AD-A199 063

(1)

DTIC FILE COPY

DOT/FAA/CT-88/23

FAA Technical Center
Atlantic City International Airport
N.J. 08405

Statistics on Aircraft Gas Turbine Engine Rotor Failures that Occurred in U. S. Commercial Aviation During 1982

R.A. DeLucia
J.T. Salvino

Naval Air Propulsion Center
Trenton, New Jersey

July 1988

Final Report

U.S. Department of Transportation
Federal Aviation Administration

88 9 29 077

NOTICE

Technical Report Documentation Page

1. Report No.	2. Government Accession No.	3. Recipient's Catalog No.
DOT/FAA/CT-88/23		

4. Title and Subtitle	5. Report Date
STATISTICS ON AIRCRAFT GAS TURBINE ENGINE ROTOR FAILURES THAT OCCURRED IN U.S. COMMERCIAL AVIATION DURING 1982	July 1988
	6. Performing Organization Code: PF32
7. Author(s): R. A. Delucia and J. T. Salvino	8. Performing Organization Report No.: DOT/FAA/CT-88/23
9. Performing Organization Name and Address: Commanding Officer, Naval Air Propulsion Center, PO Box 7176, Trenton, NJ 08628-0176	10. Work Unit No. (TRAIS)
	11. Contract or Grant No.: DOT/FA71NA AP98
12. Sponsoring Agency Name and Address: Department of Transportation, Federal Aviation Administration, Technical Center, Atlantic City International Airport, NJ 08405	13. Type of Report and Period Covered: FINAL REPORT
	14. Sponsoring Agency Code: ACT-320

15. Supplementary Notes

PROJECT MANAGER: Bruce C. Fenton FAA Technical Center
Atlantic City International Airport, NJ 08405

16. Abstract

This report presents statistics relating to gas turbine engine rotor failures which occurred during 1982 in U. S. commercial aviation service use. One-hundred and sixty-one rotor failures occurred in 1982. Rotor fragments were generated in 88 of the failures and, of these, 16 were uncontained. The predominant failure involved blade fragments. Seven disk failures occurred and all were uncontained. Seventy percent of the 161 failures occurred during the takeoff and climb stages of flight.

This service data analysis is prepared on a calendar year basis and published yearly. The data support flight safety analysis, proposed regulatory actions, certification standards, and cost benefit analyses. Keywords,

17. Key Words	18. Distribution Statement
Air Transportation, Aircraft Hazards, Aircraft Safety, Gas Turbine Engine Rotor Failures, Containment.	This document is available to the U.S. Public through the National Technical Information Service, Springfield, Virginia 22161

19. Security Classif. (of this report)	20. Security Classif. (of this page)	21. No. of Pages	22. Price
Unclassified	Unclassified	30	

Form DOT F 1700.7 (8-72) Reproduction of completed page authorized

A

ACKNOWLEDGEMENTS

We thank the following Federal Aviation Administration personnel and offices for their cooperative effort in the preparation of this report:

- Mr. Bruce Fenton, Project Manager, Engine/Fuel Safety Branch, ACT-320, for his technical assistance.
- New England Region, Burlington, MA, for providing verification of the uncontained engine rotor failure occurrences during calendar year 1982.
- Flight Standards National Field Office, Oklahoma City, OK, for providing the basic data used to prepare this report.

TABLE OF CONTENTS

LIST OF ILLUSTRATIONS

EXECUTIVE SUMMARY

This service data analysis is prepared on a calendar year basis and published annually. The data support flight safety analyses, proposed regulatory actions, certification standards, and cost benefit analyses. The following statistics are based on gas turbine engine rotor failures that have occurred in United States commercial aviation during 1982. One hundred and sixty-one rotor failures occurred in 1982. These failures accounted for approximately 9.3 percent of the 1722 shutdowns experienced by the United States commercial fleet. Rotor fragments were generated in 88 of the failures and, of these, 16 were uncontained. This represents an uncontained failure rate of 2.1 per million gas turbine engine powered aircraft flight hours, or 1.3 per million engine operating hours. Approximately 7.6 and 20.8 million aircraft flight and engine operating hours, respectively, were logged in 1982.

Turbine rotor fragment-producing failures were approximately two times greater than that of the compressor rotor fragment-producing failures (60 and 26 respectively, of the total). Fan rotor failures accounted for two of the fragment-producing failures experienced.

Blade failures were generated in 78 of the rotor failures; 8 of these were uncontained. The remaining 10 fragment-generating failures were produced by disk, rim, and seal.

Of the 102 known causes of failures (because of the high percentage of unknown causes of rotor failures, the percentages were based on the total number of known causes), the causal factors were (1) foreign object damage--41 (40.2 percent); (2) secondary causes--39 (38.2 percent); (3) design and life prediction problems--21 (20.6 percent); and (4) operational--1 (1.0 percent). One-hundred and twelve (69.6 percent) of the 161 rotor failures occurred during the takeoff and climb stages of flight. Seventy-one (80.7 percent) of the 88 rotor fragment-producing failures and 14 (87.5 percent) of the 16 uncontained rotor failures occurred during these same stages of flight.

The incidence of engine rotor failures producing fragments has remained relatively constant when compared to 1981 (88 in 1982 and 84 in 1981). The uncontained engine rotor failures likewise has remained constant (16 in 1982 and 1981). Interestingly, the 8-year (1975 through 1982) average of uncontained engine rotor failures has also remained constant at 16.

INTRODUCTION

This report is sponsored by the Federal Aviation Administration (FAA), Technical Center, located at the Atlantic City International Airport, New Jersey.

This service data analysis is published yearly. The data support flight safety analyses, proposed regulatory actions, certification standards, and cost benefit analyses.

This report presents data on rotor failure occurrences in United States (U.S.) commercial aviation. Presented in this report are statistics on gas turbine engine failures that have occurred in U.S. commercial aviation during 1982. These statistics are based on data compiled from the Flight Standards Service Difficulty Reports that were published by the FAA. Cross-checks to other accident data sources, such as the FAA New England Region Directorate, were made to substantiate the nature of an engine failure incident (i.e., contained or uncontained). The compiled data were analyzed to establish:

1. The incidence of rotor failures and the incidence of contained and uncontained rotor fragments (an uncontained rotor failure is defined as a rotor failure that produces fragments which penetrate and escape the confines of the engine casing).

2. The distribution of rotor failures with respect to engine rotor components, i.e., fan, compressor, or turbine rotors and their rotating attachments or appendages such as spacers and seals.

3. The number of rotor failures according to engine model and engine fleet hours.

4. The type of rotor fragment (disk, rim, or blade) generated at failure.

5. The cause of failure.

6. The flight conditions at the time of failure.

7. Engine failure rate according to engine fleet hours.

RESULTS

The data used for analyses are contained in appendix A; the results of these analyses are shown in figures 1 through 9.

Figure 1 shows that 161 rotor failures occurred in 1982. These rotor failures accounted for approximately 9.3 percent of the 1722 shutdowns experienced by the U.S. commercial gas turbine powered aircraft fleet during 1982. Rotor fragments were generated in 88 of the failures experienced and, of these, 16 (18.2 percent of the fragment-producing failures) were uncontained. This represents an uncontained failure rate of 2.1 per million gas turbine engine powered aircraft flight hours, or 1.3 per million engine operating hours.

Approximately 7.6 million aircraft flight hours and 20.8 million engine operating hours were logged by the U.S. commercial aviation fleet in 1982. Gas turbine engine fleet operating hours relative to the number of rotor failures and type of engines in use are shown in figure 2.

Figure 3 shows the distribution of rotor failures that produced fragments according to the engine component involved (fan, compressor, turbine), the types of fragments that were generated, and the percentage of uncontained failures according to the type of fragment generated. These data indicate that:

1. The incidence of turbine rotor fragment-producing failures was approximately two times greater than that of the compressor rotor fragment-producing failures; these corresponded to 60 (68.2 percent) and 26 (29.5 percent), respectively, of the total number of rotor failures. Fan rotor failures accounted for two (2.3 percent) of the fragment-producing failures experienced.

2. Blade fragments were generated in 78 (88.6 percent) of the rotor failures; eight (10.3 percent) of these were uncontained. The remaining 10 (11.4 percent) rotor fragment failures were produced by disk, rim, and seal. While the disk and seal failures were a relatively small percentage of the total failures, all of the disk and seal failures were uncontained.

Figure 4 shows the rotor failure distribution among the engine models that were affected and the total number of models in use.

Figure 5 contains a compilation of engine failure rates per million engine flight hours according to engine model, engine type, and containment condition. The engine failure rates per million flight hours by engine type are turbofan--6.9, turboprop--12.1, turboshaft--58.8, and turbojet-none. Uncontained engine failure rates per million flight hours by engine type were turbofan--0.4, turboprop--2.4, and turboshaft--29.4.

Figure 6 shows what caused the rotor failures to occur. Of the 102 known causes of failure (because of the high percentage of unknown causes of rotor failure, the percentages were based on the total number of known causes), the causal factors were (1) foreign object damage--41 (40.2 percent); (2) secondary causes--39 (38.2 percent); (3) design and life prediction problems--21 (20.6 percent); and operational--1 (1.0 percent).

Figure 7 indicates the flight conditions that existed when the various rotor failures occurred. One-hundred and twelve (69.6 percent) of the 161 rotor failures occurred during the takeoff and climb stages of flight. Seventy-one (80.7 percent) of the rotor fragment-producing failures and 14 (87.5 percent) of the uncontained rotor failures occurred during these same stages of flight. The highest number of uncontained rotor failures, nine (56.3 percent), happened during takeoff.

Figure 8 is a cumulative tabulation that describes the distribution of uncontained rotor failures according to fragment type, engine component involved, cause category, and flight condition (takeoff and climb are defined as "high power," all other conditions are defined as "low power") for the years 1976 through 1982. This figure is expanded yearly to include all subsequent uncontained rotor failures. These data indicate that for "secondary causes" the number of uncontained failures was approximately six times greater at "high" power than "low" power (namely 24 and 4). For "design and life prediction problems" the number of "high" power uncontained failures was approximately three times greater than "low" power (namely 20 and 7); and for "foreign object damage," the number of uncontained failures was six times greater at "high" power than "low" power (namely 6 and 1). This tabulation also indicates that of the 111 total uncontained incidences, blade failures accounted for 72.1 percent; disks failures, 15.3 percent; rim failures, 6.3 percent; and seal/spacer failures, 6.3 percent.

Figure 9 shows the annual incidence of uncontained rotor failures in commercial aviation for the years 1962 through 1982. During 1982, the incidence of uncontained rotor failures (16) was identical to those reported the previous year, 1981. Over the past 7 years, 1976 through 1982, an average of 16 uncontained rotor failures per year have occurred. During the same time period, the rate of uncontained rotor failures has remained relatively constant at an average of approximately one per million engine operating hours.

DISCUSSION AND CONCLUSIONS

The incidence of engine rotor fragment-producing failures has remained relatively constant when compared to 1981 (88 in 1982 and 84 in 1981). The uncontained engine rotor failures, likewise, has remained constant (16 in 1982 and 16 in 1981). Interestingly, the 8-year (1975 through 1982) average of uncontained engine rotor failures has also remained constant at 16.

Of the 16 uncontained events that occurred during 1982, 12 (75.0 percent) involved turbine rotors, three (18.7 percent) involved compressor rotors, and one (6.3 percent) involved a fan rotor.

The predominant cause of failure was attributed to foreign object damage (40.2 percent of the known failures) although no uncontained failures occurred in this category. Secondary causes (38.2 percent of known failures) and design and life prediction problems (20.6 percent of the known causes) each had two uncontained failures. The causes of the remaining 12 uncountained failures (75.0 percent) are unknown.

Uncontained failures occurred in three of the 10 flight modes; i.e., nine during takeoff (56.3 percent), five during climb (31.2 percent), and two on approach (12.5 percent).

The higher incidences of uncontained rotor failures in calendar years 1967 through 1973 (except for 1968) were probably due to the introduction of newly developed engines entering the commercial aviation fleet, such as the JT9D and CF6 engines.

Structural life prediction and verification is being improved by the increased use of spin chamber testing by government and industry as a means of obtaining failure data for statistically significant samples. In addition, increased development and application of high sensitivity, nondestructive inspection methods should increase the probability of cracks being detected prior to failure. The capability to reduce the causes of failures from secondary effects is also being addressed through technology development programs. However, causes due to foreign object damage still appear to be beyond the control or scope of present technology.

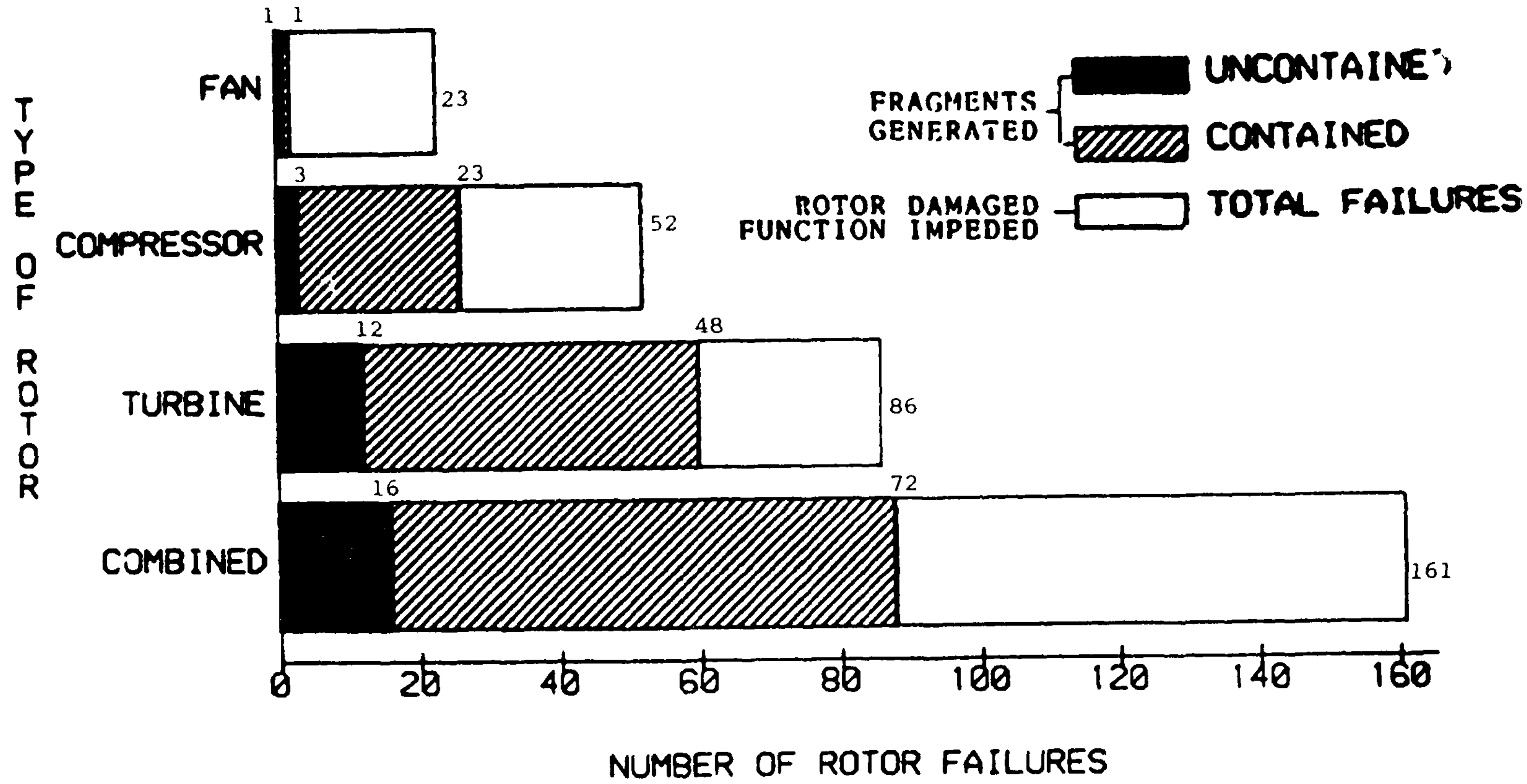


FIGURE 1. INCIDENCE OF ENGINE ROTOR FAILURES IN U.S. COMMERCIAL AVIATION - 1982

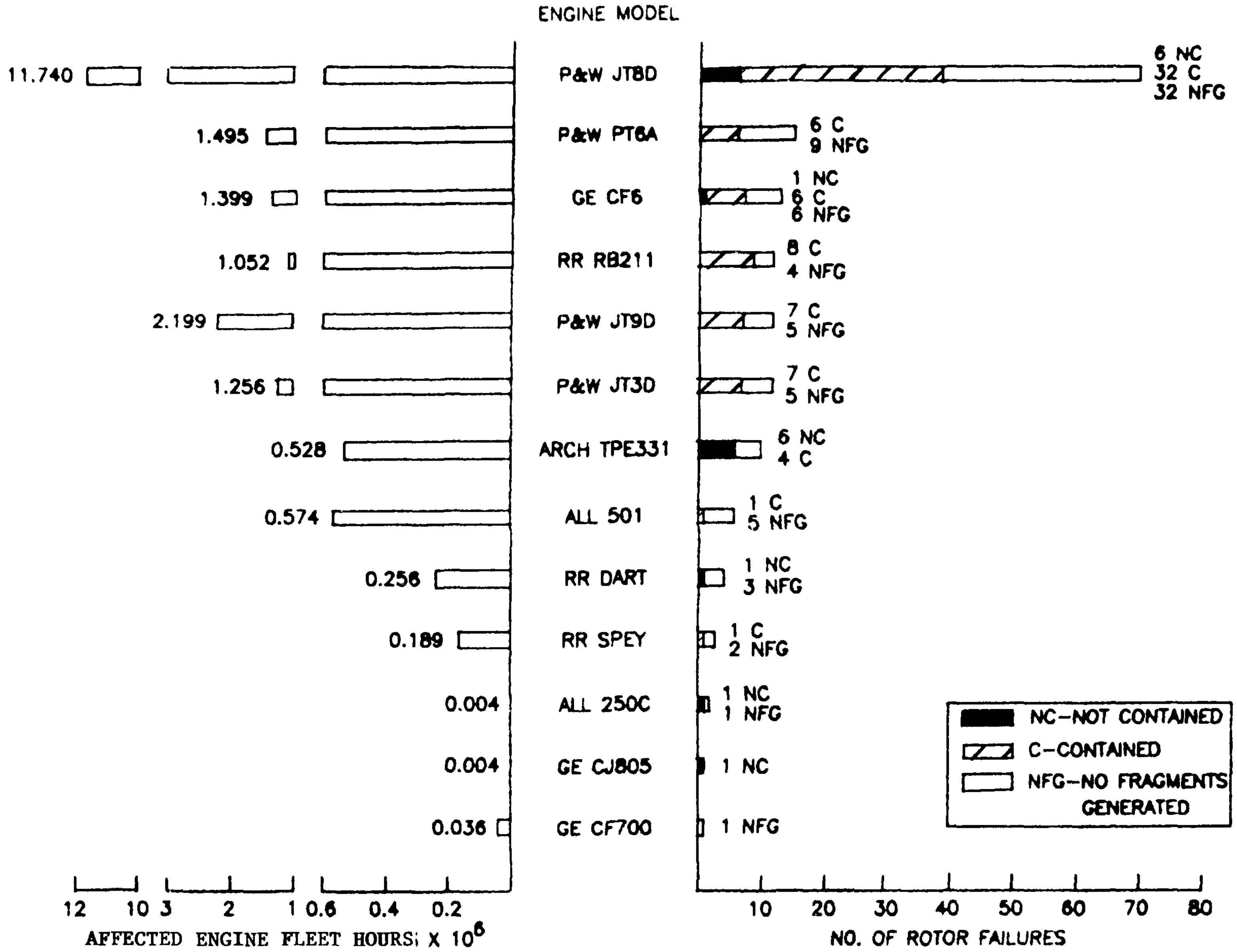


FIGURE 2. THE INCIDENCE OF ENGINE ROTOR FAILURES IN U.S. COMMERCIAL AVIATION ACCORDING TO AFFECTED ENGINE FLEET HOURS FOR EACH ENGINE MODEL - 1982

ENGINE ROTOR COMPONENT	TYPE OF FRAGMENT GENERATED									
	DISK		RIM		BLADE		SEAL		TOTAL	
	TF	UCF	TF	UCF	TF	UCF	TF	UCF	TF	UCF
FAN	0	0	0	0	2	1	0	0	2	1
COMPRESSOR	1	1	0	0	24	1	1	1	26	3
TURBINE	6	6	2	0	52	6	0	0	60	12
TOTAL	7	7	2	0	78	8	1	1	88	16

TF-TOTAL FAILURES
UCF-UNCONTAINED FAILURES

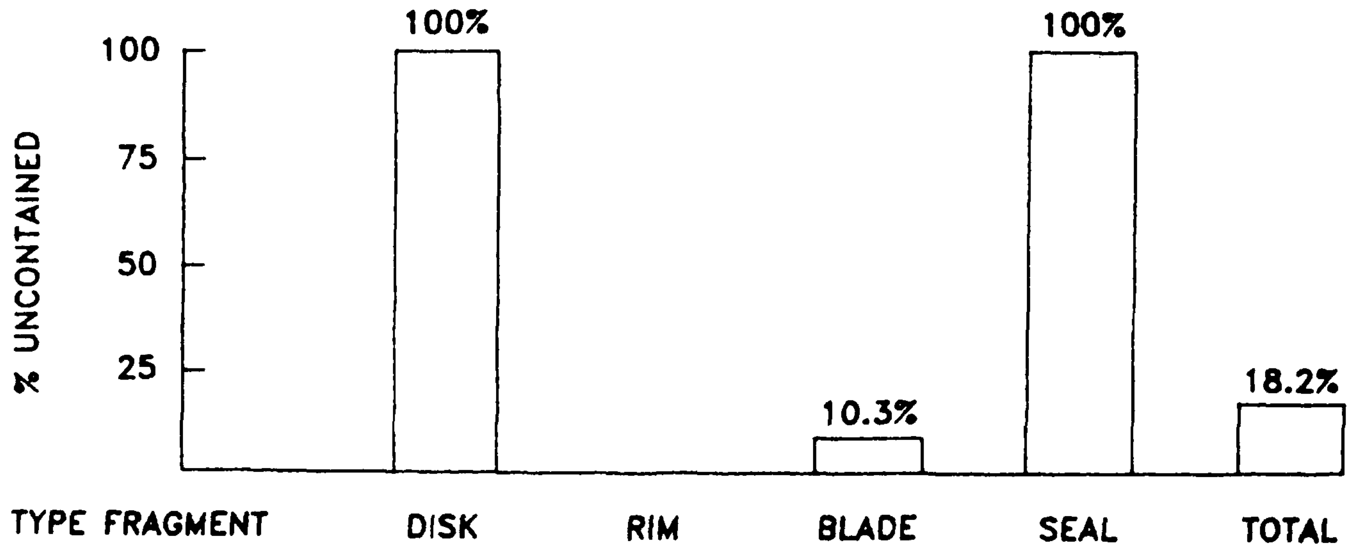
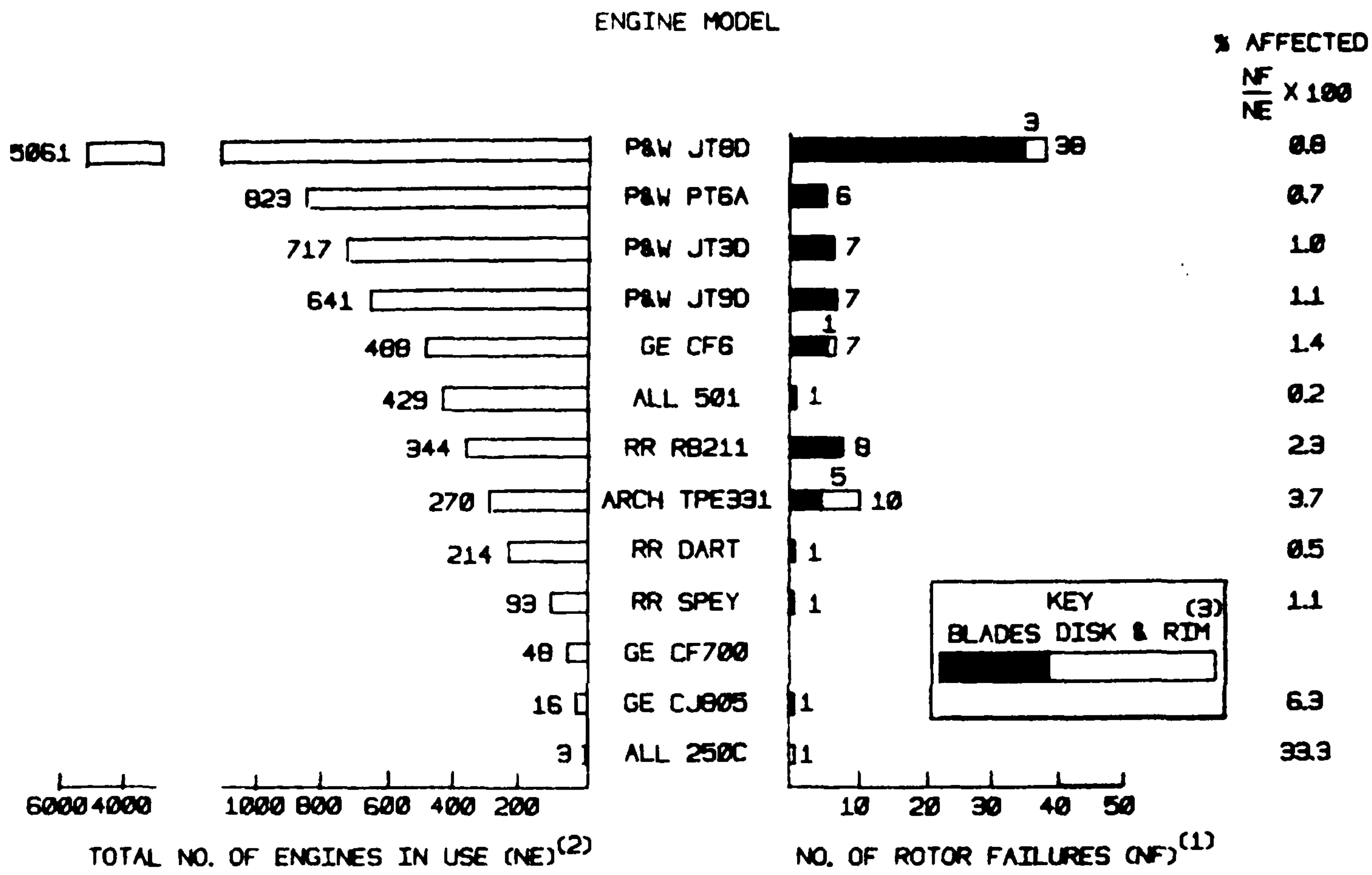


FIGURE 3. COMPONENT AND FRAGMENT TYPE DISTRIBUTIONS FOR CONTAINED AND UNCONTAINED ROTOR ENGINE FAILURES (FAILURES THAT PRODUCED FRAGMENTS) - 1982



NOTES:
(1) FAILURES THAT PRODUCED FRAGMENTS
(2) YEARLY AVG. OF AIRCRAFT IN USE AT END OF EACH MONTH
(3) SEAL/SPACER FAILURES INCLUDED IN DISK/RIM COMPILATION

FIGURE 4. THE INCIDENCE OF ENGINE ROTOR FAILURES IN U.S. COMMERCIAL AVIATION ACCORDING TO ENGINE TYPE AFFECTED - 1982

MODEL	AVG NO. IN USE	ENGINE FLIGHT HOURS	NO. OF FAILURES				FAILURE RATES PER 10^6 ENGINE FLIGHT HRS.			
		$X10^6$	C	NC	N	TOTAL	C	NC	N	TOTAL
TURBOFAN										
JT8D	5061	11.740	32	6	32	70	2.7	0.5	2.7	6.0
JT3D	717	1.256	7	0	5	12	5.6	0	4.0	9.6
JT9D	641	2.199	7	0	5	12	3.2	0	2.3	5.5
CF6	488	1.400	6	1	6	13	4.3	0.7	4.3	9.3
RB211	344	1.052	8	0	4	12	7.6	0	3.8	11.4
CF700	48	0.036	0	0	1	1	0	0	27.8	27.8
SPEY	93	0.189	1	0	2	3	5.3	0	10.6	15.9
JT15D	3	0.001	0	0	0	0	0	0	0	0
CFM56	30	0.064	0	0	0	0	0	0	0	0
CJ805	16	0.004	0	1	0	1	0	250.0	0	250.0
TOTAL	7441	17,941	61	8	55	123	3.4	0.4	3.1	6.9
TURBOPROP										
PT6A	823	1.495	6	0	9	15	4.0	0	6.0	10.0
501	429	0.574	1	0	5	6	1.7	0	8.7	10.5
TPE331	270	0.528	4	6	0	10	7.6	11.4	0	18.9
DART	214	0.256	0	1	3	4	0	3.9	11.7	15.6
BASTAN	15	0.018	0	0	0	0	0	0	0	0
250B	7	0.007	0	0	0	0	0	0	0	0
TYNE	15	0.025	0	0	0	0	0	0	0	0
TOTAL	1773	2.903	11	7	17	35	3.8	2.4	5.9	12.1
TURBOSHAFT										
AST14	15	0.025	0	0	0	0	0	0	0	0
250C	3	0.004	0	1	1	2	0	250.0	250.0	500
LTS101	5	0.005	0	0	0	0	0	0	0	0
TOTAL	23	0.034	0	1	1	2	0	29.4	29.4	58.8
TURBOJET										
JT4A	62	0.155	0	0	0	0	0	0	0	0
CJ610	8	0.003	0	0	0	0	0	0	0	0
AVON	5	0.002	0	0	0	0	0	0	0	0
TOTAL	75	0.160	0	0	0	0	0	0	0	0

C – CONTAINED NC – NOT CONTAINED N – FUNCTION IMPEDED NO FRAGMENTS GENERATED

FIGURE 5. GAS TURBINE ENGINE FAILURE RATES ACCORDING TO ENGINE MODEL AND TYPE – 1982

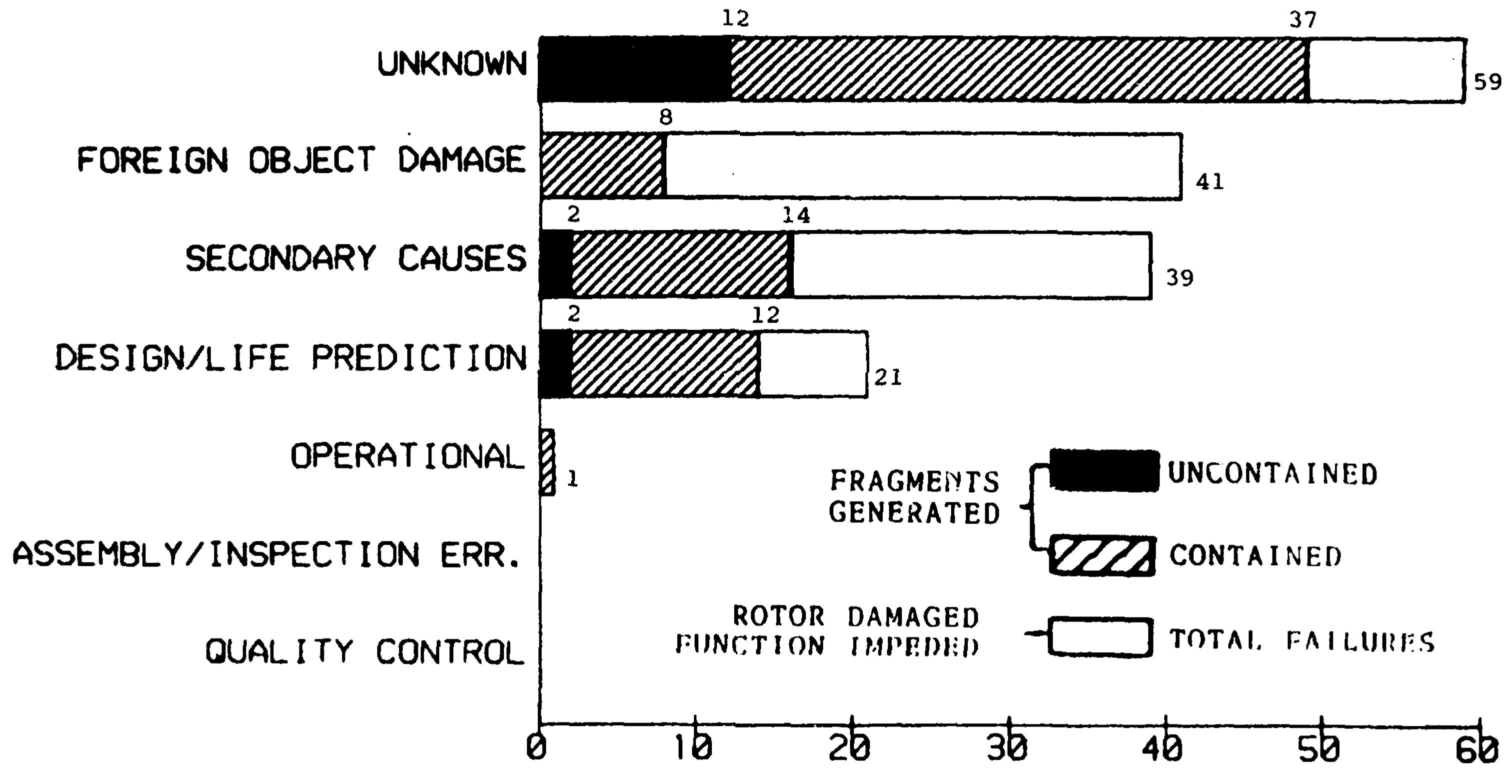


FIGURE 6. ENGINE ROTOR FAILURE CAUSE CATEGORIES - 1982

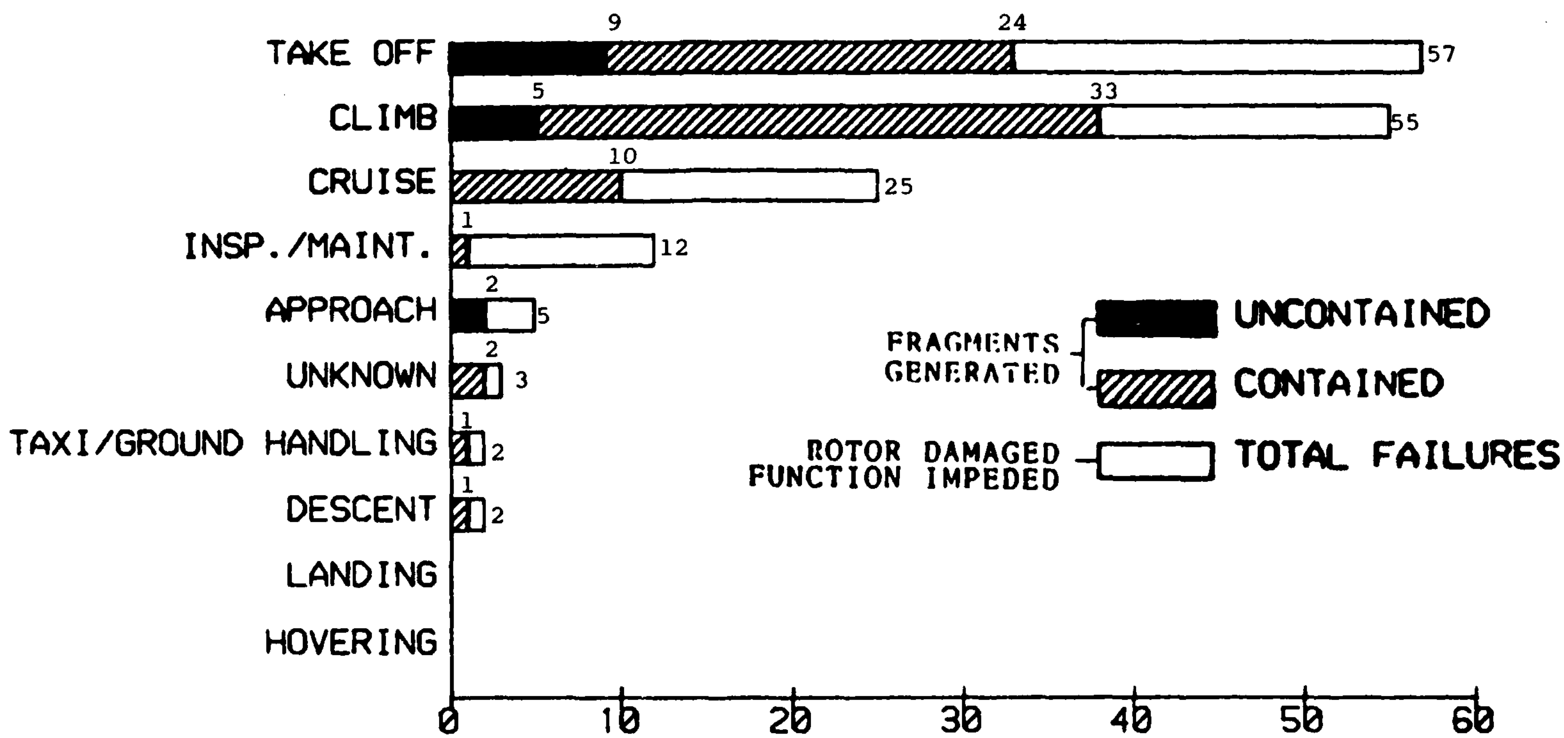


FIGURE 7. FLIGHT CONDITION AT ENGINE ROTOR FAILURE - 1982

TYPE OF FRAGMENT GENERATED	ENGINE ROTOR COMPONENT	DESIGN/LIFE PREDICTION PROBLEMS			SECONDARY CAUSES			FOREIGN OBJECT DAMAGE			QUALITY CONTROL			OPERATIONAL			ASSEMBLY/INSPECTION REPORTS			UNKNOWN			SUBTOTAL			TOTAL
(1) FLIGHT CONDITION		HI	LOW	UNK	HI	LOW	UNK	HI	LOW	UNK	HI	LOW	UNK	HI	LOW	UNK	HI	LOW	UNK	HI	LOW	UNK	HI	LOW	UNK	
DISK	FAN																									17
	COM.	4			1						1									1			7			
	TUR.		3					1												3	2	1	4	5	1	
RIM	FAN																									7
	COM.	2																		3	1		5	1		
	TUR.										1												1			
BLADE	FAN	7	1		3			5	1	2	2									3		1	20	2	3	80
	COM.	5			3	1														7	2		15	3		
	TUR.	1	3		15	3	1													7	5	2	23	11	3	
SEAL	FAN																									7
	COM.	1																		2	1		3	1		
	TUR.				2															1			3			
SUBTOTAL		20	7	0	24	4	1	6	1	2	4	0	0	0	0	0	0	0	0	27	11	4	81	23	7	111
TOTAL		27			29			9			4			0			0			42			111			

(1) TAKEOFF AND CLIMB ARE DEFINED AS "HIGH POWER" AND ALL OTHER CONDITIONS ARE DEFINED AS "LOW POWER."

FIGURE 8. UNCONTAINED ENGINE ROTOR FAILURE DISTRIBUTIONS ACCORDING TO CAUSE AND FLIGHT CONDITIONS - 1976 THROUGH 1982

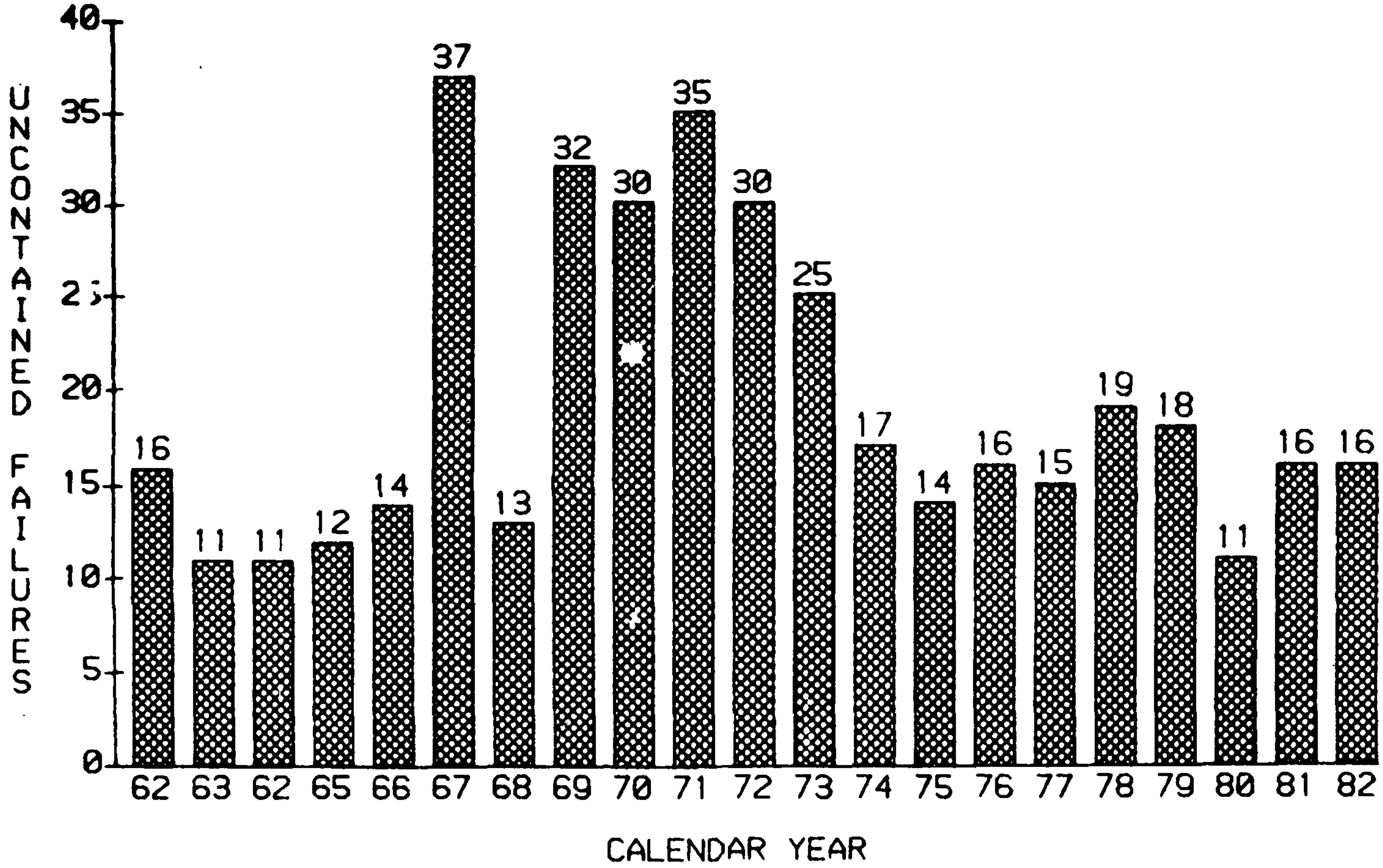


FIGURE 9. THE INCIDENCE OF UNCONTAINED ENGINE ROTOR FAILURES IN U.S. COMMERCIAL AVIATION - 1962 THROUGH 1982

APPENDIX A

Data of Engine Rotor Failures in U.S. Commercial Aviation for 1982. Compiled from the Federal Aviation Administration Service Difficulty Reports.

DATA COMPILATION KEY

Component Code:
- F - Fan
- C - Compressor
- T - Turbine

Fragment Type Code:
- D - Disk
- R - Rim
- B - Blade
- S - Seal
- N - None

Cause Code:
- 1 - Design and Life Prediction Problems
- 2 - Secondary Causes
- 3 - Foreign Object Damage
- 4 - Quality Control
- 5 - Operational
- 6 - Assembly and Inspection Error
- 7 - Unknown

Containment Condition Code:
- C - Contained
- NC - Not Contained
- N - No Fragments Generated

Flight Condition Code:
- 1 - Insp/Maint
- 2 - Taxi/Grnd Hdl
- 3 - Takeoff
- 4 - Climb
- 5 - Cruise
- 6 - Descent
- 7 - Approach
- 8 - Landing
- 9 - Hovering
- 10 - Unknown

CHARACTERISTICS OF ROTOR FAILURES - 1982

SDR NO.	SUBMITTER	AIRCRAFT	ENGINE	COMPONENT	FRAGMENT TYPE	CAUSE	CONTAINMENT CONDITION	FLIGHT CONDITION
01252036	AKBA	DC9	JT8D	C	B	3	C	3*
02082039	TWAA	B727	JT8D	C	B	3	C	4
02102035	AALA	B727	JT8D	F	B	7	C	4
02162037	SWAA	B737	JT8D	T	B	2	C	3
03012037	USAA	B727	JT8D	C	B	2	C	3
03012038	NWAA	B727	JT8D	C	B	2	C	4
03042035	PAAA	B727	JT8D	C	D	2	NC	3
04222031	UALA	B737	JT8D	T	B	1	C	3
05142021	AALA	B727	JT8D	T	B	7	C	4
05072024	BNFA	B727	JT8D	C	B	3	C	4
05182015	USAA	DC9	JT8D	T	B	7	NC	4
05202021	USAA	B727	JT8D	T	B	1	C	3
05252027	TXIA	DC9	JT8D	T	B	7	C	3
05262030	HALA	DC9	JT8D	T	R	7	C	5
06012030	PAIA	B737	JT8D	T	B	2	C	5
06022001	MIDA	DC9	JT8D	T	B	2	C	3
06032029	USAA	DC9	JT8D	T	B	1	C	4
06182029	TXIA	DC9	JT8D	C	B	3	C	5
06282026	TWAA	B727	JT8D	T	B	1	C	4
07012025	WALA	B727	JT8D	T	B	2	C	4
07262033	AKBA	DC9	JT8D	T	B	7	C	3
07282032	HALA	DC9	JT8D	C	B	3	C	4
07292023	OZAA	DC9	JT8D	T	B	2	C	4
08252038	USAA	DC9	JT8D	T	B	7	C	4
09032026	ISAA	B727	JT8D	C	S	7	NC	3
09082027	REPA	DC9	JT8D	T	B	7	C	3
09012028	USAA	DC9	JT8D	T	B	7	C	3
09172023	USAA	DC9	JT8D	C	B	3	C	3
10272034	USAA	DC9	JT8D	T	B	7	C	4
11032026	USAA	DC9	JT8D	T	B	7	NC	3
11032027	USAA	DC9	JT8D	T	B	7	NC	3
12022028	HALA	DC9	JT8D	C	B	3	C	3
12012085	USAA	DC9	JT8D	T	B	7	C	3
01063002	SWAA	B737	JT8D	T	B	2	C	3
01043023	USAA	DC9	JT8D	T	B	7	C	3
01043025	UALA	B737	JT8D	T	B	2	C	4
01063001	EALA	B727	JT8D	F	B	1	NC	3
09202030	PEXA	B737	JT8D	T	-	7	-	3
01292038	JAMA	DC9	JT8D	F	-	3	-	1
02032034	TAGA	B727	JT8D	F	-	3	-	1
02162036	TWAA	B727	JT8D	F	-	3	-	3
03012040	TAGA	B727	JT8D	F	-	3	-	6
03042034	UALA	B737	JT8D	F	-	3	-	4
03122033	TWAA	B727	JT8D	F	-	3	-	4
04062030	AFLA	B737	JT8D	T	-	7	-	5

* 2 engines affected, same aircraft

CHARACTERISTICS OF ROTOR FAILURES - 1982

SDR NO.	SUBMITTER	AIRCRAFT	ENGINE	COMPONENT	FRAGMENT TYPE	CAUSE	CONTAINMENT CONDITION	FLIGHT CONDITION
04092032	UALA	B727	JT8D	C	-	2	-	3
04212032	BNFA	B727	JT8D	T	-	2	-	3
04222030	ACLA	B737	JT8D	F	-	3	-	3
06032030	ACLA	B737	JT8D	F	-	3	-	7
06282027	PSAA	DC9	JT8D	T	-	1	-	4
08062036	SWAA	B737	JT8D	T	-	2	-	5
07302035	PAIA	B727	JT8D	T	-	7	-	4
08232028	OZAA	DC9	JT8D	F	-	3	-	4
08312028	PAIA	B737	JT8D	F	-	3	-	3
11022024	WALA	B737	JT8D	F	-	1	-	1
11122025	JAMA	DC9	JT8D	F	-	3	-	1
11302020	SWAA	B737	JT8D	C	-	3	-	3
12142029	REPA	DC9	JT8D	C	-	3	-	3
12142030	REPA	DC9	JT8D	C	-	3	-	3
01043024	OZAA	DC9	JT8D	T	-	2	-	5
02023020	AALA	B727	JT8D	C	-	1	-	1
03032036	EALA	DC9	JT8D	C	-	3	-	5
08062036	SWAA	B737	JT8D	T	-	2	-	5
11102014	USAA	DC9	JT8D	C	-	3	-	3
02232024	OZAA	DC9	JT8D	F	-	3	-	3
07272030	PAAA	B727	JT8D	F	-	3	-	3
10152024	PAIA	B727	JT8D	F	-	3	-	5
09202032	JAMA	DC9	JT8D	C	-	3	-	1
02083023	AALA	B727	JT8D	T	-	7	-	4
07192036	TWAA	B747	JT9D	C	B	7	C	3
08262037	NWAA	B747	JT9D	C	B	7	C	4
08272030	NWAA	DC10	JT9D	T	B	7	C	4
09022025	NWAA	DC10	JT9D	T	B	7	C	3
10182020	FTLA	B747	JT9D	T	B	2	C	3
10272033	NWAA	DC10	JT9D	T	B	1	C	4
02112036	PAAA	B747	JT9D	C	B	7	C	5
02262035	NWAA	B747	JT9D	C	-	2	-	3
05252028	TWAA	B747	JT9D	F	-	2	-	4
08242028	FTLA	B747	JT9D	T	-	2	-	5
09142024	NWAA	B747	JT9D	T	-	2	-	4
12022027	NWAA	B747	JT9D	T	-	2	-	4
11152024	UACA	DC8	JT3D	C	B	7	C	3
09242009	TWAA	B707	JT3D	C	B	7	C	4
09162029	DALA	DC8	JT3D	T	B	7	C	4
03082031	TWAA	B707	JT3D	T	B	7	C	4
01053012	TWAA	B707	JT3D	T	B	7	C	10
06282025	TWAA	B707	JT3C	T	B	1	C	4
08122027	UALA	DC8	JT3D	F	-	3	-	3
08122030	CAPA	DC8	JT3D	C	-	7	-	7
09292019	UACA	DC8	JT3D	T	-	7	-	10
01053012	TWAA	B707	JT3D	T	-	7	-	4
09282019	UACA	DC8	JT3D	T	-	1	-	1
10082011	DALA	DC8	JT3D	T	B	7	C	5

CHARACTERISTICS OF ROTOR FAILURES - 1982

SDR NO.	SUBMITTER	AIRCRAFT	ENGINE	COMPONENT	FRAGMENT TYPE	CAUSE	CONTAINMENT CONDITION	FLIGHT CONDITION
04142034	RIOA	DHC6	PT6A	T	B	7	C	5
09142037	MTRA	DHC6	PT6A	C	B	7	C	3
09142038	MTRA	DHC6	PT6A	C	B	7	C	4
01193072	RANA	N262	PT6A	T	B	7	C	4
10222040	PREA	DHC6	PT6A	T	B	7	C	4
06282035	CCDA	99A	PT6A	T	B	7	C	6
03042050	MVAA	99	PT6A	T	-	7	-	3
08052048	CICA	STCG73	PT6A	T	-	2	-	5
10292031	RMAA	DHC7102	PT6A	T	-	2	-	5
03102039	PCAA	N262	PT6A	T	-	2	-	2
03112032	PCAA	N262	PT6A	C	-	3	-	1
03302033	MTR	SD3-30	PT6A	T	-	2	-	5
08272029	CAIT	SD3-30	PT6A	C	-	3	-	7
10132013	AWAA	DC7	PT6A	C	-	2	-	5
11122021	RMAA	DC7	PT6A	C	-	3	-	4
03042033	AALA	DC10	CF6	T	B	7	C	4
07292022	PAAA	DC10	CF6	T	B	7	C	4
08272026	EALA	DCI0	CF6	T	R	7	C	4
08272031	EALA	DC10	CF6	T	B	5	C	4
12212026	WALA	DC10	CF6	C	B	2	NC	3
02023018	PAAA	DC10	CF6	T	B	7	C	5
04282023	PAAA	DC10	CF6	T	B	7	C	4
06222014	WALA	DC10	CF6	T	-	1	-	3
09082026	WRLA	DC10	CF6	C	-	2	-	3
09282008	WRLA	DC10	CF6	F	-	3	-	3
10192025	WALA	DC10	CF6	C	-	1	-	1
12212024	WRLA	DC10	CF6	F	-	3	-	3
12062025	WRLA	DC10	CF6	C	-	7	-	3
10012026	FDEA	MD20	CF700	C	-	3	-	4
01142036	CAAA	22	CJ805	T	B	7	NC	4
04012046	SUNA	SA226	TPE331	T	B	1	NC	4
04142036	BRIA	SA226	TPE331	T	D	7	NC	4
11262029	SWIA	SA226	TPE331	T	B	7	C	3
06032066	AMWA	SA226	TPE331	T	D	7	NC	3
10132091	AMWA	SA226	TPE331	T	B	7	C	4
11262029	SWOA	SA226	TPE331	T	D	7	NC	3
03082036	AMWA	SA226	TPE331	T	B	1	C	3
07092061	AMWA	SA226	TPE331	T	D	7	NC	3
01192041	SUNA	SA226	TPE331	T	D	7	NC	4
01272035	BRTA	SA226	TPE331	T	B	7	C	4
02102038	EALA	L1011	RB211	C	B	1	C	5
02222040	TWAA	L1011	RB211	T	B	1	C	5
03152033	TWAA	L1011	RB211	C	B	1	C	10
06012034	EALA	L1011	RB211	T	B	1	C	4
06212030	TWAA	L1011	RB211	T	B	2	C	5
07082024	TWAA	L1011	RB211	C	B	2	C	4
08102029	EALA	L1011	RB211	C	B	2	C	4
09072031	TWAA	L1011	RB211	C	B	2	C	1

CHARACTERISTICS OF ROTOR FAILURES - 1982

SDR NO.	SUBMITTER	AIRCRAFT	ENGINE	COMPONENT	FRAGMENT TYPE	CAUSE	CONTAINMENT CONDITION	FLIGHT CONDITION
02102037	EALA	L1011	RB211	F	-	3	-	3
02112038	TWAA	L1011	RB211	C	-	3	-	5
04232022	TWAA	L1011	RB211	F	-	3	-	4
07302037	TWAA	L1011	RB211	C	-	2	-	4
02122038	USAA	BAC1-11	506	C	B	1	C	3
04192031	PEAA	BAC1-11	506	C	-	2	-	3
08052035	PEAA	BAC1-11	506	C	-	3	-	3
04282025	RAAA	YS-11A	542	T	B	7	NC	7
07092007	ABXA	YS-11A	542	C	-	2	-	5
07282031	MPCA	YS-11A	542	T	-	2	-	4
02023015	ACZA	F27	532	T	-	1	-	1
01073023	REPA	CV580	501	T	B	7	C	2
01253032	ASPA	STCAP	501	C	-	2	-	4
07062031	ZIAA	188C	501	T	-	2	-	5
10262025	TIAA	382	501	C	-	3	-	3
10212020	TIAA	382	501	C	-	3	-	4
01063003	SRAA	382	501	T	-	7	-	5
05212025	SFAA	206L1	250C28	T	D	7	NC	7
07142125	ALGA	206L1	250C28	T	-	2	-	1

APPENDIX B

DISTRIBUTION LIST

Civil Aviation Authority (5)
Aviation House
129 Kingsway
London WC2B 6NN
ENGLAND

DOT/FAA Eastern Region (3)
AEA-61
JFK International Airport
Fitzgerald Federal Building
Jamaica, NY 11430

Embassy of Australia
Civil Air Attache
1601 Massachusetts Avenue, NW.
Washington, DC 20036

DOT/FAA National Headquarters
ADL-32
800 Independence Avenue, SW.
Washington, DC 20591

Scientific and Technical Information FAC
ATTN: NASA Representative
P.O. Box 8757 BWI Airport
Baltimore, MD 21240

DOT/FAA National Headquarters
AES-3
800 Independence Avenue, SW.
Washington, DC 20591

Northwestern University
Trisnet Repository
Transporation Center Library
Evanston, IL 60201

DOT/FAA Northwest Mountain Region (2)
ANM-60
17900 Pacific Highway South
C-68966
Seattle, WA 98168

DOT/Federal Aviation Administration (5)
AEU-500
American Embassy
APO New York, NY 09667

DOT/FAA Technical Center (2)
Technical Library, ACT-65A
Atlantic City Int'l Airport, NJ 08405

University of California
Service Department Institute of
Transportaion Standard Lab
412 McLaughlin Hall
Berkeley, CA 94720

DOT/FAA Alaskan Region (2)
AAL-400
701 C Street, Box 14
Anchorage, AK 99513

British Embassy
Civil Air Attache ATS
3100 Massachusetts Avenue, NW.
Washington, DC 20008

Department of Transportation (5)
Office of the Secretary
M-493.2, Building 10A
400 7th Street, SW.
Washington, DC 20590

DOT/FAA Southern Region (2)
ASO-52C4
P.O. Box 20636
Atlanta, GA 30320

DOT/FAA National Headquarters
APM-1
800 Independence Avenue, SW.
Washington, DC 20591

DOT/FAA National Headquarters (2)
APS-13, Nigro
800 Independence Avenue, SW.
Washington, DC 20591

DOT/FAA National Headquarters
APA-300
800 Independence Avenue, SW.
Washington, DC 20591

DOT/FAA Great Lakes Region (2)
AGL-60
O'Hare Office Center
2300 East Devon Avenue
Des Plaines, IL 60018

DOT/FAA Southwest Region (2)
ASW-53B
P.O. Box 1689
Fort Worth, TX 76101

DOT/FAA Mike Monroney Aeronautical Center (2)
AAC-64D
P.O. Box 25082
Oklahoma City, OK 73125

DOT/FAA Central Region (2)
ACE-66
601 East 12th Street
Federal Building
Kansas City, MO 64106

DOT/FAA National Headquarters
ADL-1
800 Independence Avenue, SW.
Washington, DC 20591

DOT/FAA National Headquarters
ALG-300
800 Independence Avenue, SW.
Washington, DC 20591

DOT/FAA Technical Center
Public Affairs Staff, ACT-5
Atlantic City Int'l Airport, NJ 08405

DOT/FAA National Headquarters
ASF-1
800 Independence Avenue, SW.
Washington, DC 20591

DOT/FAA National Headquarters
ASF-100
800 Independence Avenue, SW.
Washington, DC 20591

DOT/FAA National Headquarters
ASF-200
800 Independence Avenue, SW.
Washington, DC 20591

DOT/FAA National Headquarters
ASF-300
800 Independence Avenue, SW.
Washington, DC 20591

DOT/FAA National Headquarters
AST-1
800 Independence Avenue, SW.
Washington, DC 20591

DOT/FAA National Headquarters
ADL-2A
800 Independence Avenue, SW.
Washington, DC 20591

DOT/FAA National Headquarters (4)
AVS-1, 100, 200, 300
800 Independence Avenue, SW.
Washington, DC 20591

DOT/FAA National Headquarters
AFS-1
800 Independence Avenue, SW.
Washington, DC 20591

DOT/FAA National Headquarters
AFS-200
800 Independence Avenue, SW.
Washington, DC 20591

DOT/FAA National Headquarters
AWS-1,
800 Independence Avenue, SW.
Washington, DC 20591

DOT/FAA National Headquarters
AWS-100
800 Independence Avenue, SW.
Washington, DC 20591

DOT/FAA National Headquarters
AWS-120
800 Independence Avenue, SW.
Washington, DC 20591

DOT/FAA National Headquarters
APO-1
800 Independence Avenue, SW.
Washington, DC 20591

DOT/FAA National Headquarters
APO-200
800 Independence Avenue, SW.
Washington, DC 20591

DOT/FAA Great Lakes Region
Mr. R. Prather, ACE-140C
O'Hare Office Center
2300 East Devon Avenue
Des Plaines, IL 60018

DOT/FAA Great Lakes Region
ACE-140
O'Hare Office Center
2300 East Devon Avenue
Des Plaines, IL 60018

DOT/FAA Great Lakes Region
AGL-200
O'Hare Office Center
2300 East Devon Avenue
Des Plaines, IL 60018

DOT/FAA Central Region
ACE-100
601 East 12th Street
Federal Building
Kansas City, MO 64106

DOT/FAA Central Region
Mr. Oscar Ball, ACE-100
601 East 12th Street
Federal Building
Kansas City, MO 64106

DOT/FAA Central Region
ACE-200
601 East 12th Street
Federal Building
Kansas City, MO 64106

DOT/FAA Eastern Region
AEA-200
JFK International Airport
Fitzgerald Federal Building
Jamaica, NY 11430

DOT/FAA New England Region
ANE-100
12 New England Executive Park
Burlington, MA 01803

DOT/FAA New England Region
ANE-110
12 New England Executive Park
Burlington, MA 01803

DOT/FAA New England Region
ANE-140
12 New England Executive Park
Burlington, MA 01803

DOT/FAA New England Region
ANE-141
12 New England Executive Park
Burlington, MA 01803

DOT/FAA New England Region
ANE-142
12 New England Executive Park
Burlington, MA 01803

DOT/FAA Northwest Mountain Region
ANM-100
17900 Pacific Highway South
C-68966
Seattle, WA 98168

DOT/FAA Northwest Mountain Region
ANM-110
17900 Pacific Highway South
C-68966
Seattle, WA 98168

DOT/FAA Northwest Mountain Region
ANM-200
17900 Pacific Highway South
C-68966
Seattle, WA 98168

DOT/FAA Southern Region
ASO-200
P.O. Box 20636
Atlanta, GA 30320

DOT/FAA Southwest Region
ASW-100
P.O. Box 1689
Fort Worth, TX 76101

DOT/FAA Southwest Region
ASW-110
P.O. Box 1689
Fort Worth, TX 76101

DOT/FAA Southwest Region
M. Mathias, ASW-111
P.O. Box 1689
Fort Worth, TX 76101

DOT/FAA Southwest Region
ASW-200
P.O. Box 1689
Fort Worth, TX 76101

Federal Aviation Administration
Chief, Civil Aviation Assistance Group
Madrid, Spain
c/o American Embassy
APO New York 09285-0001

Mr. A. R. Tobiason
ATA of America
1709 New York Avenue, NW.
Washington, DC 20006

Federal Aviation Administration
Anchorage ACO
701 C Street, Box 14
Anchorage, AK 99513

Federal Aviation Administration
Atlanta ACO
1075 Inner Loop Road
College Park, GA 30337

Federal Aviation Administration
Boston ACO
12 New England Executive Park
Burlington, MA 01803

Federal Aviation Administration
Brussels ACO
c/o American Embassy
APO
New York, NY 09667

Federal Aviation Administration
Chicago ACO
Room 232
2300 East Devon Avenue
Des Plaines, IL 60018

Federal Aviation Administration
Denver ACO
10455 East 25th Avenue
Suite 307
Aurora, CO 98168

Mr. Frank Taylor
3542 Church Road
Ellicott City, MD 21043

Federal Aviation Administration
Mr. Al Astorga, CAAG
American Embassy
Box 38
APO New York 09285-0001

DOT Transportation Safety Institute
Mr. Burton Chesterfield, DMA-603
6500 South MacArthur Boulevard
Oklahoma City, OK 73125

Federal Aviation Administration
Fort Worth ACO
P.O. Box 1689
Fort Worth, TX 76101

Federal Aviation Administration
Long Beach ACO
ANM-140L
4344 Donald Douglas Drive
Long Beach, CA 90808

Federal Aviation Administration
Los Angeles ACO
P.O. Box 92007
Worldway Postal Center
Hawthorne, CA 90009

Federal Aviation Administration
New York ACO
Room 202
181 South Franklin Avenue
Valley Stream, NY 11581

Federal Aviation Administration
Seattle ACO
17900 Pacific Highway South
C-68966
Seattle, WA 98168

Federal Aviation Administration
Wichita ACO, Mid Continent Airport
FAA Building, Room 100
1891 Airport Road
Wichita, KS 67209

Mr. A. Allcock
Department of Industry
Abell House, Room 643
John Islip Street, London, SW14 LN
ENGLAND

Dr. S. J. Armour
Defense Research Establishment
Suffield
Ralston, Alberta
CANADA, TOJ 2NO

Captain Ralph Cantrell
University of Bridgeport
U.S. Army ROTC Department
Bridgeport, CT 06601

Mr. George A. Coffinberry
General Electric Company
1 Neumann Way
Mail Drop E-186
Cincinnati, OH 45215

Mr. J. Donald Collier
Air Transport Association
of America
1709 New York Avenue, NW.
Washington, DC 20006

Captain Ralph Combariati
Port Authority of NY and NJ
JFK International Airport
Jamaica, NY 11430

Mr. Edward Conklin
Sikorsky Aircraft
North Main Street
Stratford, CT 06602

Mr. Dick Coykendall
United Airlines
San Francisco International
Airport
San Francisco, CA 94128

Mr. David M. Blake
General Electric Company
Aircraft Engine Field Operations
1515 Market Street
Philadelphia, PA 19102

Mr. Terence Dixon
Boeing Aerospace Corporation
P.O. Box 3999
M/S 8J-93
Seattle, WA 98124

Mr. Thomas F. Donohue
General Electric Company
1 Neumann Way, Mail Drop H-44
P.O. Box 156301
Cincinnati, OH 45215-6301

Mr. John H. Enders
Flight Safety Foundation
5510 Columbia Pike
Arlington, VA 22204

Dr. Allen E. Fuhs
Department of Aeronautics
Naval Post Graduate School
Monterey, CA 93940

Y. Funatsu
All Nippon Airways
1-6-6, Tokyo International Airport
Ohta-KU, Tokyo 144
JAPAN

Henry A. Gill
Lockheed California Company
Building 88, B-6
P.O. Box 551
Burbank, CA 91520

Mr. David J. Goldsmith
Eastern Airlines
Miami International Airport
Miami, FL 33148

Mr. Stanley Gray
Mechanical Technology Inc.
968 Albany Shaker Road
Latham, NY 12110

G. Haigh
Air Canada
Air Canada Base, Montreal
International Airport
Quebec, CANADA H4Y 1 C2

M. Hardy
United Airlines
SFOEG, MOC
San Francisco International Airport
California 94128

W. Hock
Grumman Aerospace Corporation
B 14 035
111 Stewart Avenue
Bethpage, NY 11714

LCDR William Holland
Department of the Navy
NAVAIR 518
Naval Air Systems Command
Washington, DC 20361

Major Hudson
Air Force Inspection and Safety
SEDM
Norton Air Force Base, CA 92499

Mr. J. P. Jamieson
National Gas Turbine Establishment
Pyestock, Farnborough
Hants GU14 OLS
ENGLAND

Dr. C. W. Kauffman
The University of Michigan
Gas Dynamics Laboratories
Aerospace Engineering Building
Ann Arbor, MI 48109

FAA National Headquarters
Mr. H. Branting, AWS-120
800 Independence Avenue, SW.
Washington, DC 20591

Mr. Richard J. Linn
American Airlines
MD 4H14
P.O. Box 61616
Dallas/Fort Worth Airport, TX 75261

Captain A. S. Mattox, Jr.
Allied Pilots Association
12723 Brewster Circle
Woodbridge, VA 22191

Mr. Charles McGuire
Department of Transportation
400 7th Street, SW. (P-5)
Washington, DC 20590

Harold Marthinsen
Airline Pilots Association
Accident Investigation Department
P.O. Box 1169
Herndon, VA 22070

Dean Oliva
Lockheed
Department 7475/Building 229A
P.O. Box 551, Plant 2
Burbank, CA 91520

Dr. Robert C. Oliver
Institute for Defense Analyses
1801 North Bauregard Street
Alexandria, VA 22311

Mr. George Opdyke
AVCO Lycoming Division
550 South Main Street
Stratford, CT 06497

Dr. Robert H. Page
Texas A&M University
College of Engineering
College Station, TX 77884

Mr. Roy E. Pardue
Lockheed/Georgia Company
86 South Cubb Drive
Marietta, GA 30063

Mr. Tom Peacock
Douglas Aircraft Company
3855 Lakewood Boulevard
Longbeach, CA 90846

Mr. William Rodenbaugh
General Electric Company
Manager, Operational Planning
1000 Western Avenue
Lynn, MA 01910

C. C. Randall, P.E.
Lockheed Georgia Company
D72-47 Zone 418
Marietta, GA 30063

M. Rippen
Pratt and Whitney Aircraft
Government Products Division
P.O. Box 2691
West Palm Beach, FL 33402

E. T. Roockey
Northrop Corporation
Aircraft Division
One Northrop Avenue
Hawthorne, CA 90250

Professor Valentinas Sernas
Rutgers University
College of Engineering
P.O. Box 909
Piscataway, NJ 08854

S. Sokolsky
Aerospace Corporation
P.O. Box 91957
Los Angeles, CA 90009

Dr. Warren C. Strahle
Georgia Institute of Technology
School of Aerospace Engineering
Atlanta, GA 30332

Mr. Dick Stutz
Sikorsky Aircraft
Engineering Department
Stratford, CT 06602

Mr. A. F. Taylor
Cranfield Institute of Technology
Cranfield, Bedford, MK 43 OAL
ENGLAND

Mr. Fred Grenich
Boeing Military Airplane Company
P.O. Box 3707
M/S 4152
Seattle, WA 98124

M. Trimble
Delta Airlines
DEAT 568
Atlanta International Airport
Atlanta, GA 30320

Mr. T. Ted Tsue
Boeing Aerospace Company
P.O. Box 3999
M/S 45-07
Seattle, WA 98124

Trans World Airlines, Inc.
Kansas City International Airport
2-290
P.O. Box 20126
Kansas City, MO 64195

Mr. Ed Versaw
Lockheed/California Company
P.O. Box 551
Burbank, CA 91520

Mr. John White
National Transportation
Safety Board
800 Independence Avenue, SW.
Washington, DC 20594

Dr. S. P. Wilford
Royal Aircraft Establishment
Farnborough, Hants
GU146TD
ENGLAND

R. E. Zalesky
Lockheed California Company
P.O. Box 551
Burbank, CA 91520

Dr. Robert F. Abernethy
Pratt and Whitney Government Products
MS 711-33
Box 2691
West Palm Beach, FL 33408

Mr. James N. Bagnall
Hamilton Standard Division
United Technologies Corporation
Bradley Field Road, M/S 1A-3-6
Windsor Locks, CT 06096

Director of Engineering
Air Transport Association
1709 New York Avenue, NW.
Washington, DC 20006

H. R. Bankhead
Department of the Air Force
AFWAL/POTP
Wright-Patterson Air Force Base
Dayton, OH 45433-6563

J. A. DeMarche
Commercial Products Division
UTC Pratt and Whitney Aircraft
Engineering Building 163-12
East Hartford, CT 06108

Mr. Rudy Schwartz
Rolls-Royce Inc.
1201 Pennsylvania Avenue
Suite 230
Washington, DC 20004

Mr. Robert L. Ivan
Chief, Propulsion Division, ASD ENFP
Department of the Air Force
Wright-Patterson Air Force Base
Dayton, OH 45433

Mr. Michael D. Mead
Senior Engineer
Naval Air Systems Command
AIR 5360D
Washington, DC 20361

E. W. Walacavage, AIA Propulsion Comm.
Garrett Turbine Engine Company
111 South 34th Street
P.O. Box 5217
Phoenix, AZ 85010

J. P. Frignac, MS 503-3B
Garrett Turbine Engine Company
111 South 34th Street
P.O. Box 5217
Phoenix, AZ 85010

Mr. Daniel R. Gerard
Flight Support Directorate
Airbus Industries, Headquarters BP #33
Blagnac
FRANCE 31700

Mr. Allen E. Heyson
Aircraft Engine Group
General Electric Company
Mail Drop E-65
Cincinnati, OH 45215

Mahlon R. Hoover
Manager, Prop & Mech Syst, M/S 6F-25
Boeing Commercial Airplane Company
P.O. Box 3707
Seattle, WA 98124

Mr. George Bianchini
Allison Gas Turbine Division
General Motors Corporation
P.O. Box 420
Indianapolis, IN 46206-0420

Mr. Harry L. Lemasters
Structures Technology, MS 163-09
Pratt and Whitney Aircraft
400 Main Street
East Hartford, CT 06108

Mr. J. Fresco
Societe Turbomeca
Siege Social, Bureaux et Usine
Bordes, Bizanos
FRANCE 64320

Mr. Ronald G. Jackson
Product Support
Rolls-Royce, Inc.
1895 Phoenix Boulevard
Altanta, GA 30349

Mr. Kenneth M. Johnson, Jr.
Williamsport Division
Avco Lycoming
652 Oliver Street
Williamsport, PA 17701

Mr. Alan J. Lea, 01MD4
Pratt and Whitney Canada, Inc.
P.O. Box 10
Longueuil, Quebec J4K4X9
CANADA

Mr. Martyn Hexter
Pratt and Whitney Canada, Inc.
90 Dundas Street West
Mississauga, Ontario L5A 3Q4
CANADA

Mr. Richard Ainsworth
Stratford Division
Avco Lycoming
550 South Main Street
Stratford, CT 06497

Mr. John T. Moehring
General Electric Company
Flight Safety Section, Mail Drop J60
One Neuman Way
Cincinnati, OH 45215

Mr. Glenn Pittard
Garrett Turbine Engine Company
111 South 34th Street
P.O. Box 5217
Phoenix, AZ 85010

Mr. A. B. Wassell
Rolls-Royce Ltd.
P.O. Box 31
Derby DE2 8BJ
ENGLAND

Mr. T. Dickey
Stratford Division
Avco Lycoming
550 South Main Street
Stratford, CT 06497

Dr. John R. Fagan, M.S. T15
Allison Gas Turbine Division
General Motors Corporation
P.O. Box 420
Indianapolis, IN 46210-0420

Mr. Brad Stumpke
Mail Drop 34511
General Electric Company
1000 Western Avenue
Lynn, MA 01910

Mr. Richard Barnard
Sikorsky Aircraft Division
United Technologies Corporation
North Main Street
Stratford, CT 06602

Mr. Chet Lewis
Boeing Commerical Airplane Company
Mail Stop 9W-61
P.O. Box 3707
Seattle, WA 98124

Mr. Frank M. Shallene
Bell Helicopter Textron
P.O. Box 482
Fort Worth, TX 76101

Mr. Peter Dahm
Helicopter and Transport Division
Messerschmitt-Bolkon-Blohm GMBH
P.O. Box 801140 DX2, 8000 Munich 80
FEDERAL REPUBLIC OF GERNAMY

Mr. James B. Harbison
Boeing Vertol Company
MS 32-17
P.O. Box 16858
Philadelphia, PA 19142

Mr. Richard H. Johnson
Department E80, MC 36-41
Douglas Aircraft
3855 Lakewood Boulevard
Long Beach, CA 90846

Mr. John M. Kowalonek
Sikorsky Aircraft Division
United Technologies Corporation
North Main Street
Stratford, CT 06602

Dr. Kenneth M. Rosen
Sikorsky Aircraft Division
United Technologies Corporation
North Main Street
Stratford, CT 06601

Mr. Emmett A. Witmer
Aassachusetts Institute
of Technology
Cambridge, MA 02139

Mr. P. B. Gardner
Industrial Ceramics Division
Norton Company
One New Bond Street
Worcester, MA 01606

Mr. Jack A. Mitteer
Product Support
McDonnell Douglas Helicopter Company
5000 East McDowell Road
Mesa, AZ 85205

Captain Edwin R. Arbon
Flight Operations Safety
Flight Safety Foundation, Inc.
5510 Columbia Pike
Arlington, VA 22204-3194

Mr. Donald F. Thielke
Vice President, Safety Engineering
Flight Engineers' International Assoc.
905 16th Street, NW.
Washington, DC 20006

Mr. Barry Scott
P.O. Box 25
Moffett Field, CA 94035

Mr. A. T. Weaver, M.S. 165-30
Pratt and Whitney Aircraft
Airworthiness Engineering Division
400 Main Street
East Hartford, CT 06108

Mr. Steve Clark
Rolls-Royce Inc.
1895 Phoenix Boulevard
Atlanta, GA 30349

Mr. William Burcham
Propulsion Branch, Code OFV
NASA Ames - Dryden
P.O. Box 273
Edwards, CA 93523

Mr. Ralph E. Kesler
Delta Air Lines, Inc.
Hartsfield Atlanta International
Airport
Atlanta, GA 30320

Commander
Naval Air Systems Command
AIR-330
Department of the Navy
Washington, DC 20361

Commander
Naval Air Systems Command
AIR-330A
Department of the Navy
Washington, DC 20361

Commander
Naval Air Systems Command
AIR-5017A
Department of the Navy
Washington, DC 20361

Commander
Naval Air Systems Command
AIR-536
Department of the Navy
Washington, DC 20361

Commander
Naval Air Systems Command
AIR-5360
Department of the Navy
Washington, DC 20361

Commander
Naval Air Systems Command
AIR-5361
Department of the Navy
Washington, DC 20361

Commander
Naval Air Systems Command
AIR-5362
Department of the Navy
Washington, DC 20361

Commander
Naval Air Systems Command
AIR-530
Department of the Navy
Washington, DC 20361

Commanding Officer (15)
Naval Air Propulsion Center
PE32
P.O. Box 7176
Trenton, NJ 08628

Commanding Officer
Naval Air Engineering Center
Lakehurst, NJ 08733

Commanding Officer
Naval Air Development Center
Warminster, PA 18974

Commander
Naval Safety Center
Naval Air Station
Norfolk, VA 23511

Director
Applied Technology Laboratory
Army Research and Technology Laboratories
Fort Eustis, VA 23604

Commanding General
U.S. Army Aviation Systems Command
AMSAV-ERP
12th and Spruce Streets
St. Louis, MO 63166

Commander
Air Force Aero Propulsion Laboratory
AFSC
Wright-Patterson Air Force Base
Dayton, OH 45433

Defense Technical Information Center
Building Number 5
Cameron Station
Alexandria, VA 22314

National Aeronautics and Space Administration
NHS-22/Library
Washington, DC 20546

NASA S&T Information Facility
ATTN: Acquisition Division
P.O. Box 8757
Washington Internat'l Airport, MD 21240

NASA Lewis Research Center
Technology Utilization Office
21000 Brookpark Road
Cleveland, OH 44135

NASA Lewis Research Center
AFSC Liaison Office
21000 Brookpark Road
Cleveland, OH 44135

NASA Lewis Research Center
Library
21000 Brookpark Road
Cleveland, OH 44135

NASA Lewis Research Center
C. C. Chanis
21000 Brookpark Road
Cleveland, OH 44135

NASA Lewis Research Center
R. H. Johns
21000 Brookpark Road
Cleveland, OH 44135

United Airlines, Inc.
ATTN: J. D. Smith
VP, Flight Safety and Industry Affairs
P.O. Box 66100
Chicago, IL 60666

Pratt and Whitney Aircraft
Division of United Technologies Corp.
ATTN: Technical Library
400 Main Street
East Hartford, CT 06108

Canadian Air Transportation Admin.
ATTN: D. R. Hemming
No. 3 Temp. Building
Wellington Street, Ottawa, Ontario
CANADA

Rolls-Royce Limited
ATTN: S. Cox, Bristol Engine Division
P.O. Box 3 Filton House
Bristol BS12 7QE
ENGLAND

Civil Aviation Authority
ATTN: L. R. Wilson
Brabazon House
Redhill, Surrey
ENGLAND

Northrop Corporation
Aircraft Division
3901 West Broadway
Hawthorne, CA 90250

Hawker Siddley Aircraft
ATTN: Technical Library
Hawsidair, Hatfield
ENGLAND

Pan American World Airways
Pan American Building
ATTN: Mr. John G. Borger
Chief Engineer
New York, NY 10017

Ministry of Defense
W. J. Moschini, Engines T1, Room 151
St. Giles Court 1-13
St. Giles High St., London WC2H 8LD
ENGLAND

North American Rockwell Corporation
Aerospace and Systems Group
ATTN: Technical Library
6633 Canoga Avenue
Canoga Park, CA 91304

Bristol Siddeley Engines, Ltd.
Aero Division
ATTN: Mr. Geoffrey Morris
Filton Bristol
ENGLAND

British Aircraft Corporation, Ltd.
GPO Box 77, Filton House
ATTN: J. Wallin, Chief Prop. Engineer
Bristol BS99 7AR
ENGLAND

Director
Naval Research Laboratory
ATTN: Library, Code 2029 (ONRL)
Washington, DC 20390

DOT/Federal Aviation Adminstration
Mike Monroney Aeronautical Center
AFS-581
P.O. Box 25082
Oklahoma City, OK 73125

Office of Naval Research
ATTN: N. Basdekas
Washington, DC 20360

DOT/Federal Aviation Adminstration
Mike Monroney Aeronautical Center
AFS-580
P.O. Box 25082
Oklahoma City, OK 73125

Commander
Naval Air Systems Command
AIR-954
Department of the Navy
Washington, DC 20361

National Transportation Safety Board
Bureau of Aviation Safety
Engineering Division
ATTN: Mr. Martyn V. Clarke, Asst Chief
Washington, DC 20591

NASA Langley Research Center
ATTN: Library
Langley Station
Hampton, VA 23365

British Aerospace PLC
ATTN: M. A. Laceby, Civil Aircraft Div
GPO Box 77, Filton House
Bristol BS99 7AR
ENGLAND

The Boeing Company
Commercial Airplane Group
ATTN: Technical Library
Seattle, WA 98124

Avco Corporation
Lycoming Division
ATTN: Technical Library
550 Main Street
Stratford, CT 06497

GM Corporation
Allison Division
ATTN: Technical Library
340 White Rover Parkway
Indianapolis, IN 46296

GM Corporation
Manufacturing Division
Materials and Structures Laboratory
ATTN: Technical Library
Warren, MI 48090

Goodyear Aerospace Corporation
Aero-Structures Marketing
ATTN: Technical Library
Akron, OH 44305

Goodyear Aerospace Corporation
Arizona Division
ATTN: Technical Library
Litchfield Park, AZ 85340

Lockheed California Company
Division of Lockheed Aircraft
Corporation
ATTN: Technical Library
Burbank, CA 91503

Massachusetts Institute of Technology
ATTN: Aero Library
Aeroelastic and Structures Research Lab
Cambridge, MA 02139

University of Notre Dame
ATTN: L. H. N. Lee
Department of Aeromechanical
Engineering
Notre Dame, IN 46556

The Pennsylvania State University
ATTN: B. W. McCormick
Department of Aerospace Egnineering
233 Hammond
University Park, PA 16802

Battelle Memorial Institute
Columbus Laboratory
ATTN: Technical Library
505 King Avenue
Columbus, OH 43201

Beech Aircraft Corporation
ATTN: Technical Library
9709 East Central
Wichita, KS 67201

Aeronautical Research Association
of Princeton
ATTN: Technical Library
50 Washington Road
Princeton, NJ 08540

Garrett Turbine Engine Company
ATTN: Technical Library
402 South 36th Street
Phoenix, AZ 85034

University of West Virginia
ATTN: Technical Library
College of Engineering
Morgantown, WV 26505

Garrett Turbine Engine Company
ATTN: K. K. Sorenson
Starters and Air Turbine Motors
402 South 36th Street
Phoenix, AZ 85034

Garrett Turbine Engine Company
ATTN: D. G. Furst
Auxiliary Power Units
402 South 36th Street
Phoenix, AZ 85034

Garrett Turbine Engine Company
ATTN: Mr. Alvin R. Finklestein
Department 93-7, Adv. Prop. Eng.
402 South 36th Street
Phoenix, AZ 85034

Marquardt Corporation
ATTN: Technical Library
16555 Saticoy Street
Van Nuys, CA 91405

Commanding Officer
U. S. Army Aviation Material Lab
Fort Eustis, VA 23604

ASD (ASQ/ASNNY-QJ)
C-5A Propulsion and Power Division
ATTN: Mr. Phillip H. Evans
Wright-Patterson Air Force Base
Dayton, OH 45433

U.S. Army Materials Technology Lab
ATTN: Mr. Kenneth Abbott
Chief Engineer, Materials Branch
Watertown, MA 02172-0001

Cornell Aeronautical Lab, Inc.
ATTN: Dr. Norman S. Eiss, Jr.
Research Mechanical Manager
Applied Physics Department
Buffalo, NY 14221

U.S. Army Materials Technology Lab
ATTN: Mr. John DeLuca, SLCMT-MEC
Chief Engineer, Materials Branch
Watertown, MA 02172-0001

Air Force Flight Dynamics Laboratory
ATTN: R. M. Bader, FDTR
Wright-Patterson Air Force Base
Dayton, OH 45433

Hamilton Standard, Division of UACC
ATTN: Mr. Gerry Moltar
Mechanical Mettalurgist Technical
Staff, Testing and Analysis
Windsor Locks, CT 06096

General Electric Company
CF6 Engine Structures & Contain. Design
ATTN: J. G. Simon
Aircraft Engineering Group
Cincinnati, OH 45215

General Electric Company
Structures Design
ATTN: Technical Library
Cincinnati, OH 45215

Lockheed California Company
L1011 Structures
ATTN: Mr. Warren Stauffer
Building 90
Burbank, CA 91503

Pratt and Whitney Aircraft
of Canada, Ltd.
ATTN: Technical Library
P.O. Box 186
Highgate Springs, VT 05460

General Electric Company
Commercial Jet Engine Operation
GE Containment Program
ATTN: Mr. Gordon Oxx, Metallurgist
Cincinnati, OH 45215

Republic Steel Corporation
Special Metals Division
ATTN: Technical Library
410 Oberlin Avenue, SW.
Massillon, OH 44646

General Electric Company
SAED Advanced Applicaitons
1000 Western Avenue
ATTN: Mr. W. A. Harris, Manager
West Lynn, MA 09105

Safety Research Information Service
Research Depart., Nat'l Safety Council
ATTN: Ms. Therese A. Quirk
425 North Michigan Avenue
Chicago, IL 60611

Cornell Aeronautical Lab, Inc.
Applied Physics Department
ATTN: Paul Rosenthal
Head Engineer
Buffalo, NY 14221

Sandia Corporation
ATTN: Information Dist. Division
Albuquerque, NM 87115

Southwest Research Institute
ATTN: Technical Library
8500 Culebra Road
San Antonio, TX 87206

Office of Naval Research
Branch Office
P.O. Box 39
FPO, NY 09510

Douglas Aircraft Company
3855 Lakewood Boulevard
ATTN: Technical Library
MC 36-84
Long Beach, CA 90846

General Electric Company
1000 Western Avenue
ATTN: Technical Library
West Lynn, MA 09105

Hamilton Standard
Division of United Aircraft Corporation
ATTN: Technical Library
Windsor Locks, CT 06096

Director
Applied Technology Laboratory
U.S. Army Air Mobility R&D Lab
SAVDL-EU-TAP
Fort Eustis, VA 23604

Commanding General
U.S. Army Aviation Systems Command
AMSAV-ERD
12th and Spruce Streets
St. Louis, MO 83166

North American Rockwell Corporation
Aerospace and Systems Group
ATTN: Technical Library
6633 Canoga Avenue
Canoga Park, CA 91304

National Gas Turbine Establishment
ATTN: Materials Department
Pyestock, Farnsborough
Hants
ENGLAND

U.S. Nuclear Regulatory Commission
ATTN: Mr. Ross Chappell
Transportation Branch
Bethesda, MD 20555

Picatinny Arsenal
ATTN: Allen M. Shibley
Specialist
Plastics Technical Evaluation Center
Dover, NJ 07801

DOT/Federal Aviation Administration
Mike Monroney Aeronautical Center
Mr. Dale Crawford, AFS-500
P.O. Box 25082
Oklahoma City, OK 73125

Rolls-Royce (1971) Limited
ATTN: D. J. S. Lancaster
Bristol Engineering Division
P.O. Box 3, Filton, Bristol BS12 7QE
ENGLAND

Bendix Corporation
Utica Division
ATTN: Technical Library
211 Steward Avenue
Utica, NY 13503

Texas A&M University
ATTN: Technical Library
Department of Aerospace Engineering
College Station, TX 77843

Boston University College of Engineering
ATTN: Technical Library
11C Cummington Street
Boston, MA 02215

The City College of the University of New York
ATTN: S. B. Menkes
Department of Mechanical Engineering
New York, NY 10031

NASA Lewis Research Center
MS 500-302
21000 Brookpark Road
Cleveland, OH 44135

Air Force Systems Command
Structures Division
Design Criteria Branch (Code FDTE)
Wright-Patterson Air Force Base
Dayton, OH 45433

NASA, Office of Advanced Research
and Technology

800 Independence Avenue
Washington, DC 20546

Canadair Ltd.
ATTN: W. P. Ewanchyna
P.O. Box 6087, Station A
Montreal, Quebec H3C3G9
CANADA

DOT/FAA National Headquarters
Mr. Tom Horeff, AWS-120
800 Independence Avenue, SW.
Washington, DC 20591

Director DuCentre Exp DE LA
Navigation Aerineene
941 Orly, France

Mr. Gale Braden (FAA)
5928 Queenston St.
Springfield, VA 22152

Dr. Hans A. Krakauer
Deputy Chairman, International Airline
Pilots Association Group
Apartado 97
8200 Albufeira, Portugal

Geoffery Lipman, Executive Director
President du Conseil
In'l Found. of Airline Pass Assoc.
Case Postale 462, 1215 Geneve
15 Aeroport, Suisse, Geneva

Richard E. Livingston, Jr.
Director, Aerotech Operations for
the IAPA Group
1805 Crystal Drive, Suite 1112 South
Arlington, VA 22202

*U.S. GOVERNMENT PRINTING OFFICE: 1988--505-068/80123