the runway, rolled down a slight grade, and struck a 3 ft. deep drainage ditch 240 ft. beyond the end of the runway. All 3 landing gear failed and the aircraft slid on the bottom of the fuselage until it stopped 650 ft. beyond the runway. Crew and passengers executed emergency evacuation without incident.

Ref. ARB Summary, Pg. 4/64, and AFS-54 1964 Summary, Pg. 3

4. 4/7/64, B-707-139, Pan American, Jamaica, NY

The aircraft touched down on the far end of runway 4R at John F. Kennedy International Airport and during landing roll overran the runway and came to rest in Thurston Basin. The aircraft sustained major structural damage; there was no fire. Of the one hundred and forty-five occupants including nine crew members thirty-three received minor injuries and sixteen serious injuries. There were no fatalities. Crew and passengers executed an emergency evacuation without incident.

Ref. ARB Summary, Pg. 10/64, and AFS-54 1964 Summary, Pg. 7

5. 4/24/64, L-188C, Northwest, Cleveland, OH

The aircraft made a normal landing touchdown on runway 5L at Cleveland-Hopkins Airport, Ohio. In the after-landing roll, at a point about 3,696 feet beyond the runway threshold, the nose gear collapsed. The aircraft then slid forward and to the right, coming to rest 20 ft. off the right side of the runway, 5,280 feet from the approach threshold. No. 3 propeller separated from aircraft, damaged fuselage, and a piece penetrated cabin. Aircraft damage to power plants and fuselage was substantial. There was no fire. Some passengers still had trays upon landing. Some reported the trays prevented them from using their hands to avoid being thrown about. Others reported difficulty evacuating due to trays underfoot. Passengers were evacuated by the main entrance door, right forward emergency exit, and both emergency evacuation chutes in the aft cabin. Flight crew assisted in evacuation. Firemen arrived before evacuation was completed and assisted by holding chutes. Fire crews ready to spray foam if fire started. Six passengers received minor injuries during landing.

Ref. ARB Summary, Pg. 11/64, and NTSB File No. 1-0055

6. 5/12/64, V-745D, United, Chantilly, VA

The aircraft was landed with the landing gear fully retracted. The aircraft slid to rest on a grass area to the right of the runway. Crew executed an emergency evacuation without incident.

Ref. ARB Summary, Pg. 12/64, and AFS-54 1964 Summary, Pg. 9

7. 7/1/64, B-720B, American, Jamaica, NY

Touchdown occurred left gear first at a point about 27 feet to the right of the runway centerline. After touchdown the plane veered farther right, struck the runway boundary lights and then went off right side of the runway. It came to a stop 2,920 feet from the threshold of runway 31 and 170 feet to the right of the centerline. A small fire which broke out in the No. 3 engine was quickly extinguished. All occupants evacuated the aircraft safely. Investigation revealed extensive damage as a result of the accident. Both the right and left main landing gears were failed rearward and the right main gear separated from the aircraft.

Ref. ARB Summary, Pg. 15/64

8. 8/26/64, B-707-331C, Trans World, Kansas City, MO

During a VFR landing approach, the aircraft struck runway approach lights located 390 ft. short of the runway. Thereafter, both main landing gears were sheared from the aircraft by impact with a concrete/earthen levee located about 200 ft. short of the threshold. The aircraft then settled on the runway and slid to a stop 3,250 ft. beyond the runway threshold on the extended nose gear and the underside of the fuselage. A small friction-induced fire in the fuselage aft section was quickly extinguished with hand fire extinguishers. Most passengers evacuated by means of slides through main aft, main forward, and auxiliary forward door. Six used over wing exit. Rear galley door slide would not deploy properly. Flight crew assisted in evacuation. Evacuation required 3-4 minutes. Airport fire equipment arrived and foamed the rear fuselage area as a precautionary measure.

Ref. ARB Summary, Pg. 20/64, and NTSB File No. 1-0043

9. 9/14/64, CV-580, Frontier, Farmington, NM

The aircraft skipped at touchdown. At second touchdown the aircraft veered, the nose gear partially collapsed, and then the propeller hit the runway. Directional control was maintained and the aircraft was brought to a stop on the runway about 3,700 ft. from the approach threshold. Both propellers and engines and nose gear support trunnion were damaged. There was no fire. Passengers and crew evacuated through the left rear emergency exit door by chutes.

Ref. ARB Summary, Pg. 21/64, and NTSB File No. 1-0060

10. 9/22/64, B-720B, Western, Sacramento, CA

In the landing the aircraft touched down hard on the overrun area 13 inches short of the runway and bounced. Recovery was made and second touchdown was normal; however, in the landing roll the right main landing gear separated from the aircraft. The plane then veered off the runway, sliding on the bottoms of the right jet pods. No. 3 engine emitted smoke, but no fire was observed. Airplane came to rest 4,620 feet from approach threshold. Passengers and crew evacuated by using slides at main aft and forward main and galley doors. Evacuation required 2-3 minutes. Emergency equipment arrived about 2 minutes after accident.

Ref. ARB Summary, Pg. 21/64, and NTSB File No. 1-0063

11. 11/5/64, B-720B, United, San Francisco, CA

The aircraft was landed on runway 28-R with the main gear down and the nose gear retracted. After the nose was held off as long as possible the aircraft slid to a stop on its lower nose section. During an emergency evacuation of the aircraft three passengers received minor injuries.

Ref. ARB Summary, Pg. 26/64

12. 11/12/64, CL-44D4, Flying Tiger, Detroit, MI

Ground observation revealed the left main gear was out of its well and nearly down but the bogie had not rotated forward. Having exhausted all normal and emergency means, landing was made in which the left gear collapsed. The landing was well executed with damage minimum under the circumstances.

Ref. ARB Summary, Pg. 27/64

13. 12/15/64, V-745D, , Franklin, PA

The aircraft touched down 114 feet short of the runway threshold. The aircraft hit boundary approach lights and their concrete foundation. Impact with these objects and the ground caused substantial damage to the landing gear and other areas of the aircraft. Just before the aircraft reached the end of the runway it became airborne and, after a go-around, it was landed without further damage or incident.

Ref. ARB Summary, Pg. 30/64

14. 2/13/65, B-707, Pan American, Fresno, CA

At touchdown, No. 1 engine pod dragged on the runway, causing substantial damage. A go-around was accomplished and the No. 1 engine fire warning light illuminated while airborne. One bottle of extinguishant was discharged and the landing was accomplished without further incident.

Ref. NTSB File No. 4-0007

15. 3/5/65, DC-8, Eastern, Jamaica, NY

There was no fire. The landing was in a 50-degree right crosswind of about 20 knots and, just after touchdown, the No. 4 jet pod struck the runway and was torn from the aircraft. The landing was completed without further incident.

Ref. ARB Summary, Pg. 6/65, and AFS-54 1965 Summary, Pg. 5

16. 3/18/65, B-727, Trans World, Kansas City, MO

The aircraft dropped abruptly to a hard landing and the left wing struck the runway. The wing tip, leading edge slat, trailing edge flap, and aileron were damaged. The landing was then completed without further incident.

Ref. ARB Summary, Pg. 7/65, and AFS-54 1965 Summary, Pg. 5

17. 3/19/65, B-720, Braniff, Houston, TX

The aircraft touched down hard on the nose gear during landing and then porpoised on the main gear through two or more oscillatory cycles before it was brought under control. Left wing dropped and No. 1 and No. 2 engine pods scraped the runway. Nose gear support structure was damaged.

Ref. ARB Summary, Pg. 7/65, and AFS-54 1965 Summary, Pg. 5

18. 3/26/65, B-707-321, Pan American, Saigon, Viet Nam

The No. 4 engine pod contacted the runway on landing touchdown. An engine fire occurred and was extinguished by the engine fire extinguishing system. The aircraft taxied to the ramp under its own power. There was substantial damage to the engine and pod and pylon assembly.

Ref. NTSB File No. 1-0049, and AFS-54 1965 Summary, Pg. 6

19. 4/23/65, B-707, Pan American, Merida, Mexico

While landing, the nose gear contacted the runway prior to the main gear. The nose gear then bounced several times on the runway and collapsed. The nose gear assembly received substantial damage.

Ref. ARB Summary, Pg. 11/65, and AFS-54 1965 Summary, Pg. 9

20. 5/9/65, B-707, American, Dyess AFB, Abilene, TX

During an emergency no-flap landing, the nose gear failed in overload when it made runway contact almost immediately following touchdown on the main gear at 200 knots. There was no fire.

Ref. ARB Summary, Pg. 12/65, and AFS-54 1965 Summary, Pg. 11

21. 6/14/65, DC-8, \_\_\_\_\_, Santiago, Chile

Left main landing gear brakes were locked on touchdown causing tire blowouts and a small fire. Damage was confined to the tires, wheels, and related components of the left main gear. Passengers were evacuated via two galley doors and main doors. Two slides were punctured, one by an umbrella.

Ref. NTSB File No. 4-0039

22. 7/1/65, B-707-124, Continental, Kansas City, MO

The aircraft made a "firm" landing, in heavy rain, about 1,050 feet past the approach end of the runway. When the crew's efforts to stop the aircraft were ineffective, and the captain was convinced that they were going off the end of the runway, he used differential power and rudder to cock the aircraft to the left. The aircraft slid off the end of the runway, went through the ILS localizer antenna building, struck a dirt blast mound, slid up over the mound, and came to rest with the nose section in the perimeter road between the blast mound and a river levee. The passengers and crew evacuated the aircraft without major difficulty. There was a fire after impact.

Ref. ARB Summary, Pg. 17/65, and AFS-54 1965 Summary, Pg. 13

23. 9/1/65, BAC1-11, Mohawk, Utica, NY

The nose gear collapsed during the landing roll and the aircraft slid on the lower nose section to a safe stop on the runway.

Ref. ARB Summary, Pg. 21/65, and AFS-54 1965 Summary, Pg. 17

24. 9/11/65, B-720, Braniff, Mexico City, Mexico

The nose gear failed in the trunnion on landing and the nose gear separated from the aircraft. The aircraft skidded straight ahead and came to a stop on the runway. Damage was confined to the nose gear and lower part of the fuselage.

Ref. AFS-54 1965 Summary, Pg. 18

25. 10/14/65, AW-650, Zantop, Piqua, OH

Aircraft experienced complete loss of power on all four engines due to fuel exhaustion and landed gear-up on an interstate highway, slid 924 ft. and struck an overpass where it lost both wing tips, one outboard engine, and the tips of the vertical stabilizers, and then slid an additional 839 feet. The three crew members received minor injuries. Fire Department received call 13 minutes after accident and arrived 8 minutes later. No fire on arrival. Smoldering around right landing gear extinguished by foam. About 10 minutes later, right wing burst into flame. It was extinguished immediately. Then the nose wheel assembly started smoking and was extinguished with foam. Foam was also used on and under the left wing because of fluid leaking in the area.

Ref. NTSB File No. 1-0077 and AFS-54 1965 Summary, Pg. 22

26. 11/11/65, B-727, United, Salt Lake City, UT

The aircraft landed hard 335 feet short of the runway threshold, the main gear sheared, and the aircraft caught fire and slid about 2,838 feet on the nose gear and bottom fuselage surface, coming to rest about 150 feet off the east side of the runway. The source of the fire was a ruptured fuel line supplying the aft-mounted engines from the wing tanks. About 25 minutes after the impact, firemen entered through a hole burned through the fuselage skin and rescued three persons trapped in the aft stairwell.

Ref. ARB Summary, Pg. 28/65, and FAA Report No. AM 70-16

27. 12/8/65, F-27A, Bonanza, Yuma, AZ

The aircraft touched down 800 feet from the approach end of the runway. The landing gear was retracted after decelerating to about 50 knots 1,200 feet beyond the touchdown point. The aircraft slid a further 143 feet and came to a stop on the runway center line. Occupants evacuated via aft main door and auxiliary forward door. Extensive damage to lower fuselage, right propeller, and engine. There were no injuries or fire.

Ref. ARB Summary, Pg. 30/65, and NTSB File No. 1-0079

28. 12/15/65, NA-265, , W. Palm Beach, FL

Landing was made gear-up. Aircraft slid down the runway and came to a stop 50 feet off center and 3,000 feet from the approach end. There was no fire. Substantial damage to fuselage and flaps.

Ref. NTSB File No. 2-0974

29. 1/23/66, B-707-227, Eastern, Jamaica, NY

The flight was cleared for an ILS approach and the crew was advised that slush to a depth of ¼" remained on the freshly plowed runway. The aircraft touched down hard and bounced twice. During the touchdown and subsequent bounces, the nose gear was failed rearward. The aircraft came to rest approximately 6,800 feet beyond the initial touchdown point. There was no fire. About eight passengers evacuated by emergency chutes deployed from the port and starboard passenger entrance and galley doors. One of the emergency chutes had been installed inverted. The remaining passengers were deplaned by portable steps. Emergency equipment was on the scene and assisted in the evacuation. Nose gear damage had blocked the cockpit door. Fireman kicked in the door from the cabin. Captain decided not to use emergency chutes because of strong wind and no danger of fire.

Ref. ARB Summary, Pg. 1/66, and NTSB File No. 1-0003

30. 2/10/66, F-27J, Allegheny, Pittsburgh, PA

The nose gear collapsed during the landing rollout and the aircraft slid on the nose for about 600 feet down the runway. Emergency equipment arrived within a few seconds and firemen sprayed foam on the nose section even though there was no evidence of smoke or fire. Firemen and crew assisted passengers in evacuating through the forward cargo door. There was substantial damage to frames and fuselage skin and to the nose gear doors and no injuries to the passengers or crew.

Ref ARB Summary, Pg. 5/66, and NTSB File No. 1-0005

31. 2/13/66, B-720, Braniff, Dallas, TX

The flight touched down normally for landing. When the landing roll had progressed about 3,000 feet the crew initiated thrust reversing. As they did so, the No. 1 engine burst into flames. The crew took immediate emergency action and the fire was extinguished prior to arrival of ground emergency equipment. With the No. 1 engine shut down, the aircraft was taxied to the terminal and passengers deplaned. Resulting fire and flying debris caused extensive damage to the left wing structure and to the No. 1 engine pylon.

Ref. ARB Summary, Pg 5/66, and AFS-54 1966 Summary, Pg. 2

32. 2/23/66, CV-990, American, Carswell AFB, Fort Worth, TX

An unsafe indication was received for the right main landing gear when the gear was lowered for landing at Dallas. As precautionary measure, the aircraft was landed on a foamed runway. The landing gear did not collapse. The passengers were evacuated via escape slides. One passenger was seriously injured when he fell from the slide while leaving the aircraft.

Ref. AFS-54 1966 Summary, Pg. 3

33. 2/27/66, DC-8, Delta, New Orleans, LA

There was little deceleration on landing during a heavy rain and when the Captain realized that the aircraft would overrun the runway, he attempted to turn off an intersecting runway. The aircraft yawed and slid off the runway.

Ref. AFS-54 1966 Summary, Pg. 4

34. 3/5/66, B-727, Eastern, Miami, FL

During gear retraction after takeoff the left main gear and nose gear retracted normally but the right main gear jammed at an intermediate position. After repeated unsuccessful attempts to extend and retract the right gear the pilot selected to make a wheels up landing. The landing was accomplished on an unfoamed runway after fuel was dumped and touchdown was made approximately 1,000' from the runway threshold. The aircraft proceeded in a straight line on the runway for approximately 3,200' before coming to rest.

Ref. ARB Summary, Pg. 8/66, and AFS-54 1966 Summary, Pg. 5

35. 3/21/66, CL-44D4, Flying Tiger, Norfolk, VA

Aircraft landed hard on the left main and nose gear and the left wing in line with the left main gear separated from the aircraft. The aircraft rolled to the left over on its back, burst into flames, and continued down the runway center line in an inverted position. Two crash trucks began foaming the aircraft as it came to a stop near a runway intersection before the occupants evacuated the aircraft. Three crew members and 3 deadheading crewmen evacuated via the Captain's sliding window. All occupants received minor injuries.

Ref. ARB Summary, Pg. 11/66, AFS-54 1966 Summary, Pg. 6, and NTSB File No. 1-0013

36. 3/24/66, V-812, Continental, Colorado Springs, CO

Aircraft landed hard 2,100 feet beyond the threshold and both right main wheels separated from the axle. The aircraft continued down the runway for 4,200 feet and came to rest near the 7,000 feet marker. Engine No. 3 was smoking and methyl bromide was discharged. Firemen applied CO<sub>2</sub> to the No. 3 engine. All on board evacuated via the forward stairway door. The aircraft received major damage and there were no injuries.

Ref. AFS-54 1966 Summary, Pg. 6, and NTSB File No. 1-0020

37. 3/24/66, Learjet 23, \_\_\_\_\_, Ramona, CA

During the landing roll at Ramona, the pilot experienced hydroplaning and initiated a go-around but struck an airport boundary fence and was substantially damaged. A landing was accomplished at Miramar NAS.

Ref. ARB Summary, Pg. 11/66

38. 3/24/66, CL-44D4, Flying Tiger, Alameda, CA

The aircraft landed hard and bounced, made a go-around, and landed. The No. 3 nacelle was damaged during the hard landing. There was no fire.

Ref. ARB Summary, Pg. 12/66, and AFS-54 1966 Summary, Pg. 7

39. 4/1/66, CV-580, Allegheny, Bradford, PA

Aircraft landed hard, porpoised several times, and the nose gear collapsed. The aircraft skidded off the right side of the runway and came to rest 40 ft. from the runway edge and 650 ft. from the end. There was no fire or fuel leakage. About half of passengers evacuated through rear door chute which was held by two men who arrived as chute was being deployed. Half of passengers evacuated through front boarding stairway and two used an overwing exit. One passenger stated emergency equipment arrived 45 minutes after the accident occurred. The aircraft suffered substantial damage to both propellers and engines, fuselage underside, and nose gear. There were no injuries.

Ref. AFS-54 1966 Summary, Page 7, and NTSB File No. 1-0060

40. 5/8/66, B-727, Eastern, Fort Worth, TX

In recycling the landing gear on a training flight, the left gear actuating cylinder was thrust through the upper surface of the wing and hydraulic system fluid and pressure were lost. The aircraft landed on a foamed runway at Carswell AFB with the left gear extended and the nose gear and right main gear retracted. The aircraft was substantially damaged.

Ref. AFS-54 1966 Summary, Page 9

41. 7/11/66, CV-600, Trans Texas, Harlingen, TX

The aircraft undershot the runway threshold, bounced, came down on the runway, veered to the right, and came to rest about 3,000 ft. down and 300 ft. to the right of the runway. The right main landing gear collapsed during a rough rollout, causing substantial damage to the wing, flap, propeller, and related components. The right engine was smoking and extinguishant was discharged. Company agent helped pull main cabin door stairs down for evacuation. Four passengers deplaned through a window exit. Fire truck arrived after all occupants had evacuated the aircraft.

Ref. AFS-54 1966 Summary, Page 15, and NTSB File No. 1-0069

42. 7/20/66, B-720, FAA, Amarillo, TX

A heavy landing was made following a training flight. The landing gear collapsed causing substantial damage.

Ref. ARB Summary, Page 20/66

43. 7/21/66, L-188A, Braniff, Fort Worth, TX

While operating on a scheduled flight to Houston the aircraft was diverted to Carswell AFB after it was discovered that the left landing gear could not be lowered. An emergency landing was made on a foam covered runway with the left gear retracted. There were no injuries during the emergency evacuation.

Ref. ARB Summary, Pg. 20/66, and AFS-54 1966 Summary, Pg. 16

44. 7/29/66, Learjet 23, \_\_\_\_\_, Manted, NC

Overran wet runway on landing causing the gear to collapse. Aircraft damage was substantial.

Ref. ARB Summary, Pg. 21/66

45. 10/10/66, Learjet 23, \_\_\_\_\_, New Orleans, LA

Overran wet runway on landing and collided with a dirt bank. Aircraft damage was substantial.

Ref. ARB Summary, Pg. 28/66

46. 10/13/66, V-745D, United, Muskegon, MI

The aircraft touched down about 2,200 ft. from the approach end of the runway, continued off the far end, and came to rest 294 ft. beyond in the rain soaked, sandy sod overrun. The nose gear collapsed during the overrun causing substantial damage. All passengers and crew evacuated via the main entrance door. Firemen arrived almost immediately and used CO<sub>2</sub> on the engines, although there was no evidence of fire.

Ref. AFS-54 1966 Summary, Pg. 25, and NTSB File No. 1-0071

47. 10/18/66, B-707-131, Trans World, Los Angeles, CA

The aircraft touched down hard and bounced and hit again hard on the nose gear, causing it to separate from the aircraft. The aircraft slid on its nose and stopped 4,216 ft. down the runway from the threshold. There was a friction fire from contact of the nose section with the runway which dissipated when the aircraft came to rest. Passengers used emergency slides at main forward, main aft, and auxiliary aft doors. Front galley access door slide was not successfully operated. Eight passengers received minor injuries during the evacuation. Firemen arrived shortly after the evacuation was completed.

Ref. AFS-54 1966 Summary, Pg. 25, and NTSB File No. 1-0062

48. 10/22/66, DC-8, Delta, New Orleans, LA

The aircraft landed 69 ft. short of the runway resulting in substantial damage when five wheels and tires were destroyed and flying metal struck other aircraft structure. The aircraft stopped on the runway and the passengers deplaned via the aft passenger exit using stairs that were brought out from the terminal.

Ref. ARB Summary, Pg. 28/66, and AFS-54 1966 Summary, Pg. 26

49. 11/2/66, B-727, American, New York, NY

The aircraft undershot the landing approach and contacted an approach light platform and the lip of the runway over-water extension shearing the main landing gear. The aircraft slid down the runway on the nose gear and aft fuselage and came to rest about 4,500 ft. from the approach end. At least 2 passengers used an overwing exit, 35 used the galley door slide, and 25 used the main entrance door slide. Stewardesses had difficulty opening the doors and deploying the slides. Emergency equipment arrived before the evacuation was completed.

Ref. AFS-54 1966 Summary, Pg. 26, and NTSB File No. 1-0056

50. 11/18/66, CV-880, Delta, Fort Worth, TX

The aircraft was landed with one main gear retracted. Aircraft damage was substantial.

Ref. ARB Summary, Pg. 30/66

51. 11/26/66, B-707, American, Oakland, CA

The landing was hard and the aircraft bounced several times. A go-around then executed. The landing gear could not be retracted and the nose gear was damaged. The aircraft was landed without further incident on a foamed runway.

Ref. AFS-54 1966 Summary, Pg. 29

52. 12/4/66, V-745D, United, Chicago, IL

The aircraft slid off the left side of the runway during landing rollout due to poor runway braking action caused by freezing rain. The left main gear ran into a sod depression causing the left wing to buckle downward and twist forward. No. 1 and No. 2 propellers were also damaged. There were no injuries.

Ref. AFS-54 1966 Summary, Pg. 30

53. 12/4/66, B-720B, Continental, Los Angeles, CA

Landing gear collapsed on landing. Aircraft damage was substantial.

Ref. ARB Summary, Page 32/66

54. 12/5/66, B-727, Northwest, Minneapolis, MN

The aircraft was landed with the nose gear retracted. Aircraft damage was substantial.

Ref. ARB Summary, Page 32/66

55. 1/19/67, V-745D, United, Norfolk, VA

During the landing roll, the aircraft collided with a snow removal grader which had moved onto the runway. The grader and aircraft slid together about 219 ft. down the runway. Evacuation of the aircraft was completed in less than 1.5 minutes via the front airstair door, overwing exits, and rear passenger door evacuation slide. Emergency units arrived as the last occupants were deplaning. There was substantial damage to the engines, wings, and fuselage. There was no fire.

Ref. AFS-54 1967 Summary, Page 2, and NTSB File No. 1-0009

56. 1/20/67, FH-227, Northeast, Boston, MA

The aircraft landed with the nose gear retracted and skidded on its nose for about 1,000 ft. before coming to rest on the centerline of the runway. Crew and passengers exited via the main cabin door at the rear of the aircraft.

Ref. ARB Summary, Page 1/67, and AFS-54 1967 Summary, Page 2

57. 1/23/67, CV-640, Caribbean Atlantic, San Juan, PR

The aircraft touched down about 250 ft. short of the runway causing collapse of the nose gear and separation of the right wing with the engine and main gear. The aircraft continued down the runway and came to a stop 700 ft. from the threshold and off the right side of the runway. A small fire developed near where the right wing had separated and was extinguished by ground equipment. The occupants evacuated the aircraft via the rear galley service door and the left overwing emergency exits.

Ref. AFS-54 1967 Summary, Page 3, and NTSB File No. 1-0047

58. 2/14/67, FH-227, Northeast, Boston, MA

The landing gear was accidentally retracted during landing rollout. Underside of fuselage, right propeller, and nose gear yoke were damaged. There was no fire and no immediate evacuation of crew.

Ref. AFS-54 1967 Summary, Pg. 5, and NTSB File No. 1-0010

59. 4/7/67, B-727, United, Tampa, FL

A gear-up landing was made on a foamed runway at McDill AFB. There was no fire. Occupants evacuated via slides and overwing exits. The Flight Engineer was injured when he jumped out too far on the slide, striking the pavement with little cushioning effect. Emergency equipment and crews were on the scene immediately and assisted in evacuation and foamed the aircraft as a precaution.

Ref. AFS-54 1967 Summary, Pg. 14, and NTSB File No. 1-0022

60. 4/14/67, NA-265, Kewanee Oil Co., Rosemont, IL

The right main gear slowly collapsed on touchdown and the aircraft skidded down the runway, coming to a stop 3,000 ft. from the approach end and 20 ft. to the right of the centerline. There were no injuries or fire.

Ref. NTSB File No. 2-0436

61. 4/23/67, Lear Jet 23, \_\_\_\_\_, Spanish Fork, UT

On landing the aircraft overshot the runway and collided with ditches. Aircraft damage was substantial.

Ref. ARB Summary, Pg. 10/67

62. 4/25/67, B-707, Trans World, San Francisco, CA

The nose gear wheels left the aircraft on landing and the aircraft slid to a stop on the nose gear strut. About three-fourths of the nose gear strut was ground away. There was a minor fire after landing.

Ref. AFS-54 1967 Summary, Pg. 16

63. 4/29/67, B-727, United, Salt Lake City, UT

During the landing roll with slush and water on the runway, the aircraft began to turn, then a skid developed, and the aircraft left the runway, causing the landing gear to collapse. The aircraft came to rest on a heading about 90 degrees to the landing direction.

Ref. AFS-54 1967 Summary, Pg. 17

64. 5/18/67, B-707, Pan American, Jamaica, NY

After returning following discovery of a landing gear fault soon after takeoff, the right main gear collapsed on landing. There were no serious injuries.

Ref. ARB Summary, Pg. 12/67

65. 6/20/67, HS-125, , Islip, NY

The aircraft ran off the side of the runway towards the end of the landing run and received substantial damage. There were no serious injuries.

Ref. ARB Summary, Pg. 14/67

66. 7/25/67, G-159, Mellon, New Cumberland, PA

After a normal touchdown on a wet runway, no braking action could be obtained and the aircraft skidded off the left side of the runway and struck a 3.5 ft. high earthen bank 520 ft. from the runway shearing off the landing gear. The aircraft continued through a hedgerow and trees and came to rest 700 ft. to the left of the end of the runway. There was extensive damage to fuselage, tail, and wings.

Ref. NTSB File No. 2-0388

67. 8/8/67, BAC 1-11, Allegheny, Jamaica, NY

The nose gear failed to extend and the aircraft made a nose gear up landing. Aircraft damage was substantial.

Ref. ARB Summary, Pg. 17/67

68. 9/8/67, CV-580, Frontier, Denver, CO

A gear up landing was made on a foamed runway after the right main gear failed to extend. There was no fire.

Ref. ARB Summary, Pg. 19/67, and AFS-54 1967 Summary, Pg. 26

69. 9/12/67, Lear Jet 23, Jet International, Detroit, MI

The aircraft made a very heavy landing on touchdown causing nose over. The aircraft was destroyed. There were no serious injuries.

Ref. ARB Summary, Pg. 24/67

70. 10/18/67, V-745D, United, Allentown, PA

After a normal touchdown on a wet runway, the aircraft veered to the right and left the runway, collapsing the landing gear. Hydroplaning occurred during part of the landing roll.

Ref. ARB Summary, Pg. 21/67, and AFS-54 1967 Summary, Pg. 29

71. 11/7/67, Falcon Model 20, \_\_\_\_\_, Washington, DC

Right main landing gear retracted on landing resulting in substantial damage to the aircraft.

Ref. ARB Summary, Pg. 22/67

72. 11/14/67, L-382B, Alaska, Anchorage, AK

The aircraft landed with the left main gear not fully down and locked. There was no fire.

Ref. AFS-54 1967 Summary, Pg. 30

73. 11/28/67, V-745D, United, Raleigh, NC

The nose gear collapsed following touchdown and the aircraft came to a stop 4255 ft. from the approach threshold. A small fire in No. 1 engine was extinguished by discharge of the engine fire extinguisher. Firemen arrived shortly after aircraft came to a stop and used Ansul extinguishant to cool the nose gear area. Passengers evacuated in 30 seconds through overwing exits, airstair door, and rear door slide. A stewardess and three passengers received minor injuries due to the slide not being held properly. Aircraft damage was substantial.

Ref. ARB Summary, Pg. 23/67, and NTSB File No. 1-0058

74. 12/11/67, V-745D, United, Canton, OH

The aircraft touched down at about the mid-point of the runway, overran the runway, and impacted at the bottom of a 12 ft. drop-off about 290 ft. beyond the end of the runway when the landing gear collapsed. The wet runway showed evidence of hydroplaning. Kerosene was pouring from the wings but there was no fire. Most passengers evacuated from the rear exit, several used an overwing exit. First emergency unit arrived after most passengers had been evacuated and foamed the wings as a precautionary measure.

Ref. AFS-54 1967 Summary, Pg 33, and NTSB File No. 1-0070

75. 2/16/68, B-727, Boeing, Seattle, WA

The nosewheel touched down too hard on landing causing substantial damage to the upper fuselage.

Ref. ARB Summary, Pg. 3/68

76. 2/29/68, BAC1-11, American, Boston, MA

While landing on a 3/4 in. slush covered runway, a skid developed after reversing and the aircraft left the runway. The nose gear collapsed on striking a small ridge. One passenger received minor injuries while deplaning.

Ref. ARB Summary, Pg. 3/68, and AFS-54 1968 Summary, Pg. 5

77. 3/23/68, DC-8, Eastern, Jamaica, NY

The right main gear collapsed at 80 knots on the landing run after rolling about 2,500 ft., causing damage to the No. 3 and No. 4 engines and flap trailing edges. There was no fire. Five passengers evacuated via a chute at the aft main door and the other passengers and crew via portable steps placed at the front main entrance door.

Ref. ARB Summary, Pg. 5/68, and AFS-54 1968 Summary, Pg. 8

78. 4/23/68, DC-8, Braniff, Quito, Ecuador

The aircraft touched down about 1,200 ft. down a wet runway 10,234 ft. long, overran the runway at a speed of 18-22 knots, and entered a ditch. A fire occurred in No. 2 engine after impact.

Ref. ARB Summary, Pg. 8/68, and AFS-54 1968 Summary, Pg. 9

79. 4/28/68, DC-8, Capitol, Atlantic City, NJ

After touching down on the right side of the runway, the aircraft veered off the runway to the right, struck a ditch, failed the landing gear and pylons and caught fire. The four crew members evacuated successfully, three from the cockpit windows and the fourth through the main entrance door, however, two received serious injuries. The aircraft came to rest about 1,000 ft. to the right of the runway. A vehicle with a radio was the first to arrive at the scene and radioed for an ambulance. Fire equipment and ambulance were not able to drive directly to the scene of the accident.

Ref. AFS-54 1968 Summary, Pg. 9, and NTSB File No. 1-0009

80. 5/4/68, F-27J, , Bruni, TX

The aircraft overran on landing into heavy terrain and exploded upon impact. Airplane was destroyed by fire. Witnesses arrived at the scene in 5 minutes, saw a fire in the center fuselage, then a minor explosion, and the fire progressed into the cockpit. A 10 lb. CO<sub>2</sub> fire extinguisher extinguished the flames but the fire restarted after the extinguisher was emptied.

Ref. NTSB File No. 3-4640

81. 6/8/68, B-727, United, Salt Lake City, UT

Following a normal landing on a wet runway, the pilot misjudged the speed for turnoff and the main gear collapsed during the turn as a result of overload. There was no fire.

Ref. ARB Summary, Pg. 10/68, and AFS-54 1968 Summary, Pg. 12

82. 6/8/68, AW-650, Universal, Little Rock, AR

The aircraft landed on a foamed runway and the right main landing gear collapsed. There was no fire.

Ref. AFS-54 1968 Summary, Pg. 11

83. 6/24/68, CL-44D4, Airlift International, Saigon, Viet Nam

The aircraft landed hard and sustained major damage including drooping engines, spar damage, and buckled wing plates. The aircraft was taxied to the ramp. There were no injuries or fire.

Ref. AFS-54 1968 Summary, Pg. 13

84. 7/25/68, CV-580, Allegheny, Morgantown, WV

The right inboard wheel came off during the landing run and rolled into the right propeller. The right engine nose case disintegrated and the propeller separated from the engine. A small engine fire was extinguished by ground personnel. There were no injuries.

Ref. AFS-54 1968 Summary, Pg. 17

85. 8/5/68, B-707, Flying Tiger, Travis AFB, CA

The No. 4 engine caught fire during reversing after landing which resulted in substantial fire damage to the engine, outboard lower wing skin, wiring, and right outboard aileron. Engine fire extinguishant was discharged twice and failed to extinguish the fire. The fire was extinguished by the base fire department. The crew evacuated via an escape slide at the forward left entrance door.

Ref. AFS-54 1968 Summary, Pg. 19, and NTSB File No. 1-0055

86. 8/7/68, B-727, United, Boston, MA

The left main landing gear separated after a hard landing and the aircraft veered to the left and went off the runway at which time the right main gear folded inward. The aircraft came to rest 4,500 ft. from the threshold and 118 ft. from the left edge of the runway. There was no fire. Eighteen passengers and two stewardesses sustained minor injuries as the aircraft lurched to a stop and during the subsequent evacuation.

Ref. AFS-54 1968 Summary, Pg. 20, and NTSB File No. 1-0037

87. 8/10/68, AC-1121, Western Commanders, Van Nuys, CA

The aircraft experienced brake failure during a no-flap landing and overran the end of the runway, struck a car, and was destroyed. There was no fire.

Ref. ARB Summary, Pg. 14/68

88. 8/21/68, Learjet 24, Pitts Industries, Fort Worth, TX

After a hard landing, the pilot made a go-around and was notified that his right main landing gear was folded back. The right gear collapsed after touchdown about 3,500 ft. down a foamed runway and the aircraft veered off the runway at the 8,500 ft. marker. There was no fire. The right wing and tip tank had extensive damage.

Ref. NTSB File No. 3-3299

89. 9/7/68, FH-227, Northeast, Manchester, NH

The landing gear collapsed on landing. Aircraft damage was substantial.

Ref. ARB Summary, Pg. 15/68

90. 11/29/68, B-727, Frontier, St. Louis, MO

The aircraft veered off the runway on landing during a storm causing the nose gear to collapse. Aircraft damage was substantial.

Ref. ARB Summary, Pg. 19/68

91. 12/5/68, AC-1121, , Watertown, NY

The left gear failed on landing due to improper level off. Aircraft damage was substantial.

Ref. ARB Summary, Pg. 19/68

92. 12/31/68, HS-125, Inland Container Corp., Lincoln, NE

The aircraft made a gear-up landing. Aircraft damage was substantial.

Ref. ARB Summary, Pg. 22/68

93. 1/17/69, NA-265, , Morrisville, NC

The nose gear collapsed shortly after touchdown and the aircraft skidded to a stop 2,000 ft. down the runway. There were no injuries or fire. Evacuation was through the main door. Substantial damage to nose gear strut and doors, speed brakes, and nose structure.

Ref. NTSB File No. 3-1129

94. 1/31/69, DC-8-61, Delta, Jacksonville, FL

During landing rollout at 20-25 mph, the nose gear collapsed and the aircraft continued down the runway for another 1,300 ft. before stopping 300 ft. from the runway end. There was no fire.

Ref. AFS-54 1969 Summary, Pg. 3

95. 2/3/69, G-159, , Batesville, IN

Control was lost during landing rollout and the aircraft left the runway, coming to a stop 2750 ft. from the threshold and 50 ft. to the left of the runway. There was no fire. Substantial damage to lower fuselage, landing gear, and both propellers and engines.

Ref. NTSB File No. 3-0028

96. 4/25/69, NA-265, , Morrisville, NC

The nose gear collapsed on landing rollout. Fire broke out in the wheel well and was extinguished by airport fire equipment. Occupants evacuated without injury. Substantial damage to nose structure and burned surfaces.

Ref. NTSB File No. 3-0776

97. 5/1/69, CL-44D4, Mobil Oil, Anchorage, AK

The aircraft landed hard, bounced, and crashed on the right side of the runway with the wings separated and the fuselage inverted. The aircraft burned and was destroyed, with the airport fire department arriving after about 5 minutes. The captain and passenger escaped with serious injuries. Other crew members sustained minor injuries.

Ref. NTSB File No. 3-3871

98. 5/3/69, DC-9, Overseas National, Sacramento, CA

The aircraft landed hard, bounced, settled rapidly, and made a second and third touchdown, causing substantial damage to the fuselage keel and wrinkled skin at both sides of the wing root area. There was no fire.

Ref. ARB Summary, Pg. 9/69, and AFS-54 1969 Summary, Pg. 9

99. 7/29/69, CV-990, American, Tulsa, OK

The aircraft landed hard just short of the runway and a go-around followed. The left main gear collapsed during the subsequent landing rollout. There was no fire.

Ref. AFS-54 1969 Summary Pg. 15

100. 8/1/69, CV-600, Texas International, Houston, TX

The nose gear collapsed during landing rollout. There was no fire.

Ref. AFS-54 1969 Summary, Pg. 15

101. 8/1/69, B-707, Pan American, Brussels, Belgium

The aircraft touched down on the nose gear at a rate of descent higher than normal, bounced, veered to the left and left the runway about two-thirds down the length of the runway. The nose gear collapsed and the aircraft came to a stop against a pile of bricks. There was no fire.

Ref. ARB Summary, Pg. 14/69, and AFS-54 1969 Summary, Pg. 15

102. 8/12/69, DC-9-31, Caribbean Atlantic, St. Thomas, VI

The aircraft landed on a runway with standing water, continued 323 ft. beyond the end of the runway, and came to rest in a small building after striking several vehicles. There was no fire. One passenger sustained minor injuries during the evacuation.

Ref. ARB Summary, Pg. 15/69, and AFS-54 1969 Summary, Pg. 17

103. 9/9/69, SA-26T, \_\_\_\_\_, Norfolk, VA

The landing gear retracted during landing. There was no fire. Substantial damage to lower fuselage, landing gear doors, and both propellers and engines.

Ref. NTSB File No. 3-3856

104. 9/9/69, NA-265-40, \_\_\_\_\_, Orlando, FL

The nose gear failed during landing and the aircraft came to rest 3,256 ft. from the approach end and 28 ft. to the right of the runway centerline. There was no fire. The nose gear structure was substantially damaged.

Ref. NTSB File No. 3-3561

105. 12/13/69, B-747, Boeing, Renton, WA

During approach, the aircraft struck the edge of a lake bank about 2 ft. below and 20 ft. short of the threshold and came to a stop on the runway centerline about 3,500 ft. beyond the threshold. Small fires started in No. 3 strut and No. 4 engine which were extinguished by the airport fire department with one 15lb. CO<sub>2</sub> fire extinguisher. Hydraulic fluid was leaking together with fuel from a punctured wing tank near the fuselage.

Ref. ARB Summary, Pg. 24/69. and NTSB File No. 5-0046

106. 2/1/70, CV-580, North Central, Detroit, MI

The aircraft made a gear-up landing, went off the right side of the runway and slid to a stop along the side of the runway. Occupants evacuated from rear service door and overwing exits in 25-30 seconds. Fire equipment arrived and assisted in evacuation. There was no fire.

Ref. AFS-54 1970 Summary, Pg. 2, and NTSB File No. 1-0006

107. 2/8/70, L-1329, \_\_\_\_\_, Akron, OH

The aircraft struck power lines on approach and landed safely. The aircraft sustained extensive damage to the nose gear, fuselage skin, left wing tip leading edge flaps, and right slipper fuel tank fairing. There was no fire. Airport fire equipment responded on request of the pilot.

Ref. NTSB File No. 3-0590

108. 2/11/70, B-707, Pan American, Stockton, CA

The aircraft touched down 1,000 ft. along a wet runway, ran off the end of the runway, and struck a 3 ft. deep ditch. There was no fire.

Ref. ARB Summary, Pg. 5/70, and AFS-54 1970 Summary, Pg. 2

109. 2/14/70, Learjet 23, \_\_\_\_\_, Atlanta, GA

The aircraft overran runway on landing and collided with ILS building. Aircraft damage was substantial.

Ref ARB Summary, Pg. 5/70

110. 2/15/70, Learjet 24B, \_\_\_\_\_, Warwick, RI

The nose gear struck a snow bank at the approach end of the runway and collapsed on landing rollout. The aircraft skidded down the runway centerline and came to rest 3,000 ft. down the runway. There was extensive damage to the fuselage nose and nose gear and right and left flaps. There was no fire.

Ref. NTSB File No. 3-0375

111. 3/10/70, B-707, Eastern, Corpus Christi, TX

The aircraft touched down in the first 1/3 of a wet runway. When 800 ft. from the end of the runway, the aircraft slid off the left side of the runway and came to rest 200 ft. from the runway. Injuries received during evacuation.

Ref. ARB Summary, Page 7/70

112. 4/25/70, NA-265, Monadori Publishing Co., Hannover, Germany

On landing, the right main landing gear collapsed causing the aircraft to swerve off the runway where the nose gear also collapsed. The right wing fuel tank was ground down and an explosion in the wing caused extensive wing damage. The fire went out in 4-5 seconds. There was also substantial lower fuselage damage.

Ref. NTSB File No. 6-0029

113. 4/30/70, CL-44D4, Icelandic, Jamaica, NY

The left main landing gear retracted during touchdown and the aircraft veered off the runway. The nose gear separated and the left wing, flaps, and engines were damaged.

Ref. ARB Summary, Page 9/70

114. 5/7/70, B-727, Western, Salt Lake City, UT

Touchdown was normal on a wet runway, but braking did not decelerate the aircraft and the pilot initiated a left turn off the runway which developed into a ground loop and the right main gear collapsed. One injury was incurred during the evacuation when a passenger tumbled out of the slide chute.

Ref. ARB Summary, Page 10/70

115. 5/24/70, B-720, Western, Seattle, WA

The aircraft landed on a foamed runway with the nose gear retracted. Aircraft damage was substantial.

Ref. ARB Summary, Page 11/70

116. 6/3/70, V-810, \_\_\_\_\_, Alexandria, LA

The nose gear collapsed on landing. Aircraft damage was substantial to the four propellers and engines, nose gear, and the fuselage nose. The aircraft slid down the runway centerline coming to a stop 3,000 ft. down the runway. Passengers evacuated via the front entrance door. There was no fire. Fire department did not respond.

Ref. NTSB File No. 3-1363

117. 6/8/70, NA-265, U.S. Steel, Youngstown, OH

The main landing gear collapsed on landing rollout due to side loading, causing considerable damage to right and left wings and bottom of aft fuselage. The right wing fuel tank was leaking through breaks in the wing skin. Aircraft came to rest 3,400 ft. from the end of the runway and 48 ft. to the left of the centerline. There was no fire. Airport fire department responded.

Ref. NTSB File No. 3-1036

118. 6/26/70, B-747, Trans World, Jamaica, NY

During the landing roll, the No. 3 engine was reported to be on fire. The aircraft was stopped and emergency evacuation was started. Airport fire department arrived and extinguished the fire and assisted the evacuation. There were no injuries.

Ref. NTSB File No. 4-0030

119. 7/5/70, DC-8-63, Air Canada, Toronto, Canada

The aircraft landed heavily and shed No. 4 engine. Overshoot action was immediately taken and the climb was made straight ahead to 3,000 feet. Shortly after, following several explosions, No. 3 engine and a large section of the right wing separated in flames from the aircraft. The aircraft turned to the right, descended and collided with the ground.

Ref. ARB Summary, Pg. 16/70

120. 7/14/70, NA-265, \_\_\_\_\_, Grand Rapids, MI

The aircraft experienced hydroplaning, skidded off the runway failing all landing gear, and came to rest 6,600 ft. from the threshold and 50 ft. to the right of the runway. There was no fire. Damage was substantial to the landing gear, left wing tip, and fuselage nose.

Ref. NTSB File No. 3-0858

121. 7/28/70, YS-11A, Piedmont, Washington, DC

Shortly after touchdown the main landing gear retracted followed by the nose gear. The aircraft slid about 1,320 ft. and came to rest on the left side of the runway.

Ref. ARB Summary, Pg. 19/70

122. 9/3/70, Mystere M-20, Tenneco, Jonesboro, AR

The aircraft touched down near the approach end of a wet runway, overran the runway, and continued for 210 ft. in soft ground where the nose gear collapsed. There was no fire.

Ref. ARB Summary, Pg. 21.70, and NTSB File No. 3-1212

123. 9/8/70, DC-9-32, Delta, Louisville, KY

The aircraft touched down 156 ft. short of the runway, rolled 73 ft. toward the runway, became airborne and touched down tail first 262 ft. beyond the threshold. The aircraft came to rest 4,457 ft. beyond the point of second impact. The aircraft was substantially damaged by the initial ground contact but there was no fire.

Ref. ARB Summary, Pg. 22/70, and AFS-54 1970 Summary, Pg. 12

124. 9/15/70, DC-8-62, Alitalia, Jamaica, NY

The aircraft made a hard landing, veered off the left side of the runway, and ground looped to the left before coming to a stop in a sandy area. Three engines separated from the aircraft during the landing rollout and the fuselage split open just aft of the wing. There was a fire reported under the fuselage during the skid which went out as the aircraft stopped.

Ref. ARB Summary, Pg. 22/70, and NTSB File No. A-0003

125. 9/17/70, Learjet 23, Radiation, Inc., Quincy, MA

The aircraft ran off the end of the runway, shearing off both main landing gears, and came to rest 105 ft. from the end of the runway. Substantial damage to landing gear, stabilizer, bottom of fuselage, and left tip tank.

Ref. ARB Summary, Pg. 23/70

126. 9/18/70, Learjet 23, Jet America, Chantilly, VA

The aircraft lost a wheel during takeoff, was unable to extend the left main gear for landing, and made a gear-up landing on a foamed runway.

Ref. ARB Summary, Pg. 23/70

127. 9/29/70, B-720-027, Braniff, Dallas, TX

During landing rollout, the left main landing gear collapsed and the aircraft veered off to the left on a taxiway, coming to rest about 1,500 ft. from the end of the runway. A small fire developed in No. 2 engine nacelle which was extinguished by ground equipment.

Ref. AFS-54 Summary, Pg. 13, and NTSB File No. 1-0053

128. 12/10/70, CV-640, Caribbean Atlantic, St. Thomas, VI

The aircraft touched down and bounced several times, collapsing the nose gear, and skidded to a stop near the runway centerline about 3,000 ft. from the threshold. There was no fire and all occupants evacuated without incident. Substantial damage to propellers and fuselage nose section.

Ref. ARB Summary, Pg. 28/70, and NTSB File No. 1-0050

129. 12/16/70, B-727-224, Continental, Burbank, CA

During the landing roll, the left main landing gear collapsed rearward and the left wing tip and outboard edge of the left flap scraped the runway while the aircraft skidded for about 1,000 ft. and came to a stop on the left side of the runway. Fuel was spilled on the runway but no fire occurred. All passengers and three crew members evacuated using the slide at the left forward door. Five crew members used a ladder placed at the right galley door by the fire department which arrived at the scene within 2 minutes.

Ref. AFS-54 1970 Summary, Pg. 18, and NTSB File No. 1-0047

130. 12/28/70, B-727-200, Trans Caribbean, St. Thomas, VI

The aircraft touched down hard, bounced two times, touching down the last time about 2,700 ft. down the runway when the right wing settled to the runway, veered off the right side of the runway, continued parallel to the runway through a perimeter fence and across the perimeter road, and came to rest against a hillside about 300 ft. beyond the runway and 200 ft. to the right. The aft section of the fuselage broke away and there was also a forward fuselage break. Fire started in the left wing root area but did not intensify until 53 of the 55 occupants had evacuated. Fire equipment arrived in 1-1½ minutes after the aircraft came to rest and was unable to extinguish the fire until the cockpit and cabin area were totally consumed. The two fatalities were due to thermal injuries. Most passengers escaped through the aft fuselage break, others used slides at the right forward galley exit and right aft exit. The galley escape slide did not reach the ground and a passenger suffered a fractured vertebra because of the six-foot drop to the ground.

Ref. ARB Summary, Pg. 30/70, and NTSB File No. 1-0026

131. 1/11/71, DC-9, Delta, Jackson, MS

The aircraft veered off the left side of runway during landing on a damp runway. The left main landing gear ran off the runway 1474 ft. beyond the threshold and the right gear, 1,658 ft. The aircraft came to a stop 3,140 ft. beyond the threshold with the main gear mired in mud and the nose gear collapsed. There was no fire.

Ref. ARB Summary, Pg. 2/71, and AFS-54 1971 Summary, Pg. 1

132. 1/13/71, G-159, Goodrich, Akron, OH

The aircraft landed on an icy runway, continued off the end at about 10 mph., and rolled over railroad tracks, collapsing the landing gear. Occupants evacuated via the main door. There was no fire.

Ref. NTSB File No. 3-0008

133. 2/3/71, AC-1121, Continental Jet Corp., Omaha, NE

The aircraft struck station 2 and 3 approach lights resulting in substantial damage to the right wing and both flaps, and then made a safe landing. There was no fire.

Ref. ARB Summary, Pg. 4/71, and NTSB File No. 3-0270

134. 2/26/71, B-727, American, St. Louis, MO

Shortly after touchdown, the left main landing gear failed, allowing the left wing to drag the runway. The aircraft came to rest partially off the left side of the runway about 4,700 ft. beyond the threshold. The aircraft received substantial damage to the left wing and landing gear. There was no fire or fuel leakage. Emergency equipment arrived quickly and tried to assist in evacuation before the captain ordered passengers to evacuate. Difficulty was encountered in pulling an exit door into the cabin. Evacuation took about 3 minutes. There were no injuries.

Ref. ARB Summary, Pg. 5/71, and NTSB File No. 1-0031

135. 3/18/71, L-382, Saturn, McConnell AFB, Wichita, KS

The aircraft landed in a cross wind and the left wing came up, causing the right wing tip and No. 4 propeller to contact the runway after 1,000 ft. of landing roll. The No. 4 propeller and gear box separated with a portion of the wing outboard of No. 4 engine and the right wing caught fire and burned outboard and aft of No. 4 engine. The aircraft veered off the runway to the right at the 4,200 ft. point and came to rest 7,500 ft. from the approach threshold and 750 ft. to the right of the runway. Base fire department was at the scene as the crew left the aircraft and extinguished the fire which destroyed the outboard right wing.

Ref. ARB Summary, Pg. 6/71, and NTSB File No. 1-0020

136. 7/19/71, B-727, United, Denver, CO

The aircraft touched down 3,500 ft. down a wet runway, started to skid to the left at the 8,500 ft. point, left the runway, collapsing the main landing gears, and came to rest 9,000 ft. from the threshold. Airport fire department arrived quickly at the scene and assisted in evacuation of passengers in less than 2 minutes. All exits were used except for the galley exit which was stuck and the aft stairway which was unusable due to the aircraft attitude. The fire department stopped a minor fuel leak from the APU. There was substantial damage to the landing gear, leading and trailing edge flaps, and fuselage keel structure. There was no fire.

Ref. ARB Summary, Pg. 13/71, and NTSB File No. 1-0015

137. 8/20/71, CV-580, Allegheny, Pittsburgh, PA

The aircraft landed with the right main landing gear wheels missing and veered to the right, shearing the left main gear as the aircraft left the runway. There was no fire. All passengers and crew evacuated the aircraft in about 30 seconds.

Ref. ARB Summary, Pg. 16/71, and AFS-54 1971 Summary, Pg. 13

138. 12/4/71, DC-10, United, Chantilly, VA

The aircraft landed with 4 flat left main landing gear tires and came to a stop 9,000 ft. down the runway. Airport fire department quickly extinguished a small tire fire. Passengers deplaned via a mobile lounge.

Ref. NTSB File No. 4-0052

139. 12/17/71, B-99A, Texas International, Houston, TX

The aircraft was landed gear-up on a foamed runway. There were no injuries and no fire occurred. Aircraft damage was substantial.

Ref. AFS-54 1971 Summary, Pg. 16

140. 2/10/72, L-382E, Southern Air Transport, Montalvo, Ecuador

The aircraft touched down hard on the right rear main gear and the strut assembly separated from the truck assembly after the aircraft slowed to about 80 knots. The aircraft stayed on the runway and the crew deplaned via the forward crew door. There was no fire.

Ref. ARB Summary, Pg. 6/72, and NTSB File No. 1-0025

141. 2/28/72, Falcon 20, Johns-Manville Corp., Boston, MA

The aircraft made a gear-up landing, received major damage to the landing gear and wheel-well caused by impact friction and fire, and came to a stop 4,800 ft. from the threshold on the runway centerline.

Ref. ARB Summary, Pg. 7/72, and NTSB File No. 3-3957

142. 3/9/72, Learjet 25, E.B. Jeffress, Sturgis, MI

The aircraft touched down 61 ft. short of the runway and both main landing gears separated. The aircraft skidded off the left side of the runway and came to rest 3,800 ft. from the threshold. The aircraft received substantial damage to the landing gear, wings, and flaps. There was no fire.

Ref. ARB Summary, Pg. 9/72, and NTSB File No. 3-1409

143. 3/11/72, CV-580, Allegheny, Windsor Locks, CT

The aircraft made a sharp 90 degree turn to the left about 1,000 ft. from the end of the runway during the landing roll and struck a snow bank. There was no fire.

Ref. ARB Summary, Pg. 9/72, and AFS-54 1972 Summary, Pg. 6

144. 3/19/72, L-188C, Universal, Hill AFB, UT

Shortly after touchdown, No. 2 propeller separated from the engine, damaging the No. 1 propeller and No. 1 fuel tank, and a fire developed which engulfed the left wing. An explosion within the tank caused the loss of the left wing area outboard of the No. 1 nacelle and aft of the front spar. The aircraft came to rest on the runway at about the 4,000 ft. marker and the fire was extinguished by the base fire department using AFFF extinguishant.

Ref. ARB Summary, Pg. 10/72, and AFS-54 1972 Summary, Pg. 6

145. 5/8/72, CV-600, Texas International, Alexandria, LA

The nose gear collapsed during landing rollout and the aircraft skidded about 1,000 ft. down the runway, coming to rest about 5,000 ft. from the threshold. There was no fire. The crew could not fully open the forward right entrance door. The escape slide at the left rear cabin door was deployed but the angle was too steep to use. Mechanics manually opened the forward door and evacuation was completed without injury. Aircraft damage was substantial to the lower nose section and both propellers and engines.

Ref. AFS-54 1972 Summary, Pg. 11, and NTSB File No. 1-0015

146. 5/18/72, DC-9-31, Eastern, Fort Lauderdale, FL

The aircraft touched down hard about 3/10 down the runway, resulting in main gear failure and separation of the tail section from the aircraft. The aircraft became engulfed in flames and came to a stop on the right side of the runway. All occupants evacuated through the left forward entry door within 30 seconds after the aircraft stopped. Three passengers jumped from the door before the slide was inflated. The captain fell off the slide and was injured as were a stewardess and passenger. The fire department arrived within 40 seconds after the aircraft stopped and extinguished the fire with foam in about 2 minutes. The interior of the aircraft did not burn.

Ref. ARB Summary, Pg. 15/72, and NTSB File No. 1-0002

147. 5/25/72, NA-265, Whirlpool Corp., Minneapolis, MN

A gear-up landing was made with emergency equipment standing by. The aircraft received damage to the wing tip and fuel tank. There was no fire. Passengers and crew evacuated through the normal and emergency exits.

Ref. NTSB File No. 3-1840

148. 6/14/72, DC-9, Southern, Chicago, IL

The aircraft touched down hard about 40 ft. beyond the threshold, bounced about 10 ft. high, and touched down again about 250-300 ft. down the runway. The left inboard tire was blown during the landing. The aircraft received substantial damage. There was no fire.

Ref. AFS-54 1972 Summary, Pg. 13

149. 8/13/72, NA-265, Olin, Chicago, IL

The left main landing gear collapsed on landing with emergency equipment standing by. The aircraft came to rest on the left side of the runway about 500 ft. from the end. There was no fire. Aircraft received substantial damage to the left wingtip and left outboard wing panel.

Ref. NTSB File No. 3-1173

150. 8/28/72, NA-265-40, , Columbia, MO

The aircraft made a hard landing, collapsing the landing gear, and came to rest off the runway 1,600 ft. down and 300 ft. to the right of the centerline. There were no injuries or fire.

Ref. NTSB File No. 3-1440

151. 9/26/72, L-188A, Reeve Aleutian, Amchitka, AK

The aircraft struck the approach lights, resulting in extensive damage to the lower fuselage, inboard bottom wing planks, and flaps, and came to a stop about 3,000 ft. down the runway. There was extensive fuel leakage from the wings and the aircraft was evacuated from the forward exit. The chute did not work properly, and once inflated, the wind pushed it back under the aircraft. Emergency crew pulled the chute out and held it for an orderly evacuation. There was no fire.

Ref. ARB Summary, Pg. 28/72, and NTSB File No. 1-0043

152. 9/28/72, DC-9, Delta, Chicago, IL

The aircraft touched down hard, bounced, and made a nose high landing, resulting in substantial damage to the aft fuselage and air stair. There was no fire.

Ref. ARB Summary, Pg. 29/72, and AFS-54 1972 Summary, Pg. 19

153. 10/1/72, B-727, United, San Francisco, CA

During the landing rollout, the right main landing gear separated from the aircraft, the right wing settled to the runway, and the aircraft swerved off the runway to the right and collided with a TVOR shack about 5,000 ft. down the runway on the grass. There was no fire. Occupants evacuated within 40 seconds using all exits except the right galley door. Nine passengers sustained minor injuries during the evacuation.

Ref. ARB Summary, Pg. 30/72

154. 11/1/72, B-707, Trans World, St. Louis, MO

A fire developed in No. 2 engine when landing. During the emergency evacuation, a passenger received a broken ankle when she slid off a wing.

Ref. AFS-54 1972 Summary, Pg. 22

155. 11/1/72, B-747, Japan Airlines, Anchorage, AK

The aircraft landed with the nose gear retracted and slid down the runway centerline on the main gears and underside of the forward fuselage for about 2,500 ft. Occupants deplaned through the two forward exits on the left side via truck mounted stairways. There was no fire.

Ref. ARB Summary, Pg. 33/72

156. 11/7/72, Learjet 25, Eaton Corp., Kalamazoo, MI

The aircraft landed on a wet runway and went off the end, over a small ditch shearing the nose gear, and skidded to a stop in a muddy field. There was no fire.

Ref. NTSB File No. 3-3726

157. 12/12/72, Learjet, Zantop, Ypsilanti, MI

The aircraft touched down within the first one-third of an ice and slush covered runway, both engines flamed out due to water ingestion, and the aircraft contacted a snow bank along the left edge of the runway which resulted in separation of the nose and left main landing gear and rupture of the left wing tip fuel tank. The aircraft slid about 300 ft. past the end of the runway. There was no fire.

Ref. ARB Summary, Pg. 36/72

158. 12/12/72, B-707-331C, Trans World, Jamaica, NY

The aircraft struck an approach light support, damaging the right main landing gear, and all landing gears collapsed and all engines separated as the aircraft skidded to a stop about 500 ft. to the right of the runway edge and 2,600 ft. beyond the approach end. There was no fire. Two crew members evacuated via the cockpit windows, the other crew member used the slide at the forward cabin door. Emergency units experienced considerable difficulty and delay in locating the aircraft.

Ref. ARB Summary, Pg. 36/72, and NTSB File No. 1-0047

159. 12/15/72, B-747, Northwest, Miami, FL

The aircraft landed on a wet runway with No. 4 engine shut down due to bird ingestion, experienced hydroplaning, and overran the runway, collapsing the nose gear. There was no fire.

Ref. ARB Summary, Pg. 37/72, and AFS-54 1972 Summary, Pg. 25

160. 1/12/73, L-1011, Eastern, Miami, FL

The aircraft touched down in a tail low attitude resulting in substantial damage to the aft fuselage structure. There were no injuries or fire and the aircraft proceeded to the ramp without assistance.

Ref. AFS-54 1973 Summary, Pg. 1

161. 2/21/73, Learjet 24, Air Taxi Services, Ypsilanti, MI

The aircraft touched down 6,000 ft. down the length of a 7,500 ft. runway, became airborne again for about 320 ft. during which time it struck a series of lights, localizer antenna, and the airport boundary fence. It then contacted the surface again, slid about 240 ft. before striking the shoulder of a roadway, and came to rest partially inverted. The aircraft was destroyed.

Ref. ARB Summary, Pg. 5/73

162. 2/28/73, L-382B, Alaska International, Fletcher's Ice Island, Canada

Following a normal touchdown, the aircraft traversed several deep, hard packed snow ridges in the runway. The wings flexed downward causing No. 1 and No. 4 propellers to contact the surface. Both propellers and gear boxes were torn away. The aircraft veered to the left and came to rest in a snow bank with the fuselage atop the left side runway lights. There was a fire after impact.

Ref. ARB Summary, Pg. 6/73, and AFS-54 1973 Summary, Pg. 2

163. 3/3/73, B-727, Trans World, Wichita, KS

The aircraft landed on a wet and slippery runway and went off the left side of the runway, crossed an area of soft dirt, then a taxiway where the left main landing gear was torn away, and came to rest in mud at a point adjacent to the end of the runway. There was no fire. Three passengers received minor injuries during the emergency evacuation.

Ref. ARB Summary, Pg. 7/73, and AFS-54 1973 Summary, Pg. 2

164. 3/9/73, HFB-320, Phoenix, AZ

The aircraft made a gear up landing and came to rest on the runway centerline. A small fire fed by hydraulic fluid was extinguished by the airport fire department. Passengers evacuated via the main entry door.

Ref. NTSB File No. 3-0523

165. 3/17/73, L-382G, Saturn, Pensacola, FL

The aircraft touched down on the left main landing gear, then the right gear, followed by the nose gear which separated from the aircraft. The aircraft passed over the nose wheel, continued down the runway over arresting gear, and came to rest on the runway 3,600 ft. from the approach end. The bottom of the fuselage was substantially damaged. There was no fire.

Ref. ARB Summary, Pg. 8/73, and NTSB File No. 1-0006

166. 4/27/73, NA-265, U.S. Steel, Greensboro, NC

After touchdown on a wet runway, braking action was found to be inadequate and the aircraft skidded off the runway to the right, shearing off the landing gear. The aircraft came to rest about 5,500 ft. down the runway and 300 ft. to the right of the centerline. There was no fire. The aircraft sustained substantial damage to the landing gear, fuselage frame, and wing. Passengers evacuated via the main cabin door. The municipal fire department was prompt in responding to the accident.

Ref. NTSB File No. 3-0862

167. 6/12/73, CV-580, Allegheny, Pittsburgh, PA

The nose landing gear collapsed aft during the landing roll and the aircraft went off the side of the runway. There was no fire. One passenger received minor injury during the emergency evacuation.

Ref. ARB Summary, Pg. 15/73, and AFS-54 1973 Summary, Pg. 5

168. 6/23/73, DC-8-61, Icelandic, Jamaica, NY

When the aircraft was about 40 ft. above the runway, the spoilers were inadvertently deployed and the aircraft descended rapidly, hit the ground tail first 20 ft. short of the threshold, and stopped 6,048 ft. down the runway. No. 1 engine separated from the aircraft 720 ft. from the point of impact accompanied by fire. Six airport fire fighting units arrived at the scene 1 minute after the alarm and extinguished the fire with foam 30 seconds later. All passengers but one who was seriously injured evacuated through one of three evacuation slides available.

Ref. NTSB Report No. NTSB-AAR-73-20

169. 9/10/73, CV-990A, California Airmotive, Agana, Guam

After a hard landing, the left main landing gear collapsed followed by separation of No. 3 engine. The aircraft swerved off the left side of the runway and collided with a fire fighting water tanker 4,500 ft. down the runway and 550 ft. to the left of the centerline. About 2200 gallons of fuel were spilled from damaged No. 1 and No. 2 fuel tanks but there was no fire. Fire equipment sprayed the hot engines with water and kept a close watch for fire or any ignition source. Evacuation of the crew was via the main door and a ladder provided by the emergency units.

Ref. NTSB File No. 3-3110

170. 9/24/73, Learjet 25, Ren-Air Aviation, Sevierville, TN

The aircraft touched down about 6 ft. short of the runway, jamming the right main landing gear up through the right wing, and left the right side of the runway. There was a small wing tank puncture and no injuries or fire.

Ref. ARB Summary, Page 22/73, and NTSB File No. 3-2840

171. 10/28/73, B-737-222, Piedmont, Greensboro, NC

The aircraft touched down 2,600 ft. beyond the approach end of the runway during heavy rain showers, ran off the end of the runway, and the three landing gears collapsed as the aircraft crossed a service road 640 ft. beyond the runway. The aircraft came to rest on an incline 820 ft. from the runway. The right engine separated from the aircraft, resulting in a small fire which was not near the fuel that drained from the ruptured wing tank. Evacuation was completed in about 60 to 75 seconds through the left forward and rear doors and left overwing emergency exit.

Ref. NTSB Report No. NTSB-AAR-74-7

172. 11/9/73, Falcon, Cummings, Galesburg, IL

The aircraft touched down 100 ft. short of the runway, became airborne again, settled to the surface of the runway, and came to a stop about 2100 ft. past the approach end and off the right side of the runway on a grass area. There was substantial damage to the landing gear and wing. No fire.

Ref. NTSB File No. 3-3097

173. 11/27/73, DC-9-31, Eastern, North Canton, OH

The aircraft touched down about 1,000-1,500 ft. beyond the threshold of a wet runway, ran off the end of the runway, traversed 110 ft. of unpaved ground, plunged over a 38-foot embankment, and stopped in a level attitude in a field below about 380 ft. beyond the end of the runway. The aft fuselage section separated from the aircraft and both engines and pylons separated from the aft fuselage. The wings remained intact and attached to the fuselage but there was minor fuel spillage. There was no fire. All exits were used. Several passengers were immobilized and were carried out on backboards. All occupants were removed from the site within 20 minutes after the accident.

Ref. NTSB Report No. NTSB-AAR-74-12

174. 1/3/74, Learjet 24, Air Kamen, Johnstown, PA

The aircraft made a normal touchdown and braking action was effective until the runway intersection after which the runway was covered with glaze ice and the aircraft veered off the runway into the mud about 250 ft. from the end of the runway. Aircraft damage was substantial.

Ref. ARB Summary, Pg. 1/74

175. 1/16/74, B-707-131B, Trans World, Los Angeles, CA

The aircraft made a firm landing on the nose gear first, the left nose gear tire flattened 5,322 ft. beyond the threshold, and the nose gear and wheel well structure was pushed aft and upward into the fuselage. The aircraft stopped on the runway 6,112 ft. beyond the threshold. Fire erupted in the lower electronic bay area beneath the floor of the flight deck and was fed by hydraulic fluid from two fractured nose wheel steering hydraulic lines. The fire was not contained and eventually destroyed the interior of the cockpit and passenger cabin. Several airline employees attempted to put out the fire with small dry chemical fire extinguishers. Emergency units arrived on the scene 6 minutes after the accident and got the fire under control within 25 minutes. The aircraft was evacuated in

30-45 seconds using the cockpit side windows, four cabin door slides, and four overwing exits. During the emergency evacuation, three passengers were injured seriously and five received minor injuries when they fell off the slides or jumped off the wings.

Ref. NTSB Report No. NTSB-AAR-74-10

176. 1/17/74, B-707, Trans World, Indianapolis, IN

The aircraft touched down 1,630 ft. from the approach end with the left main landing gear 10 ft. to the left of the runway. Both gears left the runway about 200 ft. from touchdown. The aircraft continued parallel to the runway edge for 2000 ft. and crossed a taxiway after which the nose gear collapsed and penetrated the fuselage. The aircraft then veered back onto the runway and came to a stop left of the centerline about 4,000 ft. from the point of touchdown. The crew exited via an evacuation chute. There was a ground fire.

Ref. ARB Summary, Pg. 2/74, and AFS-54 1974 Summary, Pg. 2

177. 1/19/74, Falcon, Cauble Enterprises, Fort Worth, TX

The aircraft touched down 300 ft from the approach threshold, experienced hydroplaning, and went off the runway. The aircraft was destroyed.

Ref. ARB Summary, Pg. 3/74

178. 8/2/74, Learjet 24, JetWay, Shoemakersville, PA

The aircraft ran out of fuel and was landed in an alfalfa field. During the landing roll, all three landing gears were sheared as the aircraft skidded across a road and struck an embankment. Aircraft damage was substantial.

Ref. ARB Summary, Pg. 15/74

179. 10/12/74, L-188, Fairbanks Air Service, Ivishak, AK

Following a hard landing, the aircraft burned and was destroyed. The cargo flight was carrying 5,000 gallons of diesel fuel. The crew escaped without injury.

Ref. AFS-54 1974 Summary Pg. 16

APPENDIX B

TABLE 2

SURVIVABLE/SUBSTANTIAL DAMAGE LANDING ACCIDENTS

TURBINE-POWERED AIRCRAFT

1964-1974

No.	Date	Airplane	Fire		Mode of Fuel Release			Runway Cond.		Crew			Passengers			Evac.				Type of Flight					
			Yes	No	E	T	W	S	H	T	N/M	S	F	T	N/M	S	F	N	M	S	P	P	C	T	B
1	1/1/64	CV-880		X				X		8	8	0	0	63	63	0	0	X							X
2	1/12/64	F-27		X						2	2	0	0	0	0	0	0	X							X
3	2/12/64	F-27A		X						3	3	0	0	31	31	0	0	X							X
4	4/7/64	B-707-139		X						9	8	1	0	136	121	15	0	X							X
B-41 5	4/24/64	L-188C		X						7	7	0	0	77	77	0	0	X							X
6	5/12/64	V-745D		X						3	3	0	0	0	0	0	0	X							X
7	7/1/64	B-720B	E							5	5	0	0	7	7	0	0	X							X
8	8/26/64	B-707-331C	X*							8	8	0	0	130	130	0	0	X		X					X
9	9/14/64	CV-580		X						3	3	0	0	20	20	0	0	X							X
10	9/22/64	B-720B		X						7	7	0	0	48	48	0	0	X							X
11	11/5/64	B-720B		X						7	7	0	0	87	87	0	0		3						X
12	11/12/64	CL-44D4		X						3	3	0	0	0	0	0	0								X

TABLE 2 CON'T

SURVIVABLE/SUBSTANTIAL DAMAGE LANDING ACCIDENTS

No.	Date	Airplane	Fire		Mode of Fuel Release			Runway Cond.		Crew				Passengers				Eva.o.				Type of Flight			
			Yes	No	E	T	W	S	H	T	N/M	S	F	T	N/M	S	F	N	M	S	P	P	C	T	B
13	12/15/64	V-745D		X						2	2	0	0	7	7	0	0								X
14	2/13/65	B-707	E*							4	4	0	0	0	0	0	0								X
15	3/5/65	DC-8		X	X					8	8	0	0	75	75	0	0								X
16	3/18/65	B-727		X						5	5	0	0	92	92	0	0								X
17	3/19/65	B-720		X						7	7	0	0	55	55	0	0								X
18	3/26/65	B-707-321	E*							11	11	0	0	159	159	0	0								X
19	4/23/65	B-707		X						7	7	0	0	93	93	0	0								X
20	5/9/65	B-707		X						7	7	0	0	89	89	0	0								X
21	6/14/65	DC-8	X							-	-	0	0	-	-	0	0	X		X					X
22	7/1/65	B-707-124	X						X	6	6	0	0	60	60	0	0	X							X
23	9/1/65	BAC1-11		X						5	5	0	0	27	27	0	0								X
24	9/11/65	B-720		X						7	7	0	0	120	120	0	0								X
25	10/14/65	AW-650	X							3	3	0	0	0	0	0	0								X

TABLE 2 CON'T

SURVIVABLE/SUBSTANTIAL DAMAGE LANDING ACCIDENTS

No.	Date	Airplane	Fire		Mode of Fuel Release			Runway Cond.		Crew				Passengers				Evac.				Type of Flight			
			Yes	No	E	T	W	S	H	T	N/M	S	F	T	N/M	S	F	N	M	S	P	P	C	T	B
26	11/11/65	B-727	X		X					6	0	6	0	85	13	29	43								X
27	12/8/65	F-27A		X						3	3	0	0	14	14	0	0	X							X
28	12/15/65	NA-265		X						2	2	0	0	0	0	0	0								X
29	1/23/66	B-707-227		X				X		7	7	0	0	112	112	0	0	X		X					X
30	2/10/66	F-27J		X						4	4	0	0	11	11	0	0	X							X
B-43 31	2/13/66	B-720		E*						7	7	0	0	121	121	0	0								X
32	2/23/66	CV-990		X						7	7	0	0	67	66	1	0		1						X
33	2/27/66	DC-8		X					X	7	7	0	0	90	90	0	0								X
34	3/5/66	B-727		X						8	8	0	0	95	95	0	0								X
35	3/21/66	CL-44D4	X				X			3	3	0	0	3	2	1	0	X							X
36	3/24/66	V-812		X						4	4	0	0	10	10	0	0	X							X
37	3/24/66	LJ-23		X					X	2	2	0	0	0	0	0	0								X
38	3/24/66	CL-44D4		X						3	3	0	0	1	1	0	0								X

TABLE 2 CON'T

SURVIVABLE/SUBSTANTIAL DAMAGE LANDING ACCIDENTS

No.	Date	Airplane	Fire		Mode of Fuel Release			Runway Cond.		Crew				Passengers				Evac.				Type of Flight				
			Yes	No	E	T	W	S	H	T	N/M	S	F	T	N/M	S	F	N	M	S	P	P	C	T	B	
39	4/1/66	CV-580		X						3	3	0	0	44	44	0	0	X						X		
40	5/8/66	B-727		X						4	4	0	0	0	0	0	0								X	
41	7/11/66	CV-600		X						3	3	0	0	18	18	0	0	X						X		
42	7/20/66	B-720		X						5	5	0	0	0	0	0	0								X	
43	7/21/66	L-188A		X						5	5	0	0	34	34	0	0	X						X		
B-44 44	7/29/66	LJ-23		X					X	2	2	0	0	1	1	0	0									X
B-44 45	10/10/66	LJ-23		X					X	2	2	0	0	3	3	0	0									X
46	10/13/66	V-745D		X					X	4	4	0	0	7	7	0	0	X						X		
47	10/18/66	B-707-131		X						7	7	0	0	52	52	0	0		8		X		X			
48	10/22/66	DC-8		X						7	7	0	0	104	104	0	0							X		
49	11/2/66	B-727		X						6	6	0	0	66	66	0	0	X			X		X			
50	11/18/66	CV-880		X						7	7	0	0	88	88	0	0							X		
51	11/26/66	B-707		X						7	7	0	0	127	127	0	0							X		

TABLE 2 CON'T

SURVIVABLE/SUBSTANTIAL DAMAGE LANDING ACCIDENTS

No.	Date	Airplane	Fire		Mode of Fuel Release			Runway Cond.		Crew				Passengers				Evac.				Type of Flight								
			Yes	No	E	T	W	S	H	T	N/M	S	F	T	N/M	S	F	N	M	S	P	P	C	T	B					
52	12/4/66	V-745D		X					X	4	4	0	0	46	46	0	0								X					
53	12/4/66	B-720B		X						3	3	0	0	31	31	0	0								X					
54	12/5/66	B-727		X						2	2	0	0	0	0	0	0										X			
55	1/19/67	V-745D		X						4	4	0	0	46	46	0	0	X							X					
56	1/20/67	FH-227		X						3	3	0	0	15	15	0	0	X							X					
57	1/23/67	CV-640	X					X		3	3	0	0	25	25	0	0	X							X					
58	2/14/67	FH-227		X						3	3	0	0	0	0	0	0									X				
59	4/7/67	B-727		X						6	5	1	0	97	97	0	0		1						X					
60	4/14/67	NA-265		X						2	2	0	0	1	1	0	0												X	
61	4/23/67	LJ-23		X						2	2	0	0	4	4	0	0												X	
62	4/25/67	B-707	X							3	3	0	0	0	0	0	0												X	
63	4/29/67	B-727		X					X	6	6	0	0	50	50	0	0								X					
64	5/18/67	B-707		X						-	-	0	0	-	-	0	0								X					



TABLE 2 CON'T

SURVIVABLE/SUBSTANTIAL DAMAGE LANDING ACCIDENTS

No.	Date	Airplane	Fire		Mode of Fuel Release			Runway Cond.		Crew			Passengers			Evac.				Type of Flight							
			Yes	No	E	T	W	S	H	T	N/M	S	F	T	N/M	S	F	N	M	S	P	P	C	T	B		
78	4/23/68	DC-8	E					X		10	10	0	0	154	154	0	0								X		
79	4/28/68	DC-8	X		X	X				4	2	2	0	0	0	0	0	X								X	
80	5/4/68	F-27J	X							2	0	0	2	0	0	0	0										X
81	6/8/68	B-727		X						6	6	0	0	86	86	0	0								X		
82	6/8/68	AW-650		X						3	3	0	0	0	0	0	0								X		
B-47 83	6/24/68	CL-44D4		X						4	4	0	0	3	3	0	0								X		
84	7/25/68	CV-580	E							3	3	0	0	43	43	0	0								X		
85	8/5/68	B-707	E							3	3	0	0	0	0	0	0	X							X		
86	8/7/68	B-727		X						6	6	0	0	77	77	0	0	X							X		
87	8/10/68	AC-1121		X						2	0	2	0	2	2	0	0										
88	8/21/68	LJ-24		X		X				2	2	0	0	0	0	0	0										X
89	9/7/68	FH-227		X						3	3	0	0	15	15	0	0								X		
90	11/29/68	B-727		X				X		6	6	0	0	62	62	0	0								X		

TABLE 2 CON'T

SURVIVABLE/SUBSTANTIAL DAMAGE LANDING ACCIDENTS

No.	Date	Airplane	Fire		Mode of Fuel Release			Runway Cond.		Crew				Passengers				Evac.				Type of Flight			
			Yes	No	E	T	W	S	H	T	N/M	S	F	T	N/M	S	F	N	M	S	P	P	C	T	B
91	12/5/68	AC-1121		X						2	2	0	0	4	4	0	0								X
92	12/31/68	HS-125		X						2	2	0	0	5	5	0	0								X
93	1/17/69	NA-265		X						2	2	0	0	7	7	0	0								X
94	1/31/69	DC-8-61		X						14	14	0	0	168	168	0	0						X		
95	2/3/69	G-159		X						2	2	0	0	12	12	0	0								X
84-B 96	4/25/69	NA-265	X							2	2	0	0	5	5	0	0	X							X
97	5/1/69	CL-44D4	X				X			3	2	1	0	1	0	1	0							X	
98	5/3/69	DC-9		X						2	2	0	0	0	0	0	0								X
99	7/29/69	CV-990		X						3	3	0	0	0	0	0	0								X
100	8/1/69	CV-600		X						3	3	0	0	20	20	0	0						X		
101	8/1/69	B-707		X						4	4	0	0	0	0	0	0								X
102	8/12/69	DC-9-31		X					X	5	5	0	0	114	114	0	0	1					X		
103	9/9/69	SA-26T		X						1	1	0	0	1	1	0	0								X
104	9/9/69	NA-265-40		X						1	1	0	0	3	3	0	0								X
105	12/13/69	B-747	X				X			3	3	0	0	8	8	0	0								X





TABLE 2 CON'T

SURVIVABLE/SUBSTANTIAL DAMAGE LANDING ACCIDENTS

No.	Date	Airplane	Fire		Mode of Fuel Release			Runway Cond.		Crew				Passengers				Evac.				Type of Flight			
			Yes	No	E	T	W	S	H	T	N/M	S	F	T	N/M	S	F	N	M	S	P	P	C	T	B
134	2/26/71	B-727		X						6	6	0	0	84	84	0	0	X			X	X			
135	3/18/71	L-382	X					X		3	3	0	0	1	1	0	0							X	
136	7/19/71	B-727		X					X	6	6	0	0	93	93	0	0	X			X	X			
137	8/20/71	CV-580		X						4	4	0	0	50	50	0	0	X					X		
138	12/4/71	DC-10	X							12	12	0	0	97	97	0	0						X		
139	12/17/71	B-99A		X						2	2	0	0	12	12	0	0						X		
B-51 140	2/10/72	L-382E		X						3	3	0	0	0	0	0	0	X						X	
141	2/28/72	Falcon 28	X							2	2	0	0	0	0	0	0								X
142	3/9/72	LJ25		X						1	1	0	0	1	1	0	0								X
143	3/11/72	CV-580		X						3	3	0	0	17	17	0	0						X		
144	3/19/72	L-188C	X				X			3	3	0	0	0	0	0	0							X	
145	5/8/72	CV-600		X						3	3	0	0	12	12	0	0	X			X	X			
146	5/18/72	DC-9-31	X			X				4	2	2	0	6	5	1	0			3			X		



TABLE 2 CON'T

SURVIVABLE/SUBSTANTIAL LANDING ACCIDENTS

No.	Date	Airplane	Fire		Mode of Fuel Release			Runway Cond.		Crew				Passengers				Evac.				Type of Flight			
			Yes	No	E	T	W	S	H	T	N/M	S	F	T	N/M	S	F	N	M	S	P	P	C	T	B
161	2/21/73	LJ24		X						2	0	0	2	1	0	1	0								X
162	2/28/73	L-382B	X							5	5	0	0	3	3	0	0							C	
163	3/3/73	B-727		X				X		7	7	0	0	63	63	0	0	3					X		
164	3/9/73	HFB-320	X							2	2	0	0	8	8	0	0	X							X
165	3/17/73	L-382G		X						3	3	0	0	0	0	0	0							X	
166	4/27/73	NA-265		X				X		2	2	0	0	3	3	0	0	X							X
167	6/12/73	CV-580		X						3	3	0	0	50	50	0	0	1					X		
168	6/23/73	DC-8-61	X		X					9	7	2	0	119	113	6	0	X		X		X			
169	9/10/73	CV-990A		X		X				4	4	0	0	0	0	0	0						X		
170	9/24/73	LJ25		X		X				2	2	0	0	8	8	0	0								X
171	10/28/73	B-737-222	X		X	X		X		5	5	0	0	90	90	0	0	X					X		
172	11/9/73	Falcon		X						2	2	0	0	4	4	0	0								X
173	11/27/73	DC-9-31		X		X		X		5	5	0	0	21	20	1	0						X		



APPENDIX C

Survivable/Substantial Damage Takeoff Accident Summaries

Turbine-Powered Aircraft

1964-1974

1. 5/29/64, B-707-331, Trans World, Paris, France

During take-off, before reaching speed  $V_1$ , vibration caused the pilot to abort the take-off. During the deceleration, the aircraft pulled over to the right and left the runway at the end of its roll, collapsing the nose gear. Passengers and crew executed an emergency evacuation without incident.

Ref. ARB Summary, Pg. 13/64, and AFS-54 1964 Summary, Pg. 9

2. 6/4/64, Learjet 23, Learjet Corp., Wichita, KS

After an extended take-off roll and slower-than normal acceleration, the left engine was cut off at 100 knots. The aircraft became airborne but failed to accelerate and climb normally and shortly thereafter began to settle. During this period, an unsuccessful attempt was made to restart the inoperative left engine. When it was apparent the aircraft could not continue, a forced landing was initiated to a wheatfield. The pilot actuated the landing gear to the extended position; however, the gear did not fully extend before touchdown. The gear collapsed and the aircraft slid to an upright stop with no injuries to the pilots. A fire broke out near the right engine nacelle, spread, and destroyed the aircraft.

Ref. ARB Summary, Pg. 13/64

3. 8/26/64, AW-650, Zantop, Oscola, MI

The Captain stated he rotated the aircraft at 96 knots, and when airborne the landing gear was retracted. He said the aircraft then began to porpoise badly, and he closed the throttles and landed the aircraft wheels up. Marks on the runway showed that the aircraft touched down wheels up 3,500 feet from the approach end of runway 24 and slid to a stop 2,700 feet beyond the point of initial contact. Crew executed an emergency evacuation without incident.

Ref. ARB Summary, Pg. 19/64, and AFS-54 1964 Summary, Pg. 13

4. 11/23/64, B-707-331, Trans World, Rome, Italy

After the pilot decided to abort the takeoff, the aircraft started to decelerate, but at a much slower rate than expected, and at the same time veered strongly to the right with the result that the right landing gear was grazing the runway edge. The aircraft continued travelling beyond the declared runway limit and struck with No. 4 engine a pavement roller which was being used for maintenance work on taxiway 16/34 in an authorized area. After travelling a further 260 m, the aircraft came to a stop with fire on board. After three tank explosions which occurred as the aircraft was being evacuated, it was engulfed in flames and completely destroyed.

Ref. ARB Summary, Pg. 28/64, and ICAO Accident Digest No. 16 Vol. III

5. 3/14/65, SE-210, United, Ypsilanti, MI

The Captain aborted the takeoff and ordered the First Officer to shut down the left engine. While the First Officer was doing this, the left engine fire warning light came on and both Freon bottles were discharged successfully extinguishing the fire. When the aircraft was brought to a stop, the passengers, who had been given instructions, exited the aircraft. Although the evacuation was generally considered orderly, three of the 22 passengers who evacuated the aircraft through the window exits were injured, one seriously. Fire damage to the left engine nacelle area was substantial.

Ref. ARB Summary, Pg. 6/65

6. 4/16/65, F-27A, Bonanza, Las Vegas, NV

A practice no-flap takeoff was initiated. At rotation, the aircraft veered left, became uncontrollable and cartwheeled off the runway, coming to rest about 557 feet left of the runway and 6,000 feet from the takeoff end.

Ref. ARB Summary, Pg. 11/65, and AFS-54 1965 Summary, Pg. 7

7. 5/11/65, B-707-120, American, El Paso, TX

During landing gear retraction after takeoff, the No. 7 right main wheel with its brake and axle attached fell from the aircraft. Emergency aircraft and cabin procedures were carried out, fuel was dumped, and the aircraft was landed safely.

Ref. ARB Summary, Pg. 13/65, and AFS-54 1965 Summary, Pg. 11

8. 9/13/65, CV-880, Trans World, Kansas City, MO

Shortly after takeoff on a training flight, the aircraft descended and struck the ground 900 ft. beyond the end of the runway and 650 ft. to the right of the extended centerline and slid to a stop 1800 ft. beyond the end of the runway. At impact the aircraft attitude was about 16 degrees noseup and 12 degrees right wing-down. Substantial damage occurred at impact, and all but the right wing and empennage were destroyed by the subsequent fire. The four crew members escaped uninjured.

Ref. ARB Summary, Pg. 22/65, and AFS-54 1965 Summary, Pg. 19

9. 2/24/66, DH-125, \_\_\_\_\_, Des Moines, IA

After takeoff power was applied, and as the aircraft accelerated in the takeoff roll, the co-pilot noticed the elevator and aileron gust lock had not been disengaged. He called out a warning to the pilot and while the aircraft continue to accelerate, the latter attempted, without success, to remove the control lock. He then tried to abort the takeoff but due to the high speed of the aircraft and the short runway distance remaining, the aircraft overran the runway, struck a ditch, and went into a ploughed field. The plane stopped 785 feet beyond the runway.

Ref. ARB Summary, Pg. 7/66

10. 4/9/66, B-720, United, Oakland, CA

Shortly after a rolling takeoff was initiated on a wet runway, the aircraft began to drift to the left and the captain elected to abort the takeoff. The aircraft continued to drift to the left and went off the side of the runway and became mired in wet sand and mud. The nose gear snapped off below the trunnion. Occupants left by way of the forward main cabin door. There were no injuries.

Ref. AFS-54 1966 Summary, Pg. 8

11. 6/26/67, V-745D, United, Grand Rapids, MI

The aircraft experienced a nose gear shimmy during the takeoff roll. The nose gear collapsed and the aircraft came to rest 1500 ft. down the runway on the centerline. A small fire developed in the forward baggage compartment in the nose section. The fire department responded promptly and extinguished the fire and assisted in evacuation which occurred via the overwing exits and rear exit slide. Five passengers were injured during the evacuation, one seriously when he fell off the slide onto the runway.

Ref. AFS-54 1967 Summary, Pg. 22, and NTSB File No. 1-0036

12. 9/3/67, L-188, National, New Orleans, LA

The aircraft was directionally uncontrollable on takeoff, veered to the left off the runway, and the nose gear collapsed. There was no fire.

Ref. AFS-54 1967 Summary, Pg. 25

13. 9/8/67, B-707, Pan American, Frankfurt, Germany

The No. 3 engine 14th stage compressor disintegrated during the takeoff run, causing shrapnel damage to the No. 3 and 4 pylons, flaps, aileron, and fuel tank. The right wing became involved in fire from leaking fuel. The fire was extinguished by airport fire equipment. Emergency evacuation procedures were followed, during which a number of passengers were injured.

Ref. ARB Summary, Pg. 19/67, and AFS-54 1967 Summary, Pg. 27

14. 11/6/67, B-707, Trans World, Erlanger, KY

The No. 4 engine experienced a compressor stall during the takeoff run as the aircraft passed a mired DC-9 adjacent to the runway with engines running. The takeoff was aborted and the aircraft overran the runway by 421 ft. During the ground slide, the fuselage upper structure ruptured just forward of the wing root, and the right wing failed inboard of the No. 4 engine. Engine Nos. 1 and 2 partially separated and engine No. 3 separated from the wing structure. Ground fire occurred in the area of the right wing separation and the Nos. 3 and 4 engines.

Ref. ARB Summary, Pg. 22/67, and NTSB Report No. SA-401

15. 11/22/67, B-707, BOAC, Honolulu, HI

The No. 1 engine L.P. turbine disc disintegrated during the takeoff run, causing considerable damage to the wing and landing gear. The takeoff was aborted and fire developed under the right wing which was extinguished by the airport fire department.

Ref. ARB Summary, Pg. 23/67

16. 1/27/68, B-707, World Airways, Oakland, CA

The aircraft started to skid as power was applied in a turn onto a wet runway and went off the runway into soft sand, damaging No. 3 engine, pylon, and right main landing gear. There was no fire.

Ref. ARB Summary, Pg. 2/68, and AFS-54 1968 Summary, Pg. 4

17. 3/21/68, B-727, United, Chicago, IL

The aircraft failed to climb or accelerate on takeoff and the takeoff was aborted. The aircraft settled back on the right side of the runway, and came to rest 1,100 ft. beyond the runway and 300 ft. to the right of its centerline after striking a drainage ditch which resulted in a fuel fed ground fire that consumed much of the aircraft. The captain received a serious back injury and the first officer was injured slightly when evacuating the aircraft through the cockpit windows. Fire equipment arrived after the crew had evacuated.

Ref. ARB Summary, Pg. 4/68, and NTSB File No. 1-0023

18. 4/8/68, B-707-465, BOAC, London, England

About one minute after takeoff, No. 2 engine failed and a few seconds later caught fire. The crew, having started an Engine Failure Drill had to change directly to an Engine Fire Drill. However, the fire did not go out and the aircraft was maneuvered for the quickest possible return to land. During the approach, No. 2 engine fell away from the aircraft. The aircraft made a good landing and when it came to stop, the fire, which had continued to burn near the No. 2 engine position, increased in intensity and the fuel tanks in the port wing exploded. Emergency evacuation was started as soon as the aircraft came to stop but four of the passengers and 1 stewardess were overcome by heat and did not escape. The overall efficiency of the airport fire service was seriously reduced by poor deployment of some appliances and by equipment failures.

Ref. ARB Summary, Pg. 6/68

19. 7/28/68, Jet Falcon, Jet Aviation, Cleveland, OH

During takeoff, the aircraft struck a flock of gulls, collided with a vehicle and boundary fence, and crash landed in the lake. A total of 315 dead seagulls was found in the area. One engine compressor unit was 20% filled with bird debris, the other 17%.

Ref. ARB Summary, Pg. 12/68

20. 12/19/68, AC-1121, \_\_\_\_\_, Buffalo, NY

The aircraft swung off the runway on the takeoff run due to the right tire blowing out. The gear collapsed due to overload. Aircraft damage was substantial.

Ref. ARB Summary, Pg. 20/68

21. 12/27/68, DC-9, Ozark, Sioux City, IA

After takeoff at about 50-80 ft. altitude, the right wing dropped, then the aircraft rolled to the left and the left wing contacted the runway. The aircraft was leveled and struck the ground 110 ft. beyond the threshold and came to rest 1,181 ft. beyond the threshold in a grove of trees. There was no fire.

Ref. ARB Summary, Pg. 21/68, and AFS-54 1968 Summary, Pg. 31

22. 2/9/69, B-727, Pan American, West Berlin, Germany

Takeoff was aborted prior to rotation due to second stage compressor disc failure and fire in No. 3 engine. The fire was extinguished after the second bottle was discharged. During emergency evacuation, two passengers received serious injuries.

Ref. ARB Summary, Pg. 4/69, and AFS-54 1969 Summary, Pg. 5

23. 2/27/69, L-1329-8, , Fort Lauderdale, FL

Both right main landing gear tires blew out during rotation for takeoff and the aircraft veered off the runway, causing the nose gear to collapse. The aircraft skidded to a stop 6,850 ft. from the point where the takeoff run started and 125 ft. off the right side of the runway. There was no fire. Damage was substantial to the nose structure, nose gear, and right main gear.

Ref. NTSB File No. 3-2177

24. 6/24/69, CV-880, Japan Air Lines, Moses Lake, WA

The aircraft started to yaw to the right shortly after lift-off, the right wing went down, and No. 4 engine pod contacted the runway 6,500 ft. down the runway. The aircraft went off the runway and continued through 2,600 ft. of rough terrain, breaking up and bursting into flames before it came to rest. Four crew members escaped from the burning aircraft through a break in the fuselage, but only two survived. The aircraft was completely destroyed.

Ref. ARB Summary, Pg. 11/69

25. 7/15/69, DHC-6, New York Airways, Jamaica, NY

The aircraft crashed in a steep dive after an intersection takeoff caused by wake turbulence of a departing B-707. There was fire after impact and the aircraft was destroyed.

Ref. AFS-54 1969 Summary, Pg. 12

26. 7/29/69, B-727, Airlift International, Jamaica, NY

Takeoff was started on the wrong runway and was aborted, but the aircraft overran the runway and came to rest 1,000 ft. beyond the threshold with the nose gear collapsed and damage to the left wing and bottom of the fuselage. There was no fire.

Ref. ARB Summary, Pg. 14/69, and AFS-54 1969 Summary, Pg. 14

27. 9/17/69, DC-8, Delta, Dallas, TX

The left main landing gear bogie beam failed during the takeoff run and the aircraft was stopped in about 300 ft. There was no fire.

Ref. ARB Summary, Pg. 17/69, and AFS-54 1969 Summary, Pg. 20

28. 10/16/69, DC-8-63F, Seaboard World, Stockton, CA

Following a touch and go landing, the takeoff was aborted and the aircraft overran the runway, ran across three ditches and a road, and came to rest 792 ft. beyond the threshold with the nose and left gear collapsed and No. 2 engine separated. A small fire developed in the No. 2 pylon area. Before crash crew personnel could apply foam to the fire, an explosion occurred in the left wing and a fire engulfed the aircraft. Seventeen minutes elapsed before foam was applied to the fire. Crew evacuated through the forward main cabin door. Aircraft was destroyed.

Ref. AFS-54 1969 Summary, Pg. 21, and NTSB File No. 1-0058

29. 11/28/69, DC-8, Eastern, Newark, NJ

Takeoff was aborted due to 12th stage compressor disc failure and fire in No. 4 engine and the aircraft was moved to a taxiway off the runway. No. 4 engine was ablaze and was extinguished by ground equipment. Damage was caused by uncontained fragments to the right wing, ailerons, Nos. 2, 3, and 4 pylons and landing gear doors. The No. 4 fuel tank was also punctured.

Ref. ARB Summary, Pg. 22/69, and AFS-54 1969 Summary, Pg. 22

30. 12/1/69, B-707-321B, Pan American, Sydney, Australia

The aircraft struck a flock of seagulls during the takeoff run and ingested birds in No. 2 and No. 3 engines, causing a power loss in No. 2 engine. The takeoff was aborted and the aircraft overran the runway and struck the approach lighting system which caused the nose gear and left main gear to separate. The aircraft came to rest 560 ft. beyond the end of the runway and the crew and passengers safely evacuated the aircraft. There was no fire.

Ref. ARB Summary, Pg. 23/69, and AFS-54 1969 Summary, Pg. 22

31. 4/19/70, DC-8, SAS, Rome, Italy

The first stage fan disc of No. 1 engine disintegrated during the takeoff run. Fragments bounced off the runway against the underside of the wing and punctured the No. 2 center fuel tank, spilling fuel which caught fire immediately. Several low energy explosions resulted. There were no fatalities and the aircraft was destroyed.

Ref. ARB Summary, Pg. 9/70

32. 6/9/70, DC-8F, Trans Caribbean, Bangor, ME

Two tires on the right main landing gear blew out during takeoff and the takeoff was aborted. A fire developed in the right main gear assembly. The aircraft stopped on a taxiway at the end of the runway and occupants evacuated via overwing exits and chutes deployed from the left side. Two persons received serious injuries during the evacuation when using a slide which had not inflated. Fire equipment arrived during the evacuation and extinguished the gear fire when evacuation was completed.

Ref. AFS-54 1970 Summary, Pg. 8, and NTSB File No. 1-0029

33. 7/19/70, B-737-222, United, Philadelphia, PA

Shortly after lift off, No. 1 engine failed and the aircraft was landed straight ahead on the runway. The aircraft continued off the end of the runway and received substantial damage before coming to rest some 1,600 ft. beyond. There was no fire.

Ref. ARB Summary, Pg. 18/70, and AFS-54 1970 Summary, Pg. 9

34. 8/24/70, L-188, Universal, Hill AFB, UT

Shortly after lift off, the aircraft pitched over and impacted the runway 8,200 ft. from the threshold. The aircraft became engulfed in flame on impact and slid 2,400 ft. down the runway. The fuselage broke forward of the wings. The crew evacuated through the cockpit windows when the first fire truck arrived. Eight pieces of fire apparatus responded to the fire. The entire aircraft, with the exception of the cockpit, was destroyed by fire.

Ref. ARB Summary, Pg. 21/70, and NTSB File No. 1-0027

35. 11/27/70, DC-8-63F, Capitol, Anchorage, AK

The aircraft failed to become airborne during the takeoff run and overran the end of the runway, struck a low wooden barrier, the ILS structure, and a 12 ft. deep drainage ditch before coming to a stop about 3,400 ft. beyond the end of the runway. Fire broke out on the left side of the aircraft following impact with the ILS structure at which point structural damage was incurred in the left wing area. Major structural damage occurred on the second impact with the drainage ditch, at which time the aft section of the cabin broke open and the right wing tore loose spilling the fuel contained therein. A large fire then erupted on the right side of the aircraft. The aircraft was destroyed in the intense ground fire which developed subsequent to the crash. Forty-six passengers and one flight attendant received fatal injuries as a result of the post-crash fire. A unit of the airport fire department arrived on the scene within 3 minutes after the crash occurred and initiated fire fighting and rescue activities. All airport fire units were operating at the scene within 5 minutes after the alert. Several minutes after the accident occurred, two fairly large explosions were observed emanating from the left side of the aircraft. Subsequent explosions occurred and hampered fire-fighting and rescue operations.

Ref. NTSB File No. 1-0025

36. 11/30/70, B-707, Trans World, Tel-Aviv, Israel

While taking off, the aircraft collided with a KC-97 being towed down the runway with its landing gear and wing and struck the ground 5,800 ft. from the threshold and 800 ft. to the right of the centerline. Both aircraft caught fire and were destroyed.

Ref. ARB Summary, Pg. 28/70, and NTSB File No. 1-0054

37. 6/4/71, HFB-320, Executive Airlines, Pittsburgh, PA

The aircraft began to veer to the right during the takeoff run and the takeoff was aborted, causing both wheels to lock and blow tires. The aircraft came to rest on the right side of the runway at the 8,000 ft. marker. Overheating of the right wheel resulted in fire which consumed the tire, fiberglass fairing,

metal skin, and stringers in the wheel well area. The airport fire department extinguished the burning right tire within about 2 minutes.

Ref. ARB Summary, Pg. 11/71, and NTSB File No. 3-1995

38. 6/20/71, B-747-151, Northwest, Tokyo, Japan

The aircraft veered to the left during the takeoff run, went off the runway about 2,000 ft. from the threshold, crossed a drainage ditch, and came to rest on a taxiway with a failed left wing landing gear about 3,000 ft. from the threshold and 200 ft. to the left of the centerline. The passenger deplaned normally about one hour later. There was no fire.

Ref. ARB Summary, PG. 12/71, and NTSB File No. 1-0039

39. 7/21/71, B-707-323, American, Dallas, TX

The first and second stage fan assemblies separated from No. 3 engine during the takeoff run about 1,500 - 2,000 ft. down the runway and the takeoff was aborted. The aircraft turned onto a taxiway, the engine fire extinguisher was discharged, and the passengers were deplaned via a mobile stair. No. 4 engine was also substantially damaged by fragments from No. 3 engine. Two holes were punctured in No. 3 main fuel tank and numerous holes were punctured in the forward right section of the fuselage and lower inboard aft flap section. There was no fire.

Ref. ARB Summary, Pg. 14/71

40. 7/30/71, B-747, Pan American, San Francisco, CA

The aircraft did not become fully airborne at the end of the runway during takeoff and struck an approach light structure. Two passengers were seriously injured by approach light structure material which penetrated the cabin. Three of the four hydraulic systems were disabled, two main landing gears were damaged, and one of the right horizontal stabilizer spars was severed. The aircraft was flown for about 90 minutes to jettison 300,000 lb. of fuel after which the aircraft made a hard landing and experienced a brake fire. Seventeen passengers were injured during emergency evacuation, including eight with serious back injuries.

Ref. ARB Summary, Pg. 15/71, and AFS-54 1971 Summary, Pg. 10

41. 8/28/71, NA-265, \_\_\_\_\_, Stonewall, TX

The aircraft verred to the left during the takeoff run, went through a fence and over a pipe, and skidded to a stop about 1,500 ft. beyond the runway and 90 ft. to the left of the centerline. The landing gear and fuselage were substantially damaged. There was no fuel leakage or fire.

Ref. NTSB File No. 3-3798

42. 3/19/72, DC-9, Delta, Atlanta, GA

The compressor section of the right engine failed during takeoff run and a small fire was observed. The engine fire extinguisher was discharged and extinguished the fire. The takeoff was aborted. Shrapnel punched a large hole in the aft fuselage in the buffet area. A small fire developed in the buffet area which was extinguished by hand CO<sub>2</sub> bottles on board the aircraft. No emergency evacuation was accomplished. There were no injuries.

Ref. ARB Summary, Pg. 10/72, and AFS-54 1972 Summary, Pg. 7

43. 8/13/72, B-707, JAT, Jamaica, NY

The aircraft ran off the end of the runway following a rejected takeoff, struck the blast fence, and came to a stop about 120 ft. from the end of the runway and 80 ft. to the right. The left wing and No. 1 and No. 2 engines were damaged by impact and the ensuing fire. Emergency equipment arrived on the scene in about four minutes and extinguished the flames. A steward and 15 passengers were injured during the evacuation from the aircraft.

Ref. ARB Summary, Pg. 24/72

44. 9/13/72, B-707, Trans World, San Francisco, CA

Two tires of the right main landing gear failed during the takeoff run and the takeoff was aborted, however, the aircraft overran the end of the runway and a breakwater and came to rest in the water about 50 ft. from the shoreline. The fuselage was broken slightly forward of the wing. The nose gear and No. 2 engine separated from the aircraft. The outboard 6 ft. of the left wing broke away when it struck wooden approach light stanchions. There were no injuries or fire.

Ref. ARB Summary, Pg. 27/72, and AFS-54 1972 Summary, Pg. 18

45. 12/20/72, DC-9-31, North Central, Chicago, IL

At lift off, the aircraft collided with a CV-880 taxiing across the runway, lost the right main landing gear, and touched down on an intersecting runway, failing the nose gear and left main landing gear. Fire was seen around the aft section of the aircraft as it came to a stop. The first unit of the fire department responded within one minute of the alarm. A total of 11 units responded and extinguished the fire in 16 minutes. The fuselage was gutted by fire. Four passengers and a stewardess escaped through the left forward overwing exit, another passenger

through the right forward overwing exit, and the other surviving passengers through the main entry door where the escape slide was deployed but did not inflate. One stewardess received serious injuries during her escape. Passengers testified that smoke was dense in the cabin during the evacuation and that no lights were visible or used.

Ref. ARB Summary, Pg. 37/72, and NTSB File No. 1-0017

46. 3/5/73, B-707, American, Denver, CO

During a three-engine takeoff, the aircraft swerved off the runway to the right, became airborne, went into a steep bank to the left, and the left wing tip and No. 2 engine dragged on the ground. The aircraft settled back on the runway, continued across the runway to the left, and came to a stop 8,600 ft. from the threshold and 1,000 ft. to the left of the centerline. The No. 1 engine separated from the wing when it struck the ground during the turn and a small, fuel-fed fire broke out in the No. 1 pylon. The nose gear collapsed and there was substantial damage to the underside of the aircraft nose. The crew evacuated through the right cockpit side window as the cockpit door was jammed due to buckling of the cabin floor just aft of the door. Airport fire equipment arrived shortly after the aircraft came to a stop and extinguished the fire in the engine pylon.

Ref. ARB Summary, Pg. 7/73, and NTSB File No. 1-0009

47. 4/24/73, DC-8, Airlift International, Jamaica, NY

During the takeoff run, a fire broke out in the left main landing gear and the takeoff was aborted. Debris from the left gear dislodged the left main fuel drain plug from the fuel tank and created a major fuel leak which intensified the fire in the left main landing gear.

Ref. ARB Summary, Pg. 10/73

48. 6/20/73, DC-8, Overseas National, Bangor, ME

During the takeoff roll, sparks were emitted from the right side of the aircraft and the takeoff was aborted. A fire developed in the right main landing gear wheel well area during the rollout. The fire department responded with six pieces of equipment and extinguished the fire within about 3 minutes. The passengers and crew evacuated via 8 of the 12 available emergency exits during which 30 passengers sustained minor injuries and 2 passengers received serious injuries.

Ref. ARB Summary, Pg. 12/73

49. 6/22/73, DC-9, Hughes Airwest, Spokane, WA

The aircraft experienced severe vibration during the takeoff run and the takeoff was aborted. The aircraft was brought to a stop 200 ft. before the end of the runway. The tower observed fire on the right main landing gear tires during takeoff and alerted the fire department which arrived a few minutes after the aircraft stopped and extinguished the fire. Passengers and crew evacuated without incident.

Ref. ARB Summary, Pg. 16/73

50. 12/17/73, DC-9, Eastern, Greensboro, NC

Acceleration decreased at about 80 knots during the takeoff run on a runway covered with 3-5 inches of wet snow and slush and the takeoff was aborted. Directional control was lost and the aircraft skidded off the left side of the runway, struck a taxiway, and came to rest about 5,200 ft. from the takeoff starting point with both main landing gear and a 10 ft. section of the left wing aft spar web separated from the aircraft. Emergency equipment was enroute by the time the aircraft stopped. When the first truck arrived, there was no fire, but fire broke out under the rear of the aircraft where considerable fuel had accumulated and was extinguished within 3 minutes of the accident. All equipment arrived within 3 minutes after the alert. Passengers were evacuated through the forward entrance door within 5 minutes. An additional 2 minutes were required to evacuate a passenger in shock with a minor back injury.

Ref. AFS-54 1973 Summary, Pg. 16, and NTSB File No. 1-0035

51. 1/4/74, B-727, United, Tampa, FL

During the takeoff run, the No. 3 engine ingested part of the tread which separated from the No. 3 main landing gear tire and the takeoff was aborted at the end of the runway with a fire in the right wheel well. During the evacuation of the aircraft, one passenger received a fractured leg and one passenger received minor injuries.

Ref. AFS-54 1974 Summary, Pg. 1

52. 2/8/74, DC-8, UTA, Los Angeles, CA

A flat No. 6 tire on the left main landing gear caused a vibration through the aircraft during the takeoff run and the takeoff was aborted with a fire in the area of the left main gear. The aircraft was brought to a stop on a taxiway and the fire was extinguished by the airport fire department. About half of the passengers evacuated

the aircraft by the right forward escape chute and the two right overwing exits. The remaining passengers used ladders placed by the fire department at the left front exit and the two rear exits after the fire was extinguished. One passenger sustained a broken ankle during the evacuation.

Ref. ARB Summary, Pg. 5/74

53. 3/27/74, DC-8-63, World Airways, Anchorage, AK

Severe vibration was experienced during the takeoff run, the takeoff was aborted, and the aircraft stopped about 400 ft. from the end of the runway with fire in the left main landing gear wheel well. The airport fire department extinguished the fire. Emergency evacuation was accomplished using four emergency evacuation chutes and overwing exits on the right side of the aircraft. One passenger sustained serious injury and 12 passengers received minor injuries during evacuation. Damage was confined to the left main gear tires and brakes.

Ref. AFS-54 1974 Summary, Pg. 5

54. 5/19/74, AW-650, Dept. of Interior, Anchorage, AK

The aircraft could not get airborne and the takeoff was aborted. The aircraft overran the end of the runway and came to rest in a wooded area about 2,000 ft. after the end of the runway. The aircraft was destroyed by the impact and subsequent fire.

Ref. ARB Summary, Pg. 12/74

55. 11/20/74, B-747, Lufthansa, Nairobi, Kenya

The aircraft failed to gain altitude shortly after takeoff and crashed tail-down in a field 500 yards from the end of the runway. The aircraft was destroyed by the impact and subsequent fire.

Ref. ARB Summary, Pg. 19/74

56. 11/25/74, B-707, Pan American, Beirut, Lebanon

The takeoff was aborted due to an engine failure. An emergency evacuation was accomplished with the aircraft on the runway due to an engine fire. The aft main entrance door chute extended but did not inflate. One passenger sustained a broken hip when he jumped off the wing.

Ref. AFS-54 Summary, Pg. 14

APPENDIX C

TABLE 3

SURVIVABLE/SUBSTANTIAL DAMAGE TAKEOFF ACCIDENTS

TURBINE-POWERED AIRCRAFT

1964-1974

No.	Date	Airplane	Fire		Mode of Fuel Release			Runway Cond.		Crew				Passengers				Evac.				Type of Flight				
			Yes	No	E	T	W	S	H	T	N/M	S	F	T	N/M	S	F	N	M	S	P	P	C	T	B	
1	5/29/64	B-707-331		X						14	14	0	0	89	89	0	0	X					X			
2	6/4/64	LJ23	X							2	2	0	0	0	0	0	0							X	X	
3	8/26/64	AW-650		X						3	3	0	0	0	0	0	0	X					X			
4	11/23/64	B-707-331	X		X					11	4	2	5	62	8	11	43						X			
5	3/14/65	SE-210	E*							5	5	0	0	50	49	1	0		2	1			X			
6	4/16/65	F-27A		X						2	0	2	0	0	0	0	0							X		
7	5/11/65	B-707-120		X						7	7	0	0	119	119	0	0						X			
8	9/13/65	CV-880	X		X					4	4	0	0	0	0	0	0	X						X		
9	2/24/66	DH-125		X						2	0	2	0	4	4	0	0								X	
10	4/9/66	B-720		X				X		7	7	0	0	1	1	0	0	X					X			
11	6/26/67	V-745D	X							3	3	0	0	30	29	1	0		4	1			X			
12	9/3/67	L-188		X						5	5	0	0	0	0	0	0						X			

TABLE 3 CON'T

SURVIVABLE/SUBSTANTIAL DAMAGE TAKEOFF ACCIDENTS

No.	Date	Airplane	Fire		Mode of Fuel Release			Runway Cond.		Crew				Passengers				Evac.				Type of Flight					
			Yes	No	E	T	W	S	H	T	N/M	S	F	T	N/M	S	F	N	M	S	P	P	C	T	B		
13	9/8/67	B-707	X			X				10	10	0	0	164	163	1	0	X	1					X			
14	11/6/67	B-707	X				X			7	7	0	0	29	27	1	1							X			
15	11/22/67	B-707	X			X				11	11	0	0	41	40	1	0							X			
16	1/27/68	B-707		X				X		9	9	0	0	1	1	0	0									X	
17	3/21/68	B-727	X			X				3	2	1	0	0	0	0	0	1	1					X			
18	4/8/68	B-707-465	X**							11	10	0	1	116	74	38	4							X			
C-16 19	7/28/68	Falcon		X						3	3	0	0	0	0	0	0										X
20	12/19/68	AC-1121		X						2	2	0	0	2	2	0	0										X
21	12/27/68	DC-9-15		X						4	1	3	0	64	64	0	0							X			
22	2/9/69	B-727	E*							6	6	0	0	110	108	2	0		2					X			
23	2/27/69	L-1329-8		X						2	1	1	0	6	6	0	0										X
24	6/24/69	CV-880	X							5	0	2	3	0	0	0	0										X
25	7/15/69	DHC-6	X			X				3	0	1	2	11	4	6	1							X			
26	7/29/69	B-727		X						3	3	0	0	1	1	0	0								X		
27	9/17/69	DC-8		X						7	7	0	0	77	77	0	0							X			

TABLE 3 CONT

SURVIVABLE/SUBSTANTIAL DAMAGE TAKEOFF ACCIDENTS

No.	Date	Airplane	Fire		Mode of Fuel Release			Runway Cond.		Crew				Passengers				Evac.				Type of Flight			
			Yes	No	E	T	W	S	H	T	N/M	S	F	T	N/M	S	F	N	M	S	P	P	C	T	B
28	10/16/69	DC-8-63F	X		X					5	5	0	0	0	0	0	0	X							X
29	11/28/69	DC-8	E			X				7	7	0	0	116	116	0	0							X	
30	12/1/69	B-707-321B		X						11	11	0	0	125	125	0	0	X						X	
31	4/19/70	DC-8	X			X				11	9	2	0	54	44	10	0							X	
32	6/9/70	DC-8F	X							10	10	0	0	218	216	2	0		2					X	
33	7/19/70	B-737-222		X						6	6	0	0	55	54	1	0							X	
C-17 34	8/24/70	L-188	X							3	2	1	0	0	0	0	0								X
35	11/27/70	DC-8-63F	X			X	X			10	3	6	1	219	130	43	46							X	
36	11/30/70	B-707	X							3	3	0	0	0	0	0	0							X	
37	6/4/71	HFB-320	X							2	2	0	0	0	0	0	0								X
38	6/20/71	B-747-151		X						11	11	0	0	203	203	0	0							X	
39	7/21/71	B-707-323		X		X				8	8	0	0	105	105	0	0							X	
40	7/30/71	B-747	X							19	19	0	0	199	189	10	0		19	8	X		X		
41	8/28/71	NA-265		X						2	2	0	0	2	2	0	0								X
42	3/19/72	DC-9	X*							5	5	0	0	82	82	0	0							X	

TABLE 3 CON'T

SURVIVABLE/SUBSTANTIAL DAMAGE TAKEOFF ACCIDENTS

No.	Date	Airplane	Fire		Mode of Fuel Release			Runway Cond.		Crew				Passengers				Evac.				Type of Flight							
			Yes	No	E	T	W	S	H	T	N/M	S	F	T	N/M	S	F	N	M	S	P	P	C	T	B				
43	8/13/72	B-707	X			X				11	11	0	0	175	175	0	0	16					X						
44	9/13/72	B-707		X						3	3	0	0	0	0	0	0								X				
45	12/20/72	DC-9-31	X			X				4	4	0	0	41	22	9	10			1	X	X							
46	3/5/73	B-707	X		X					3	3	0	0	0	0	0	0									X			
47	4/24/73	DC-8	X			X				3	3	0	0	0	0	0	0								X				
48	6/20/73	DC-8	X							10	10	0	0	251	248	3	0	30	2			X							
C-18 49	6/22/73	DC-9	X							5	5	0	0	103	103	0	0	X				X							
50	12/17/73	DC-9	X			X		X		4	4	0	0	85	85	0	0					X							
51	1/4/74	B-727	X							7	7	0	0	111	110	1	0	1	1			X							
52	2/8/74	DC-8	X							9	9	0	0	153	152	1	0		1			X							
53	3/27/74	DC-8-63	X							11	11	0	0	219	218	1	0	12	1			X							
54	5/19/74	AJ-650	X							3	3	0	0	2	2	0	0								X				
55	11/20/74	B-747	X			X				17	9	4	4	140	69	16	55					X							
56	11/25/74	B-707	E							9	9	0	0	21	20	1	0		1	X	X								
			<u>36</u>	<u>20</u>				<u>2</u>	<u>1</u>	<u>363</u>	<u>27</u>	<u>15</u>	<u>3656</u>		<u>160</u>	<u>156</u>	<u>85</u>		<u>23</u>										

\*Fire extinguished by aircraft equipment

\*\*Fatalities from this accident are not included in the takeoff accident fatality statistics since they occurred after the aircraft had returned to the airport.

C-iv

APPENDIX D

Survivable/Substantial Damage Inflight Accident Summaries

Turbine-Powered Aircraft

1964-1974

1. 6/9/65, DC-8, National, San Francisco, CA

About five minutes after takeoff the flight was climbing through 7,000 ft. when the No. 1 engine fire warning light came on. The engine was immediately shut down and both fire bottles were discharged; however, visual inspection showed a fire in the engine had not been put out and increasing in intensity. The crew immediately returned to the airport of departure, abandoning fuel dump plans and made a safe landing. Emergency evacuation of the passengers was conducted, and the fire was put out by ground fire fighting equipment.

Ref. ARB Summary, Pg. 15/65

2. 6/28/65, B-707-321B, Pan American, Travis AFB, CA

The aircraft experienced an explosive disintegration of the third stage turbine disc of the No. 4 engine shortly after takeoff at an altitude of about 800 ft. above the ground. Disintegration of the turbine disc was followed by a fire in the No. 4 engine area and an explosion in the outboard reserve fuel tank. The No. 4 engine and 28 ft. of the right outer wing separated from the aircraft. The fire was extinguished and a successful emergency landing was accomplished at Travis Air Force Base California, with no injuries to the 143 passengers or 10 crew members aboard the flight.

Ref. ARB Summary, Pg. 16/65, and AFS-54 1965 Summary, Pg. 12

3. 11/24/65, F-27A, Pacific, San Francisco, CA

Shortly after reaching 6,000 ft., m.s.l., and while cruising in the vicinity of known thunderstorm activity, the aircraft was struck by lightning. The aircraft received lightning strike damage but was landed normally at San Francisco. Investigation disclosed that lightning penetrated the fuselage at the left nose gear door, immediately aft of the radome, and exited at both wingtips. The main discharge force was expended explosively in the area of the left outboard wing section, causing distortion of wing skin. There was no evidence of fuel leakage or fuel tank damage.

Ref. ARB Summary, Pg. 28/65

4. 12/4/65, B-707, Trans World, Jamaica, NY

The B-707 aircraft and an L-1049C aircraft collided at about 11,000 ft. The L-1049C crash landed and the B-707 continued to a safe landing at JFK International Airport.

Ref. ARB Summary, Pg. 29/65, and AFS-54 1965 Summary, Pg. 26

5. 12/25/65, DC-8-33, Japan Air Lines, Oakland, CA

At 4,500 feet after takeoff in a scattered cloud condition there was an explosion in the No. 1 engine and fire broke out in the engine area. The fire was subsequently extinguished and the aircraft was landed safely at the Oakland, California International Airport. There were no injuries to the crew and passengers; the aircraft was substantially damaged by the engine explosion and fire that followed.

Ref. ARB Summary, Pg. 32/65

6. 8/4/66, N-262A-12, Lake Central, Morgantown, WV

While descending for a landing, the first stage turbine wheel in the left engine disintegrated and fire was visible. No. 1 and No. 2 fire extinguishers were used and the propeller was feathered. The landing was completed without incident other than a blown left tire due to excessive braking. Three passengers were injured, two seriously, when they were struck by pieces of the disintegrating turbine wheel which penetrated the fuselage.

Ref. ARB Summary, Pg. 22/66, and AFS-54 1966 Summary, Pg. 18

7. 8/11/66, N-262A-12, Lake Central, Martinsburg, WV

The third stage turbine wheel in the left engine disintegrated and the engine caught fire. No. 1 fire bottle was used and the fire appeared to go out then re-ignited. The second bottle extinguished the fire but the propeller could not be feathered. A safe landing was made. One passenger was injured when struck by a fragment of the disintegrating turbine wheel that penetrated the fuselage.

Ref. ARB Summary, Pg. 22/66, and AFS-54 1966 Summary, Pg. 19

8. 4/8/67, N-262A, Lake Central, Chicago, IL

After takeoff at about 3,000 ft., a fire was observed in the right engine nacelle with flames extending over top of the wing. The engine was shut down and both extinguishing bottles were discharged which failed to extinguish the fire. The aircraft landed and passengers and crew evacuated the aircraft. Emergency equipment arrived shortly after all had evacuated and extinguished the fire in about 15 seconds. Aircraft damage was substantial.

Ref. AFS-54 1967 Summary, Pg. 14, and NTSB File No. 1-0035

9. 4/25/67, CV-640, Caribbean Atlantic, San Juan, PR

A hydraulic fluid fire developed in the left wheel well when the landing gear was lowered for landing. The left engine was shut-down and the fire extinguisher was discharged but the fire continued to burn and the hydraulic system failed. The aircraft veered to the right after touchdown, collapsing the left gear, and came to rest 4,325 ft. from the threshold. All occupants evacuated from the right side of the aircraft. The fire which had continued burning was extinguished by the fire department.

Ref. AFS-54 1967 Summary, Pg. 16, and NTSB File No. 1-0055

10. 6/19/67, Learjet 24A, \_\_\_\_\_, Tahoe Valley, CA

Aircraft collided with trees following a low pass. Precautionary landing made. There were no injuries.

Ref. ARB Summary, Pg. 13/67, and NTSB File No. 2-0449

11. 6/24/67, CV-880, Delta, Newark, NJ

While climbing to cruise altitude, the No. 4 engine caught fire as a result of failure of the eighth stage compressor rotor. The No. 4 pylon, flap, and wing were also damaged and the aircraft was landed with no further incident. There was no fire damage.

Ref. ARB Summary, Pg. 15/67, and AFS-54 1967 Summary, Pg. 21

12. 7/31/67, V-745D, Aloha, Honolulu, HI

During cruise flight at 4,000 ft., a passenger noticed fire and smoke coming from the cabin floor. The fire was extinguished with a water extinguisher. The fire was caused by an improperly repaired external power isolating relay. The smoke was moderate in density and white and gray in color. The captain depressurized the cabin for smoke evacuation. No smoke masks or supplemental oxygen were used during the emergency. The aircraft made a normal landing and passengers deplaned at terminal gate.

Ref. ARB Summary, Pg. 17/67, and NTSB File No. 1-0037

13. 3/27/68, DC-9, Ozark, St. Louis, MO

The DC-9 and a Cessna C-150F collided about 1.5 miles from the airport. The Cessna crashed and the DC-9 sustained light damage and made a safe landing. There was no fire. After touchdown, the tower advised the DC-9 that fuel was leaking from the right wing and the right engine was shut down after reversing. The left engine was secured during rollout and the aircraft was stopped adjacent to the taxiway where passengers and crew deplaned through the forward airstair door. Airport fire equipment stood by throughout the evacuation.

Ref. ARB Summary, Pg. 5/68, and NTSB File No. 1-0012

14. 6/26/68, B-727, American, Columbus, OH

The aircraft was landed after an inflight fire alarm (false) for No. 2 engine and emergency evacuation procedures were instituted. Two passengers received serious injuries and one passenger and stewardess received minor injuries during the evacuation.

Ref. AFS-54 1968 Summary, Pg. 14

15. 8/4/68, CV-580, North Central, Milwaukee, WI

The CV-580 and a Cessna C-150 collided about 11.5 miles from the airport at 2,700 ft. The Cessna's cabin section and landing gear were imbedded in the right forward baggage compartment area of the CV-580 which sustained extensive damage. The CV-580 made a safe landing and there were no injuries to the occupants. There was no fire.

Ref. ARB Summary, Pg. 13/68, and AFS-54 1968 Summary, Pg. 18

16. 11/19/68, B-707, American, Chantilly, VA

While climbing through FL 290, the No. 1 engine turbine section disintegrated, damaging a fuel tank, hydraulic supply line, flap, and fuselage. Engine fire extinguisher was discharged as a precautionary measure and the aircraft was landed at Dulles International Airport. A passenger attached slide at the rear entrance door when he noticed fuel leaking from the left wing. Five passengers used the slide. Remaining passengers departed via mobile passenger lounge. Firemen covered fuel spill area with a blanket of foam.

Ref. ARB Summary, Pg. 18/68, and NTSB File No. 1-0047

17. 11/19/68, B-707, Continental, Denver, CO

Explosion and fire severely scorched a lavatory as the aircraft was descending through 24,000' for a landing at Denver. The fire was extinguished by crew members and a safe emergency landing was made.

Ref. ARB Summary, Pg. 18/68

18. 8/3/69, B-707, American, Fort Worth, TX

The B-707 and a Cessna 172 collided at an altitude of about 8,500 ft. The left wing of the Cessna was torn away and the left horizontal stabilizer of the B-707 was damaged. The crew requested emergency equipment to stand by and the B-707 made a successful landing. There was no fire.

Ref. AFS-54 1969 Summary, Pg. 17, and NTSB File No. 1-0051

19. 3/28/70, B-720B, Western, Annette Island, AK

The aircraft was in flight at FL 330 when the compressor section of No. 1 engine disintegrated. Fragments damaged the fuselage, wings, ailerons, flaps, pylon, No. 2 engine thrust reverser, and fin and rudder. An emergency landing was made with no further damage and no injury. There was no fire.

Ref. ARB Summary, Pg. 8/70, and AFS-54 1970 Summary, Pg. 5

20. 4/6/70, YS-11A, Piedmont, Charleston, WV

The aircraft was struck by lightning at 7,000 ft. about 24 miles from the airport. The lightning entered the aircraft on the left side forward of the cockpit and exited at the rudder. The upper portion of the rudder was missing after landing. There was no fire.

Ref. ARB Summary, Pg. 8/70, and NTSB File No. 1-0007

21. 1/9/71, B-707, American, Newark, NJ

The B-707 and a Cessna C-150 collided at about 3,000 ft. The Cessna crashed and the B-707 received damage to the left wing and an engine pod which caused hydraulic fluid loss. The landing gear was lowered manually, the flaps electrically, and the aircraft made a safe landing. Nose steering did not work and the aircraft was towed to the ramp where the passengers deplaned normally.

Ref. AFS-54 1971 Summary, Pg. 1, and NTSB File No. 1-0001

22. 4/10/71, Learjet 23, , Danville, IL

On final approach, the right hand battery had a thermal runaway. Inflight fire and substantial damage resulted.

Ref. ARB Summary, Pg. 8/71

23. 4/11/71, Learjet 25, Wm. T. Burton Industries, Lake Charles, LA

On final approach, the right hand battery overheated causing electrical failure and inflight fire. After landing, the crew extinguished the fire with dry type and CO<sub>2</sub> extinguishers with assistance from the airport fire department.

Ref. ARB Summary, Pg. 8/71, and NTSB File No. 3-3819

28. 2/19/72, B-727, Eastern, Chantilly, VA

An APU fire warning was received enroute and the aircraft was landed and brought to a stop on the runway. One passenger received a cracked vertebra during the emergency evacuation. There was no aircraft damage or fire.

Ref. AFS-54 1972 Summary, Pg. 3

29. 6/12/72, DC-10-10, American, Detroit, MI

The lower left aft cargo door separated from the aircraft at about 11,750 ft. which caused partial collapse of the cabin floor into the cargo compartment, disrupting various control cables resulting in partial loss of elevator control and complete loss of control over the rudder and No. 2 engine. The aircraft went off the side of the runway during the landing roll. There was no fire. All occupants evacuated via emergency chutes with minor injuries to eight passengers.

Ref. ARB Summary, Pg. 17/72, and AFS-54 1972 Summary, Pg. 13

30. 6/28/72, G-1159, Linden Flight Service, Jamaica, NY

The aircraft experienced a thermal runaway of No. 1 battery which caused a complete electrical failure and fire which was confined to the battery compartment aft of the rear pressure bulkhead. The aircraft was landed without an operative anti-skid system. Heavy braking destroyed the main gear tires and caused damage to the main gear.

Ref. ARB Summary, Pg. 20/72, and NTSB File No. 3-1253

31. 1/20/73, B-707, American, Chicago, IL

After takeoff at 1,300 ft., the No. 4 engine third stage turbine disc separated, accompanied by a loss of hydraulic pressure. Fragments penetrated the No. 4 fuel tank in the right wing causing severe fuel leaks. There was no fire. The aircraft landed without further incident. The passengers were deplaned through the normal exits at the end of the runway.

Ref. ARB Summary, Pg. 2/73, and AFS-54 1973 Summary, Pg. 1

24. 5/9/71, F-27F, Phillips Petroleum, McAlester, OK

Smoke was observed coming from behind the instrument panel in flight and the aircraft was landed, stopped on the first taxiway, and the engines were shut off. The passengers deplaned through the aft cabin door while the crew used two hand fire extinguishers on the fire in the aircraft nose section, but the fire continued. A local city fire truck extinguished the fire with water.

Ref. ARB Summary, Pg. 9/71, and NTSB File No. 3-4233

25. 8/4/71, B-707-320C, Continental, Los Angeles, CA

The B-707 and a Cessna C-150J collided about 9 miles from the airport at 4,000 ft. Both aircraft landed safely. The B-707 received substantial damage to the right wing and the top of No. 4 reserve fuel tank was torn open. There was no fire.

Ref. ARB Summary, Pg. 15/71, and NTSB File No. 1-0025

26. 8/18/71, DC-9, Delta, Savannah, GA

The aircraft struck a large bird at about 2,500 ft. shortly after takeoff. The bird penetrated the radome, pressure bulkhead, and entered the cockpit. All DC power was lost. Emergency battery power was employed and the aircraft was landed without further incident.

Ref. ARB Summary, Pg. 16/71, and AFS-54 1971 Summary, Pg. 12

27. 11/8/71, B-747, Eastern, Jamaica, NY

Fire occurred in No. 1 engine during the initial climb after takeoff. Two extinguisher bottles were discharged but the fire was not extinguished. The aircraft returned for a landing with emergency equipment standing by. The engine fire went out during the landing roll and the aircraft returned to the terminal where the passengers deplaned. There was extensive damage to No. 1 engine and wing flaps.

Ref. ARB Summary, Pg. 21/71, and NTSB File No. 4-0050

32. 7/11/73, B-707, Varig, Paris, France

Heavy smoke was emitted from the left rear lavatory a few minutes before landing. A CO<sub>2</sub> extinguisher was used, but the smoke spread to the rear of the cabin. An emergency descent was initiated, the aircraft was depressurized, the rear discharge valve was opened, but the smoke progressed forward to the cockpit. The aircraft made a forced landing 4 miles short of the airport. Ground contact was hard and both main landing gears were torn off. The aircraft, still nose high, slid on the engines which were torn off one after the other. The aircraft came to a stop with no major damage to the structure and Nos. 2,3, and 5 fuel tanks intact. The impact caused an explosion of No. 4 fuel tank, however, the fire did not propagate to No. 3 tank. After the aircraft came to a stop, the cabin fire quickly spread and the top of the rear half of the fuselage melted. The seven occupants of the cockpit evacuated through the side windows. Two cabin attendants went out through the forward left door and another through the galley forward right door. Most of the passengers were found still seated and strapped to their seats. The time from crash impact to arrival of the first rescue team was less than 10 minutes.

Ref. ARB Summary, Pg. 17/73

33. 7/27/73, B-727, FAA, Oklahoma City, OK

The aircraft struck a Cessna 172 during a training flight, sustained substantial damage to the elevator, and landed safely, coming to a stop 6,000 ft. down and off to the right of the runway. No. 3 engine would not come out of reverse. There was no fire.

Ref. NTSB File No. 3-3645

34. 8/8/73, B-727, Braniff, Chantilly, VA

A right main landing gear tire exploded as the aircraft climbed to 17,000 ft. following takeoff, causing a rapid decompression and loss of hydraulic pressure. An emergency landing was made on a foamed runway with the right main gear slightly cocked. The aircraft was stopped on the runway. No injuries were sustained during evacuation through the 3 door exits. There was no fire.

Ref. AFS-54 1973 Summary, Pg. 8, and NTSB File No. 1-0039

35. 11/3/73, DC-10, National, Albuquerque, NM

The No. 3 engine fan disintegrated at 39,000 ft., causing substantial damage to the right side of the fuselage and No. 1 engine. A window was broken by shrapnel from the engine and rapid decompression resulted. A passenger seated next to the window was sucked out. The cabin filled with thick and irritating smoke and an emergency landing was made 19 minutes after the engine failure. Occupants evacuated via the emergency slides. One slide failed to operate.

Ref. ARB Summary, Pg. 23/73, and AFS-54 1973 Summary, Pg. 14

36. 7/8/74, DC-10, National, Tampa, FL

Cowling from the aft section of No. 1 engine separated during climbout through FL 250. The cowling tore large holes in the left wing leading edge and upper wing surface before being ingested into the No. 2 engine. An emergency landing was made without further incident.

Ref. ARB Summary, Pg. 14/74, and AFS-54 1974 Summary, Pg. 9

37. 7/10/74, B-727, American, Chicago, IL

No. 3 engine fire warning light came on at FL 120, and an unscheduled landing was made. Two passengers were seriously injured during the emergency evacuation. The fire warning was false.

Ref. AFS-54 1974 Summary, Pg. 10

## APPENDIX D

TABLE 4

SURVIVABLE/SUBSTANTIAL DAMAGE INFLIGHT ACCIDENTSTURBINE-POWERED AIRCRAFT

1964-1974

No.	Date	Airplane	Fire		Mode of Fuel Release			Crew				Passengers				Evac.				Type of Flight					
			Yes	No	E	T	W	T	N/M	S	F	T	N/M	S	F	N	M	S	P	P	C	T	B		
1	6/ 9/65	DC-8	E					7	7	0	0	71	71	0	0	X					X				
2	6/28/65	B-707-321B	E		X		X	10	10	0	0	143	143	0	0						X				
3	11/24/65	F-27A		X				3	3	0	0	30	30	0	0						X				
4	12/ 4/65	B-707		X				7	7	0	0	51	51	0	0						X				
D-11 5	12/25/65	DC-8-33	E*					10	10	0	0	31	31	0	0						X				
6	8/ 4/66	N-262A-12	E*					3	3	0	0	16	14	2	0						X				
7	8/11/66	N-262A-12	E*					3	3	0	0	14	13	1	0						X				
8	4/ 8/67	N-262A	E					3	3	0	0	6	6	0	0	X					X				
9	4/25/67	CV-640D	X					3	3	0	0	54	54	0	0	X					X				
10	6/19/67	LJ24A		X				2	2	0	0	4	4	0	0										X
11	6/24/67	CV-880	E*					6	6	0	0	53	53	0	0						X				
12	7/31/67	V-745D	X*					3	3	0	0	30	30	0	0						X				

TABLE 4 CON'T

SURVIVABLE/SUBSTANTIAL DAMAGE INFLIGHT ACCIDENTS

No.	Date	Airplane	Fire		Mode of Fuel Release			Crew				Passengers				Evac.				Type of Flight					
			Yes	No	E	T	W	T	N/M	S	F	T	N/M	S	F	N	M	S	P	P	C	T	B		
13	3/27/68	DC-9		X		X		5	5	0	0	44	44	0	0	X					X				
14	6/26/68	B-727		X				7	7	0	0	25	23	2	0		2	2			X				
15	8/ 4/68	CV-580		X				3	2	1	0	9	9	0	0						X				
16	11/19/68	B-707		X		X		7	7	0	0	31	31	0	0						X				
17	11/19/68	B-707	X*					7	7	0	0	63	63	0	0						X				
18	8/ 3/69	B-707		X				5	5	0	0	0	0	0	0									X	
19	3/28/70	B-720B		X				7	7	0	0	20	20	0	0						X				
20	4/ 6/70	YS-11A		X				4	4	0	0	21	21	0	0						X				
21	1/ 9/71	B-707		X				3	3	0	0	14	14	0	0						X				
22	4/10/71	LJ23	X					2	2	0	0	4	4	0	0										X
23	4/11/71	LJ25	X					2	2	0	0	0	0	0	0										X
24	5/ 9/71	F-27F	X					3	3	0	0	20	20	0	0	X									X
25	8/ 4/71	B-707-320C		X		X		9	9	0	0	87	87	0	0						X				
26	8/18/71	DC-9		X				5	5	0	0	56	56	0	0						X				
27	11/ 8/71	B-747	E*					13	13	0	0	202	202	0	0						X				

D-12

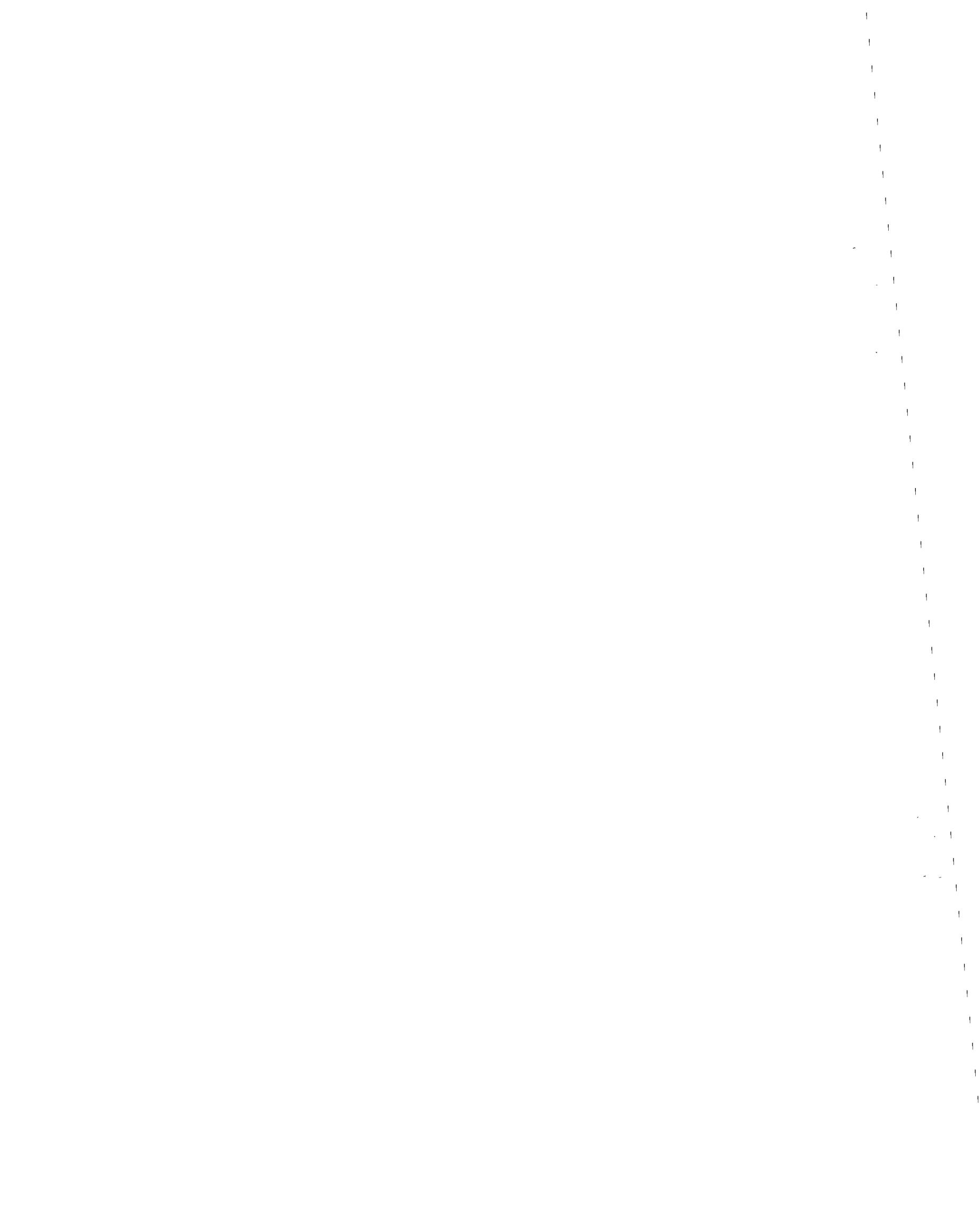
D-11

TABLE 4 CON'T

SURVIVABLE/SUBSTANTIAL DAMAGE INFLIGHT ACCIDENTS

No.	Date	Airplane	Fire		Mode of Fuel Release			Crew				Passengers				Evac.				Type of Flight						
			Yes	No	E	T	W	T	N/M	S	F	T	N/M	S	F	N	M	S	P	P	C	T	B			
28	2/19/72	B-727		X				6	6	0	0	81	81	1	0			1				X				
29	6/12/72	DC-10-10		X				11	11	0	0	56	56	0	0			8				X				
30	6/28/72	G-1159	X					2	2	0	0	5	5	0	0											X
31	1/20/73	B-707		X		X		8	8	0	0	64	64	0	0							X				
32	7/11/73	B-707	X			X		17	10	0	7	117	0	1	116							X				
33	7/27/73	B-727		X				4	4	0	0	0	0	0	0											X
34	8/ 8/73	B-727		X				6	6	0	0	75	75	0	0			X				X				
35	11/ 3/73	DC-10		X				12	12	0	0	115	114	0	1			X			X	X				
36	7/8/74	DC-10		X		X		12	12	0	0	160	160	0	0							X				
37	7/10/74	B-727		X				8	8	0	0	59	57	2	0			2				X				
			9	21				228		1	7	1831		9	117			10	5							

\* Fire extinguished by aircraft equipment



APPENDIX E

Taxiing Accident and Incident Summaries

Turbine-Powered Aircraft

1964-1974

1. 6/30/64, DC-8, National, Jamaica, NY

The wing of the DC-8 struck the wing of an L-049 Constellation as the DC-8 was being guided into position at the gate. There were no injuries and no fire.

Ref. NTSB File No. 1-0031 and AFS-54 1964 Summary, Pg. 10

2. 10/30/64, DC-8, Eastern, Jamaica, NY

While the DC-8 was being taxied to the terminal, the wing tip struck a parked DC-7. No fire.

Ref. AFS-54 1964 Summary, Pg. 16

3. 11/12/64, B-707-123B, American, Nashville, TN

While taxiing from the terminal to the active runway for takeoff, nos. 5 and 6 main landing gear axles failed at the truck beam, causing loss of both left rear wheels. Except for bending and slight skin separation of the left inboard flap, the damage was confined to components of the left main landing gear.

Ref. AFS-54 1964 Summary, Pg. 17

4. 1/4/65, B-720B, \_\_\_\_\_, Salt Lake City, UT

No. 2 engine failed to produce full power on runup for takeoff and was shut down. As the aircraft was taxied back to the ramp, an attempt was made to restart no. 2 engine and a fire occurred in the reverser section. Fire extinguishers were discharged, extinguishing the fire. Damage was limited to no. 2 engine.

Ref. NTSB File No. 4-0001

5. 1/8/65, DC-8, Eastern, San Juan, PR

Halfway through a turn into the ramp, the right landing gear separated at the bogie swivel hinge point. There were no injuries or fire. Evacuation was through normal exits.

Ref. NTSB File No. 1-0034 and AFS-54 1965 Summary, Pg. 1

6. 2/18/65, NA-265A, Hanna Mining Co., Washington, D.C.

Landing gear collapsed on the taxiway after a simulated hydraulic system failure. There were no injuries or fire.

Ref. NTSB File No. 2-0026

7. 10/15/65, DC-8, United, San Diego, CA

The DC-8 was being directed in a circular taxiing maneuver when the left wing tip struck the rudder and horizontal stabilizer of a parked Navy F-4G aircraft.

Ref. AFS-54 1965 Summary, Pg. 22

8. 8/22/66, SE-210, United, Newark, NJ

The nose wheel axle failed while the aircraft was being taxied. Both nose wheels separated from the aircraft and the aircraft continued for about 300 ft. while skidding on the nose gear strut. There were no injuries.

Ref. AFS-54 1966 Summary, Pg. 19

9. 9/25/66, B-727, Pacific, San Francisco, CA

The aircraft experienced a loss of brake action while taxiing to the terminal gate area and collided with an aircraft tug and the terminal building. The aircraft and terminal, including the passenger loading "jetway", were substantially damaged. Two stewardesses were thrown against the cockpit door when the aircraft stopped. One received minor injuries. A third stewardess was thrown to the floor and slid up the aisle. Passengers had seat belts on and deplaned by the rear stair door.

Ref. AFS-54 1966 Summary, Pg. 22, and NTSB File No. 1-0054

10. 11/14/66, F-27, Ozark, Chicago, IL

While taxiing to the runway for takeoff, the nose gear collapsed and the right main gear retracted partially and the aircraft dropped to the ramp and rested on the fuselage. The engines were

shutdown and the passengers evacuated through the lavatory emergency exit. One passenger injured his back and required assistance in evacuation. The support bracket for the stewardess jump seat was bent which caused her to be held suspended in a semi-sitting position by the seat belt. There was no fire.

Ref. AFS-54 1966 Summary, Pg. 27, and NTSB File No. 1-0035

11. 4/27/67, L-1329, Hercules, Brunswick, GA

The aircraft taxied into three parked cars after a hydraulic system malfunction. Fuel tank ruptured, no fire, no injuries.

Ref. NTSB File No. 2-1204

12. 1/1/68, DC-8, Capitol International, McGuire AFB, Wrightstown, NJ

During taxi out for takeoff, the aircraft passed over an icy area and slid off the taxi strip. The nose wheel struck the side of the runway, bending the nose gear back and buckling and tearing the fuselage. There was no fire.

Ref. AFS-54 1968 Summary, Pg. 1

13. 9/6/68, L-188, American, Cleveland, OH

While taxiing to the gate after landing, the left wing tip and No. 1 propeller of the L-188 struck the right wing of a B-720 holding short of the active runway. The B-720 developed a fuel spill and a precautionary emergency slide evacuation was ordered by the captain and accomplished in about 50 seconds. Fire trucks washed down the fuel spill. The L-188 passengers and crew deplaned using the integral boarding stairs.

Ref. AFS-54 1968 Summary, Pg. 23, and NTSB File No. 1-0056

14. 12/23/68, DC-8, \_\_\_\_\_, Newark, NJ

A wheel from the right main landing gear came off during the turn from the runway to the taxiway. A small fire developed in the right gear at the ramp following deplaning of passengers and was extinguished by ramp personnel using sand.

Ref. NTSB File No. 4-0027

15. 1/30/69, B-737, Trans World, Roanoke, VA

The brakes failed following a high-speed taxi run to check the brakes and the aircraft was turned down a taxiway and stopped. The crew noticed that the main landing gears were on fire and evacuated the aircraft. The crew kept the fires from spreading by using small fire bottles. Emergency equipment arrived in

15-20 minutes and extinguished the fires.

Ref. NTSB File No. 4-0001

16. 5/8/69, DC-8, Delta, and FH-227, Ozark, Chicago, IL

The two aircraft collided while taxiing at the intersection of two taxiways with the left wing of the DC-8 passing over the right wing of the FH-227 and sustaining damage from the propeller. There was no fire.

Ref. AFS-54 1969 Summary, Pg. 10, and NTSB File No. 1-0035

17. 5/14/69, B-727, National, Washington, D.C.

The aircraft taxied around another B-727 holding short of the runway and sustained substantial wing tip damage upon contact with the wing tip of the holding aircraft. There was no fire.

Ref. AFS-54 1969 Summary, Pg. 10

18. 6/25/69, B-727, Trans World, Chicago, IL

The aircraft was taxied down a wet runway at high speed to turn around for takeoff and skidded off the runway, coming to rest near the end of the runway with the left main gear collapsed. There was no fire. One passenger received serious injury during the emergency evacuation.

Ref. AFS-54 1969 Summary, Pg. 11

19. 6/27/69, V-745, Aloha, Honolulu, HI

The brakes failed and the aircraft taxied into a parked DC-9 shortly after departure from the loading gate. There was no fire. Passengers deplaned without incident.

Ref. AFS-54 1969 Summary, Pg. 11, and NTSB File No. 1-0048

20. 8/7/69, AC-1121, Airco, Niagara Falls, NY

The right brake failed during a high-speed taxi run to check the anti-skid system and the aircraft ran off the runway. The hot brakes started several grass fires which were extinguished by the airport fire department. The aircraft sustained substantial structural damage.

Ref. NTSB File No. 3-3755

21. 8/18/69, DC-9, Southern, Eglin AFB, FL

The wing tip struck a parked fuel truck while the aircraft was taxiing from the departure gate. The aircraft sustained substantial damage to the wing tip and fuel vent box. There was no fire.

Ref. AFS-54 1969 Summary, Pg. 18, and NTSB File No. 1-0021

22. 9/15/69, B-727, Trans World, Philadelphia, PA

While taxiing to the active runway, the evacuation alarm was inadvertently actuated by a stewardess. A passenger was seriously injured during evacuation when she fell through a slit in the escape slide.

Ref. AFS-54 1969 Summary, Pg. 20

23. 10/9/69, DC-8, United, Jamaica, NY

While taxiing to the terminal after landing, the captain was advised by a following aircraft that the No. 3 engine was on fire. Evacuation was executed with a few minor injuries. The small engine fire quickly went out. The airport fire department sprayed the engine with water as a precaution.

Ref. NTSB File No. 4-0045

24. 11/20/69, DC-8, Eastern, Miami, FL

The aircraft was being taxied to the ramp area and the left wing struck the empennage of a parked DC-8-63. There was substantial damage to both aircraft. There was no fire.

Ref. AFS-54 1969 Summary, Pg. 22, and NTSB File No. 1-0050

25. 2/16/70, L-1329, \_\_\_\_\_, Des Plaines, IL

The aircraft, while taxiing on No. 1 and No. 4 engines, had insufficient hydraulic pressure for braking, drifted into a parked aircraft, and sustained damage to the left external fuel tank. There was no fire.

Ref. NTSB File No. 3-0952

26. 5/15/70, L-382, Delta, San Francisco, CA

As the aircraft taxied to the terminal, a fire occurred in the left landing gear. Portable extinguishers failed to extinguish the fire and it spread rapidly. The fire was extinguished by the airport fire department using foam.

Ref. ARB Summary, Pg. 11/70

27. 5/22/70, AC-1121B, Devore Aviation, Atlantic City, NJ

The left main landing gear collapsed during taxi tests and the aircraft came to rest 70-80 ft. to the left of the runway centerline. The failed landing gear strut punctured the wing, causing fuel spillage. There was no fire. Airport fire department responded promptly.

Ref. NTSB File No. 5-0011

28. 9/15/70, FH-227B, Mohawk, Philadelphia, PA

During taxi to the gate position, the left wing tip struck a passenger jetway. Passengers deplaned via the main entrance door. There was no fire.

Ref. NTSB File No. 1-0020

29. 11/4/70, B-727, National, Savannah, GA

During taxi, the right main landing gear support beam failed. The right wing was extensively damaged on ground contact. Occupants exited via the ventral stair. There was no fire.

Ref. AFS-54 1970 Summary, Pg. 14

30. 12/23/70, CV-580, Frontier, Kansas City, MO

While taxiing to the terminal, the aircraft made a right turn and the left main landing gear collapsed. There was some smoke and fuel spewed out on the ramp. One passenger received a minor injury as occupants evacuated via the slide of the left rear exit. Passengers were away when fire equipment arrived. There was no fire.

Ref. AFS-54 Summary, Pg. 18, and NTSB File No. 1-0044

31. 7/23/71, B-747, United, Chicago, IL

After a short taxi, the crew was informed of an engine fire and an emergency evacuation was initiated. Four persons had minor injuries and one had a serious injury, possibly because rain made the slides slick. The engine fire was extinguished by the airport fire department.

Ref. AFS-54 1971 Summary, Pg. 9

32. 8/8/71, V-745D, Aloha, Honolulu, HI

During taxi to the terminal after landing, smoke was detected coming from below the cabin floor. The aircraft was stopped on the taxiway and the passengers and crew evacuated via the forward airstairs. The airport emergency equipment responded within 2 minutes and fire was brought under control within 3.5 minutes. The cockpit and cabin were severely damaged by fire due to a thermal runaway of the left nickel-cadmium battery.

Ref. ARB Summary, Pg. 15/17, and NTSB File No. 1-0013

33. 9/1/72, B-747, Trans World, Jamaica, NY

While taxiing out for takeoff, multiple tire failures caused a heat build-up in the rear of the left main body landing gear resulting in fire. Evacuation was ordered but engines were not shut down immediately. One chute was blown under the fuselage and rendered useless. Several passengers were injured when engine blast knocked them over as they left the chute. Other injuries occurred when passengers landed on broken glass after one of the passengers had dropped a bottle. Eight passengers sustained serious injuries and 74 received minor injuries. Airport fire equipment arrived in about 2 minutes and extinguished the fire in about 5 minutes by which time evacuation was terminated.

Ref. NTSB File No. 1-0013

34. 10/30/72, B-727, Northwest, Washington, D.C.

While taxiing to the terminal, the left main landing gear failed and the aircraft settled on the left wing. Passengers deplaned via mobile stairs brought to the aircraft. There was no fire.

Ref. AFS-54 1972 Summary, Pg. 22

35. 11/8/72, B-727, Eastern, Atlanta, GA

While taxiing out for takeoff, the right main landing gear collapsed causing substantial damage to the right wing tip, flaps, and trailing edge panels. A small fuel spillage was cleaned up by airport fire equipment. There was no fire. Two crew members evacuated via the right cockpit window, another used the main door chute.

Ref. NTSB File No. 1-0040

36. 12/20/72, CV-880, Delta, Chicago, IL

The aircraft was taxiing across the runway and was struck by a DC-9 which was taking off. The aircraft was substantially damaged by the impact. There was no fire.

Ref. ARB Summary, Pg. 37/72, and AFS-54 1972 Summary, Pg. 26

37. 4/9/73, B-707, Pan American, Miami, FL

The nose landing gear collapsed aft into the underside of the fuselage as the aircraft was turned onto the runway for takeoff. Damage was sustained by eight fuselage stringers, two formers, fuselage skin, the electronic compartment, and the forward cargo compartment floor area. The crew deplaned via a ladder supplied by emergency units.

Ref. ARB Summary, Pg. 9/73, and AFS-54 1973 Summary, Pg. 4

38. 12/9/73, B-727, Northwest, Madison, WI

During a turn to a taxiway, the right horizontal stabilizer and elevator struck a hangar door resulting in substantial damage. There was no fire.

Ref. AFS-54 1973 Summary, Pg. 16, and NTSB File No. 1-0033

## APPENDIX E

TABLE 5

SUBSTANTIAL DAMAGE TAXIING ACCIDENTS AND INCIDENTSTURBINE-POWERED AIRCRAFT

1964-1974

No.	Date	Airplane	Fire		Mode of Fuel Release			Crew				Passengers				Evac.				Type of Flight						
			Yes	No	E	T	W	T	N/M	S	F	T	N/M	S	F	N	M	S	P	P	C	T	B			
1	6/30/64	DC-8		X				7	7	0	0	22	22	0	0							X				
2	10/30/64	DC-8		X				7	7	0	0	81	81	0	0							X				
3	11/12/64	B-707-123B		X				7	7	0	0	59	59	0	0							X				
4	1/ 4/65	B-720B		E*				3	3	0	0	79	79	0	0							X				
5	1/ 8/65	DC-8		X				7	7	0	0	83	83	0	0							X				
6	2/18/65	NA-265A		X				2	2	0	0	0	0	0	0											X
7	10/15/65	DC-8		X				3	3	0	0	111	111	0	0							X				
8	8/22/66	SE-210		X				5	5	0	0	8	8	0	0							X				
9	9/25/66	B-727		X				6	6	0	0	64	64	0	0							X				
10	11/14/66	F-27		X				3	3	0	0	40	39	1	0							X	X			
11	4/27/67	L-1329		X			X	2	2	0	0	0	0	0	0											X
12	1/ 1/68	DC-8		X				9	9	0	0	183	183	0	0							X				

TABLE 5 CON'T

SUBSTANTIAL DAMAGE TAXIING ACCIDENTS AND INCIDENTS

No.	Date	Airplane	Fire		Mode of Fuel Release			Crew				Passengers				Evac.				Type of Flight							
			Yes	No	E	T	W	T	N/M	S	F	T	N/M	S	F	N	M	S	P	P	C	T	B				
13	9/6/68	L-188		X				5	5	0	0	36	36	0	0								X				
14	12/23/68	DC-9	X					7	7	0	0	39	39	0	0								X				
15	1/30/69	B-737	X					8	8	0	0	73	73	0	0								X				
16	5/ 8/69	DC-8/FH-227		X				11	11	0	0	63	63	0	0								X				
17	5/14/69	B-727		X				6	6	0	0	63	63	0	0								X				
18	6/25/69	B-727		X				6	6	0	0	61	60	1	0			I					X				
19	6/27/69	V-745		X				3	3	0	0	11	11	0	0								X				
20	8/ 7/69	AC-1121		X				3	3	0	0	0	0	0	0												X
21	8/18/69	DC-9		X				4	4	0	0	19	19	0	0								X				
22	9/15/69	B-727		X				7	7	0	0	69	68	1	0			I	X				X				
23	10/ 9/69	DC-8	E*					8	8	0	0	70	70	0	0			X					X				
24	11/20/69	DC-8		X				5	5	0	0	0	0	0	0												X
25	2/16/70	L-1329		X				2	2	0	0	0	0	0	0												X
26	5/15/70	L-382	X					3	3	0	0	0	0	0	0									X			
27	5/22/70	AC-1121B		X		X		2	2	0	0	0	0	0	0												X

TABLE 5 CON'T

SUBSTANTIAL DAMAGE TAXIING ACCIDENTS AND INCIDENTS

No.	Date	Airplane	Fire		Mode of Fuel Release			Crew				Passengers				Evac.				Type of Flight							
			Yes	No	E	T	W	T	N/M	S	F	T	N/M	S	F	N	M	S	P	P	C	T	B				
28	9/15/70	FH-227B		X				3	3	0	0	9	9	0	0								X				
29	11/ 4/70	B-727		X				6	6	0	0	25	25	0	0								X				
30	12/23/70	CV-580		X		X		3	3	0	0	30	30	0	0		1						X				
31	7/23/71	B-747	E					16	16	0	0	184	183	1	0		4	1		X			X				
32	8/8/71	V-745D	X					3	3	0	0	19	19	0	0								X				
33	9/1/72	B-747	X					18	18	0	0	335	327	8	0		74	8		X			X				
34	10/30/72	B-727		X				6	6	0	0	21	21	0	0								X				
35	11/8/72	B-727		X		X		3	3	0	0	0	0	0	0												X
36	12/20/72	CV-880		X				7	7	0	0	81	81	0	0								X				
37	4/ 9/73	B-707		X				3	3	0	0	0	0	0	0												X
38	12/9/73	B-727		X				6	6	0	0	16	16	0	0								X				
			6	30				215		0	0	1954		12	0		79	11									

\*Fire extinguished by aircraft equipment

APPENDIX F

Parked Accident and Incident Summaries

Turbine-Powered Aircraft

1964-1974

1. 11/19/64, AW-650, Zantop, Gwinn, MI

After a normal landing the aircraft was taxied to the parking ramp. Inspection of the aircraft after shutting down the engines revealed that the leading edge of the left horizontal stabilizer was burned. While the pilots were in the operations building reporting the damage to the aircraft, the leading edge of the left horizontal stabilizer burst into flames. The fire was quickly extinguished by the flight engineer with a portable CO<sub>2</sub> extinguisher.

Ref. ARB Summary, Pg. 27/64

2. 3/4/66, DC-9, Delta, Chicago, IL

While passengers were deplaning, the right hand stair rail telescoped. One passenger fell to the pavement and received serious injuries.

Ref. AFS-54 1966 Summary, Pg. 5

3. 8/30/66, Britannia, British Eagle International, London, England

During pressure refueling, an explosion occurred within the starboard wing causing tank rupture and limited structural damage in the region of No. 4 tank and to the engine nacelle beneath it. Ignition was attributed to electrostatic discharge in the tank ullage.

Ref. RAE Technical Report 67080

4. 9/6/68, B-720, United, Cleveland, OH

While holding short of the active runway, the right wing was struck by the left wingtip and No. 1 propeller of a taxiing L-188. (See Appendix D, Accident No. 13)

Ref. AFS-54 1968 Summary, Pg. 23, and NTSB File No. 1-0056

5. 9/23/68, B-727, American, Springfield, IL

Following an inflight bomb threat, the aircraft was landed and taxied to an inactive runway and parked. Emergency evacuation procedures were instituted during which 5 passengers sustained fractures and 7 received minor injuries.

Ref. AFS-54 1968 Summary, Pg. 24

6. 2/2/69, B-707, Trans World, Chantilly, VA

The aircraft was parked in preparation to deplane passengers. A mobile lounge, arriving for the passengers, failed to stop and struck the front door area which received substantial damage. There was no fire.

Ref. AFS-54 1969 Summary, Pg. 4, and NTSB File No. 1-0003

7. 8/7/69, B-720, United, Philadelphia, PA

While the aircraft was parked unattended at the gate, a fire originated inside the aft lavatory from electrical overheating and/or arcing at the electric shaver outlet, spread up the walls of the lavatory to the interior cabin area over the ceiling, and gutted the interior. Fire department extinguished the fire with foam and water within about an hour.

Ref. ANA-420 Trip Report dated 8/14/69

8. 8/29/69, B-707, Trans World, Damascus, Syria

Because of a threat to blow up the aircraft, slides were used to evacuate the aircraft as soon as it stopped after landing. One passenger fractured a leg during the evacuation.

Ref. AFS-54 1969 Summary, Pg. 19

9. 3/2/70, B-720, United, Chicago, IL

On the third attempt to restart the No. 1 engine after being shutdown during a delay before takeoff, a fire started in the tailpipe section. Two engine fire extinguisher bottles were discharged without success. Evacuation was completed in about 50 seconds, using 2 slides and over-wing exits. The right forward and left rear slides were unusable. One passenger fractured an ankle when he slid off the wing to the pavement. The fire burned itself out as the evacuation was completed. Fire equipment arrived 4-5 minutes later.

Ref. AFS-54 1970 Summary, Pg. 3, and NTSB File No. 1-0024

10. 4/22/70, B-707, Trans World, Indianapolis, IN

The aircraft parked on the ramp caught on fire due to a capacitor failure in the cove light. The fire melted cabin formers and seat backs and completely gutted the interior. Fire equipment arrived on the scene one hour after start of the fire.

Ref. NTSB File No. 4-0024

11. 5/3/70, B-727-100, United, Minneapolis, MN

The aircraft was being refueled when, after 8 minutes, a low order explosion took place in No. 2 fuel tank. Fuel vapor and smoke were observed and internal tank damage resulted. Ignition was attributed to static discharge.

Ref. CRC Report No. 466, May 1974

12. 5/18/70, B-727, United, Chicago, IL

As the APU was started with the aircraft on the taxiway, dense smoke and fumes entered the cabin and the passengers were evacuated, half using the left main door slide and galley door slide, and half using the four overwing exits. One passenger jumped from the wing and broke his heel. There was no fire.

Ref. NTSB File No. 1-0036

13. 6/3/70, B-727, Eastern, Newark, NJ

The APU caught fire while boarding passengers and the extinguishing agent was discharged. The ground crew also used portable extinguishers. Fire department arrived about one minute after the alert. Passengers and crew evacuated via the forward main door. The top surface of the right wing near the APU exhaust and the exhaust door were damaged by the fire.

Ref. NTSB File No. 1-0015

14. 9/19/70, B-747, \_\_\_\_\_, Jamaica, NY

The No. 1 engine torched during starting and spread fuel and flames on the underside of the wing aft of the tail pipe. The torching extinguished itself and the aircraft was unloaded without incident.

Ref. NTSB File No. 4-0032

15. 10/27/70, B-747, Pan American, London, England

The aircraft was stopped on the taxiway after landing due to a fire warning on No. 2 engine. Passengers were evacuated, sustaining 8 minor injuries. Damage was isolated to No. 2 engine and was caused by an over-temperature condition.

Ref. NTSB File No. 4-0062

16. 12/23/70, B-727-100, Braniff, Minneapolis, MN

The aircraft was being refueled when, after 5 minutes, a low order explosion took place in No. 2 fuel tank. Extensive wing damage resulted.

Ref. CRC Report No. 466, May 1974

17. 12/31/70, B-737, United, Washington, DC

While servicing the oxygen system at the ramp, an explosion and fire occurred behind the service panel. The fire caused extensive damage to the cabin interior and was extinguished by the airport fire department.

Ref. NTSB File No. 4-0080

18. 5/7/71, B-737, Piedmont, Charlotte, NC

An engine over-heat warning occurred during starting and the captain ordered an emergency evacuation. Overwing window exits were used and a passenger was seriously injured in jumping off the wing.

Ref. AFS-54 1971 Summary, Pg. 5

19. 5/15/71, DC-8, United, San Francisco, CA

During starting, an air hose broke and flailed the aircraft, making enough noise that the crew ordered an evacuation. Six passengers were injured while jumping off the wing.

Ref. AFS-54 1971 Summary, Pg. 5

20. 6/29/71, B-747, Trans World, Paris, France

Occupants were evacuated via emergency chutes due to a bomb threat and 22 passengers were injured, one seriously.

Ref. AFS-54 1971 Summary, Pg. 8

21. 3/3/72, DC-8-61, United, Hilo, HI

No. 1 engine torched during starting, alarming a steward who ordered an emergency evacuation. Twenty-nine passengers used escape slides before the evacuation was halted. Seven passengers were injured during the evacuation, one seriously when she fell from the side of the chute. There was no fire.

Ref. AFS-54 1972 Summary, Pg. 4, and NTSB File No. 1-0024

22. 5/10/72, DC-9, Eastern, Atlanta, GA

Prior to boarding passengers, a fire due to an electrical short broke out behind the overhead coat rack area. The captain and F/O tried to extinguish the fire with CO<sub>2</sub>, but they were forced to leave because of heavy smoke. Airport fire equipment responded in about 3 minutes and extinguished the fire with water. The interior of the aircraft was destroyed.

Ref. NTSB File No. 1-0018

23. 5/23/72, B-707, Trans World, Jamaica, NY

During cargo loading, a small fire started in the aft lower baggage compartment which was caused by leaking phosphorous tribromide coming in contact with humiseal. The fire was extinguished by airport fire equipment. Several cartons and sacks of mail sustained water damage.

Ref. NTSB File No. 4-0013

24. 6/10/72, B-727, \_\_\_\_\_, New York, NY

A passenger requested oxygen while the aircraft was parked. As a stewardess opened the oxygen bottle regulator valve, there was an explosion and a flash of fire. The fire ignited the clothing of two stewardesses and the upholstery on one seat. The Captain extinguished the fire and assisted the stewardesses off the aircraft with the help of the Flight Engineer. All passengers deplaned via a plane-mate vehicle except 6 who needed special assistance.

Ref. NTSB File No. 1-0049

25. 6/21/73, DC-8-53, Air Canada, Toronto, Canada

About five minutes after pressure fueling began, a violent explosion occurred in the right wing No. 3 fuel tank which was followed by another explosion and a fire which engulfed and destroyed the aircraft. Two fueling personnel were seriously injured.

Ref. Unpublished CRC Report

26. 10/18/73, DC-8, Capitol International, Spokane, WA

A fire started under a fuel truck parked under the left wing just after fueling of the aircraft had been completed. The fire engulfed the truck and damaged the wing and both engines. Airport emergency units responded and extinguished the fire in about 3 minutes. The Captain received minor injuries when he fell down the main exit stairs while deplaning.

Ref. NTSB File No. 4-0023

27. 12/22/73, B-727, American, Detroit, MI

Two evacuation chutes were deployed with the aircraft on a ramp due to a bomb threat. One passenger sustained a serious injury during the evacuation.

Ref. AFS-54 1973 Summary, Pg. 17

28. 4/20/74, L-1011, Trans World, Boston, MA

While the aircraft was parked unattended at the gate, a fire originated at the center seat area of rows 23 and 24, spread through the entire cabin area, and almost completely consumed the cabin interior.

Ref. ANA-420 Trip Report dated 6/20/74

29. 11/21/74, DC-9, Eastern, Jamaica, NY

While holding for an intersection take-off, the aircraft was struck by a B-747 which sustained minor damage. The vertical stabilizer of the DC-9 was substantially damaged.

Ref. AFS-54 1974 Summary, Pg. 14

30. 11/26/74, B-747, Trans World, Rome, Italy

While holding for take-off clearance, smoke and sparks were emitted from a cove light, the evacuation signal was activated, and slides were deployed. Three passengers received serious injuries when the left overwing slide did not inflate. There was no fire.

Ref. AFS-54 1974 Summary, Pg. 15



