NAVAL AIR PROPULSION CENTER

TRENTON, NEW JERSEY 08628

NAPC-PE-23
NASA-CR-165388

ROTOR FRAGMENT PROTECTION PROGRAM: STATISTICS ON AIRCRAFT GAS TURBINE ENGINE ROTOR FAILURES THAT OCCURRED IN U. S. COMMERCIAL AVIATION DURING 1978

By R. A. DELUCIA & J. T. SALVINO

APPROVED FOR PUBLIC RELEASE: DISTRIBUTION UNLIMITED

UNCLASSIFIED

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

REPORT DOCUMENTATION PAGE

READ INSTRUCTIONS BEFORE COMPLETING FORM

1. REPORT NUMBER	
2. GOVT ACCESSION NO.	
3. RECIPIENT'S CATALOG NUMBER	
4. TITLE (and Subtitle)	ROTOR FRAGMENT PROTECTION PROGRAM: STATISTICS ON AIRCRAFT GAS TURBINE ENGINE ROTOR FAILURES THAT OCCURRED IN U. S. COMMERCIAL AVIATION DURING 1978
5. TYPE OF REPORT & PERIOD COVERED	Final Report, 1977 - 1978
6. PERFORMING ORG. REPORT NUMBER	NAPC-PE-23
7. AUTHOR(s)	R. A. DeLucia and J. T. Salvino
8. CONTRACT OR GRANT NUMBER(s)	NASA DPR C-41581-B, Mod. 10
9. PERFORMING ORGANIZATION NAME AND ADDRESS	Commanding Officer Naval Air Propulsion Center (PE42) Trenton, New Jersey 08628
10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS	None
11. CONTROLLING OFFICE NAME AND ADDRESS	National Aeronautics and Space Administration Lewis Research Center Cleveland, Ohio 44135
12. REPORT DATE	September 1981
13. NUMBER OF PAGES	
14. MONITORING AGENCY NAME & ADDRESS (if different from Controlling Office)	
15. SECURITY CLASS. (of this report)	UNCLASSIFIED
15a. DECLASSIFICATION/DOWNGRADING SCHEDULE	

16. DISTRIBUTION STATEMENT (of this Report)

APPROVED FOR PUBLIC RELEASE: DISTRIBUTION UNLIMITED

17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)

18. SUPPLEMENTARY NOTES

"Structures and Mechanical Technologies Division, Lewis Research Center, Cleveland, Ohio 44135, Advisor, C. C. Chamis
Other report designation: NASA-CR-165388."

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

Air Transportation
Aircraft Hazards
Aircraft Safety
Gas Turbine Engine Rotor Failures

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

This report presents statistical information relating to the number of gas turbine engine rotor failures which occurred during 1978 in commercial aviation service use. The predominant failure involved blade fragments, 82.4 percent of which were contained. Although fewer rotor rim, disk and seal failures occurred, 33.3%, 100% and 50% respectively were uncontained. Sixty-five percent of the 166 rotor failures occurred during the takeoff and climb stages of flight.

DD FORM 1 JAN 73 1473 EDITION OF 1 NOV 65 IS OBSOLETE
S/N 0102-014-6601

UNCLASSIFIED

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

NAVAL AIR PROPULSION CENTER

TRENTON, NEW JERSEY 08628

PROPULSION TECHNOLOGY AND PROJECT ENGINEERING DEPARTMENT

NAPC-PE-23
NASA-CR-

ROTOR FRAGMENT PROTECTION PROGRAM: STATISTICS ON AIRCRAFT GAS TURBINE ENGINE ROTOR FAILURES THAT OCCURRED IN U. S. COMMERCIAL AVIATION DURING 1978

Prepared by: R. A. DeLucia
R. A. DELUCIA

J. T. Salvino
J. T. SALVINO

Approved by: T. E. Elsasser
T. E. ELSASSER

APPROVED FOR PUBLIC RELEASE:
DISTRIBUTION UNLIMITED

AUTHORIZATION: NASA DPR C-41581-B, MOD. 10

N82-70343#

ACKNOWLEDGEMENTS

We thank the Flight Standards National Field Office, Federal Aviation Administration, Oklahoma City, Oklahoma, for their cooperative effort in providing the basic data used for this report.

TABLE OF CONTENTS

LIST OF FIGURES

INTRODUCTION

This report has been prepared as part of the Rotor Fragment Protection Program (RFPP), which is sponsored by the National Aeronautics and Space Administration (NASA)[1] and conducted by the Naval Air Propulsion Center (NAPC). The objective of the RFPP is to develop criteria for the design of devices that will be used on aircraft to protect occupants and the aircraft structure from the potentially lethal and devastating fragments that are generated by gas turbine engine rotor failures.

Presented in this report are statistics on gas turbine rotor failures that have occurred in U. S. commercial aviation during 1978. These statistics are based on data compiled from the Flight Standards Service Difficulty Reports (SDRs) that were published by the Department of Transportation, Federal Aviation Administration (FAA). The compiled data were analyzed to establish:

1. The incidence of rotor failures and the incidence of contained and uncontained[2] rotor fragments.

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

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

4. The cause of failure.

5. The type of engines involved.

6. The flight condition at the time of failure.

RESULTS

1. The data used for analysis are contained in APPENDIX A. The results of these analyses are shown in Figures 1 through 7.

a. Figure 1 shows that 166 rotor failures occurred in 1978. These rotor failures accounted for approximately 8.4% of the 1971 shutdowns experienced by the gas turbine powered U. S. commercial aircraft fleet during 1978.

---

[1]NASA DPR C-41581-B, Mod. 8.

[2]An uncontained rotor failure is defined as a rotor failure that produces fragments which penetrate and escape the confines of the engine casing.

Rotor fragments were generated in 125 of the failures experienced and, of these, 19 (15.2% of the fragment producing failures) were uncontained. This represents an uncontained failure rate of 3.6 per million gas turbine engine powered aircraft flight hours, or 1.1 per million engine operation hours. Approximately 6.8 million and 21.4 million aircraft flight and engine operating hours, respectively, were logged by the U. S. commercial aviation fleet in 1978.

b. Figure 2 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 fragment generated. These data indicate that:

(1) The incidence of turbine rotor fragment producing failures was approximately two times greater than that of compressor rotor fragment producing failures; these corresponded to 60% and 34.4%, respectively, of the total number of rotor failures. Fan rotor failures accounted for 5.6% of the fragment producing failures experienced.

(2) Blade fragments were generated in 95.2% of the rotor failures; 13.4% of these were uncontained. The remaining rotor fragments failures (4.8%) produced disk, rim and seal fragments, of which 100%, 33.3% and 50%, respectively were uncontained.

c. Figure 3 shows the rotor failure distribution among the types of engines that were affected, and the total number of that type engine in use.

d. Figure 4 shows what caused the rotor failures to occur. Of the known causes of failure(1), the dominant causal factors were: (1) Secondary Causes (44.2%); (2) Foreign Object Damage (FOD) (31.7%), and (3) Design and Life Prediction Problems (19.2%).

e. Figure 5 indicates the flight conditions that existed when the various rotor failures occurred. Approximately 65% of the 166 rotor failures occurred during the takeoff and climb stages of flight. Approximately 68% of the rotor fragment producing failures, and 79% of the uncontained rotor failures, occurred during these same stages of flight. The highest percentage of uncontained rotor failures (53%) were experienced during takeoff.

f. Figure 6 is a cumulative tabulation that describes the distribution of uncontained rotor failures according to fragment type, engine component involved, cause category and flight condition(2) for the years 1976, 1977 and 1978. This figure will be expanded yearly to include all subsequent uncontained rotor failures. These data indicate that: for "design and life prediction problems"

(1) Because of the high percentage of unknown causes of rotor failure, the percentages were based on the total number of known causes.

(2) Takeoff and climb are defined as "High Power", all other conditions are defined as "Low Power".

the numbers of uncontained failures were two times greater at "high" power than "low" power (namely 10 and 5); but for all other causes, the prevailing condition was "high power". Additional conclusions should become evident from this table with the accumulation of future data.

g. Figure 7 shows the annual incidence of uncontained rotor failures in commercial aviation for the years 1962 and 1978. During 1978, the incidence of uncontained rotor failure increased by four over the previous year, 1977. Over the past five years, 1974 through 1978, an average of 16.2 uncontained rotor failures per year have occurred. During this same time period, the rate of uncontained rotor failures has remained relatively constant at an average of approximately one per million engine operating hours.

CONCLUSIONS

1. The incidence of rotor failure and uncontained failure is significantly high enough to warrant continuation of the experimental and analytical efforts that constitute the RFPP.

2. Of all types of fragments generated at rotor failure, disks and fan blade fragments, because of their size and high energy content, continue to be the threat that must be addressed in the RFPP.

3. It appears that causes such as FOD, structural life and integrity prediction, and secondary effects, are primarily responsible for most of the rotor failures that occur. Progress in the ability to predict structural life is being made through numerous programs sponsored both by Government agencies and by industry. The capability to reduce the causes of failures from secondary effects, such as bearing or seal failures, also is being addressed through technological programs. However, causes due to FOD still appear to be beyond the control or scope of present technology.

INCIDENCE OF ROTOR FAILURE IN U.S. COMMERCIAL AVIATION 1978

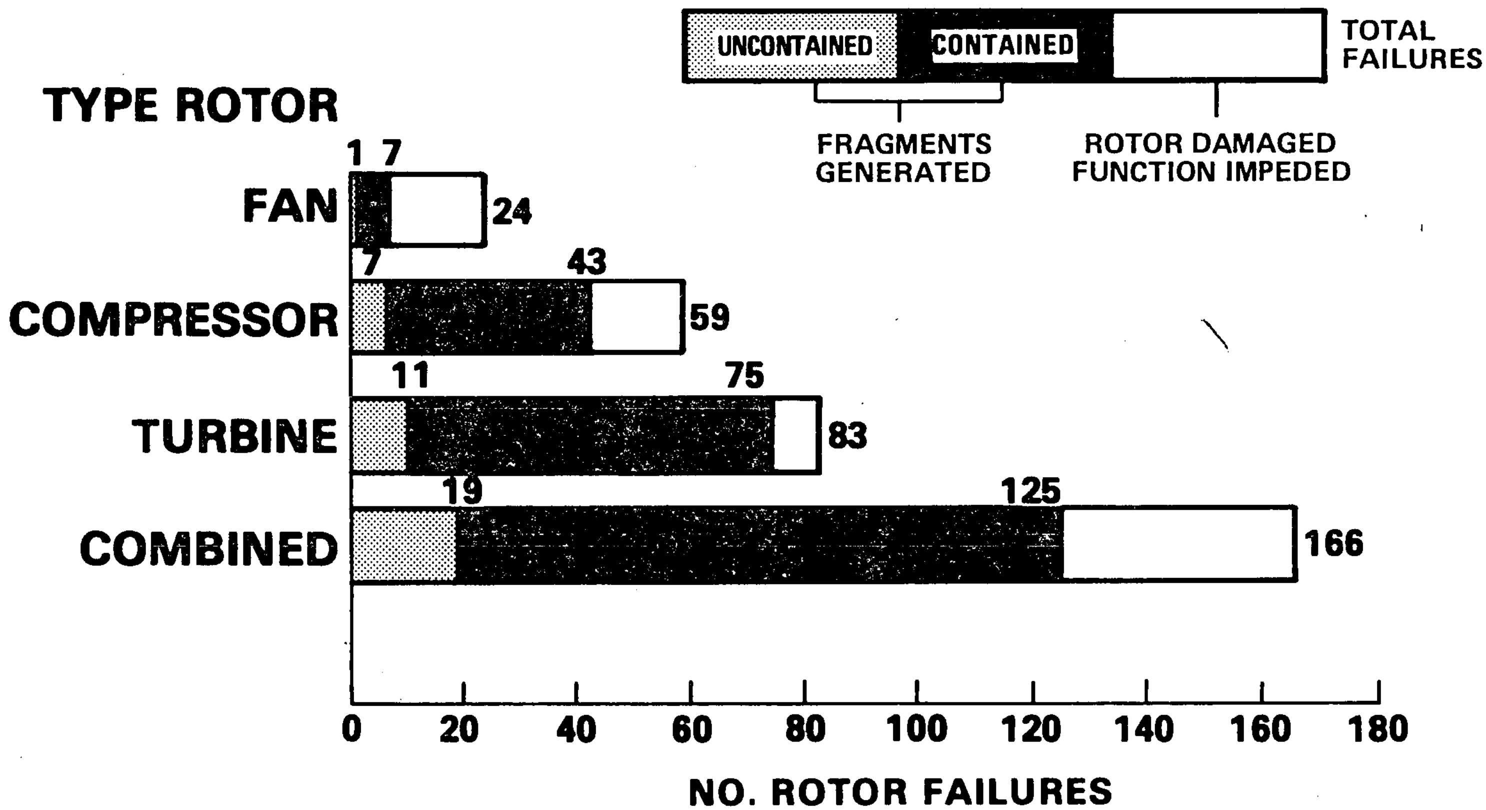


FIGURE 1

COMPONENT AND FRAGMENT TYPE DISTRIBUTIONS FOR CONTAINED AND UNCONTAINED ROTOR FAILURES(1) — 1978

ENGINE ROTOR COMPONENT	TYPE OF FRAGEMENT GENERATED									
	DISK		RIM		BLADE		SEAL		TOTALS	
	TF	UCF	TF	UCF	TF	UCF	TF	UCF	TF	UCF
FAN	0	0	0	0	7	1	0	0	7	1
COMPRESSOR	1	1	0	0	40	5	2	1	43	7
TURBINE	0	0	3	1	72	10	0	0	75	11
TOTALS	1	1	3	1	119	16	2	1	125	19

(1) FAILURES THAT PRODUCED FRAGMENTS

TF – TOTAL FAILURES
UCF – UNCONTAINED FAILURES

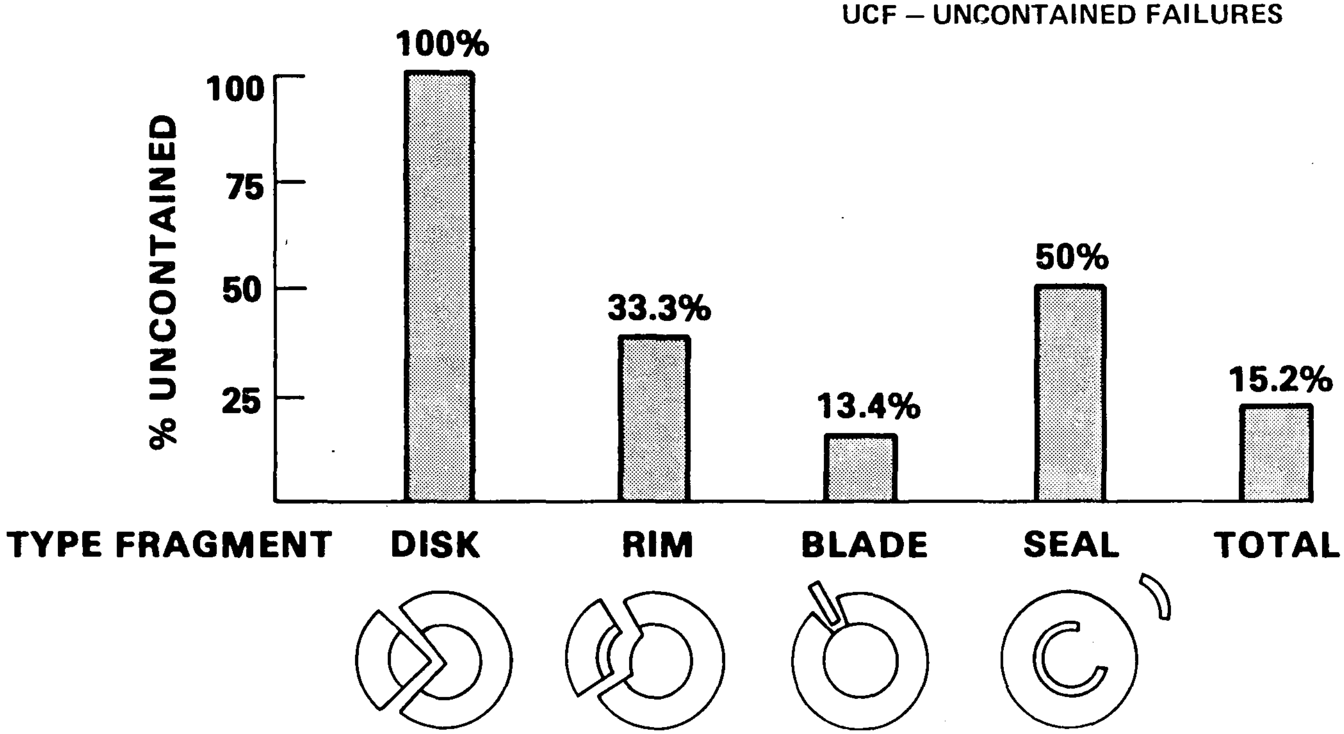
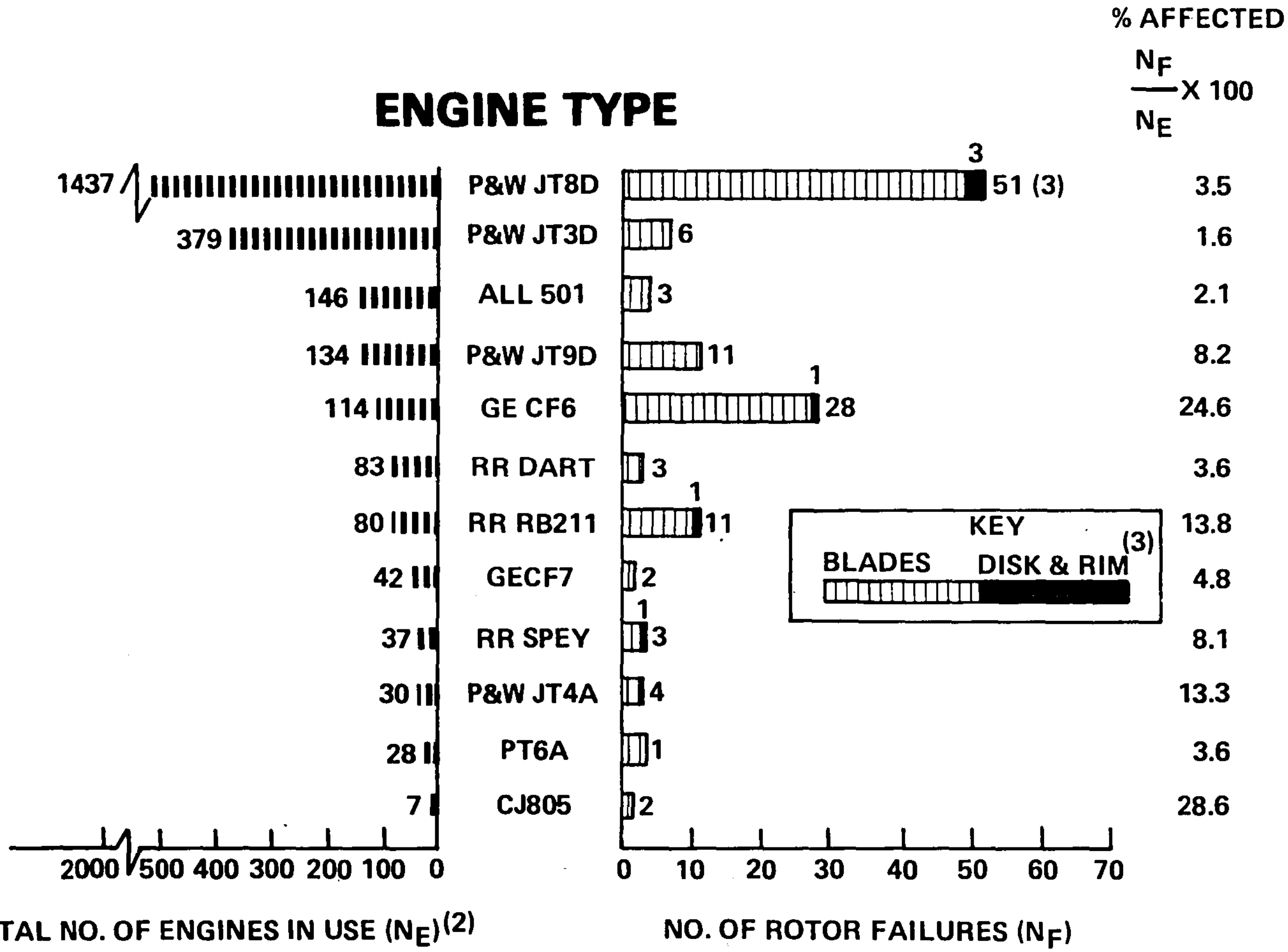


FIGURE 2

NAPC-PE-23

THE INCIDENCE OF ROTOR FAILURE(1) IN U.S. COMMERCIAL AVIATION ACCORDING TO ENGINE TYPE AFFECTED — 1978



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

FIGURE 3

ROTOR FAILURE CAUSE CATEGORIES — 1978

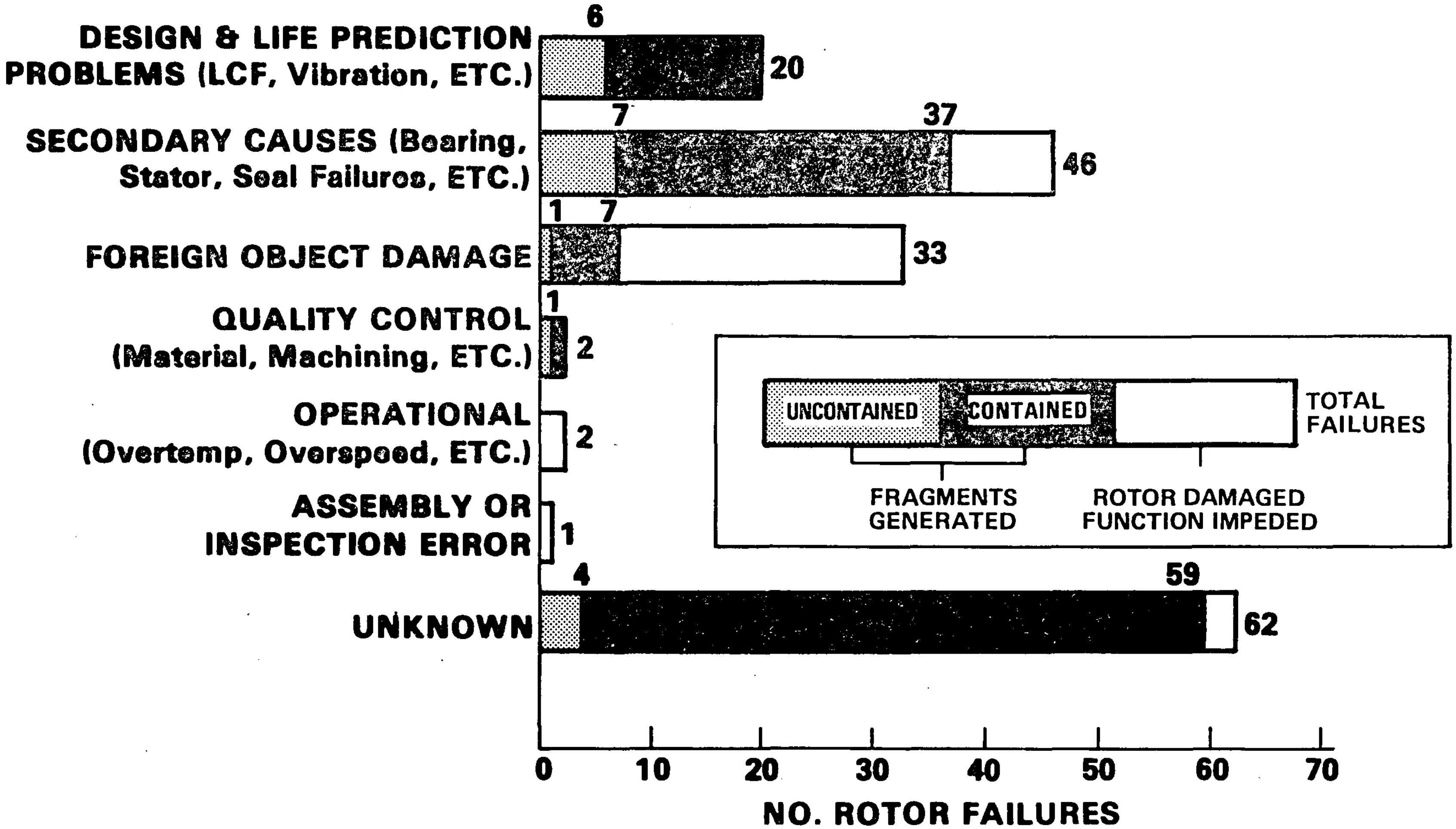
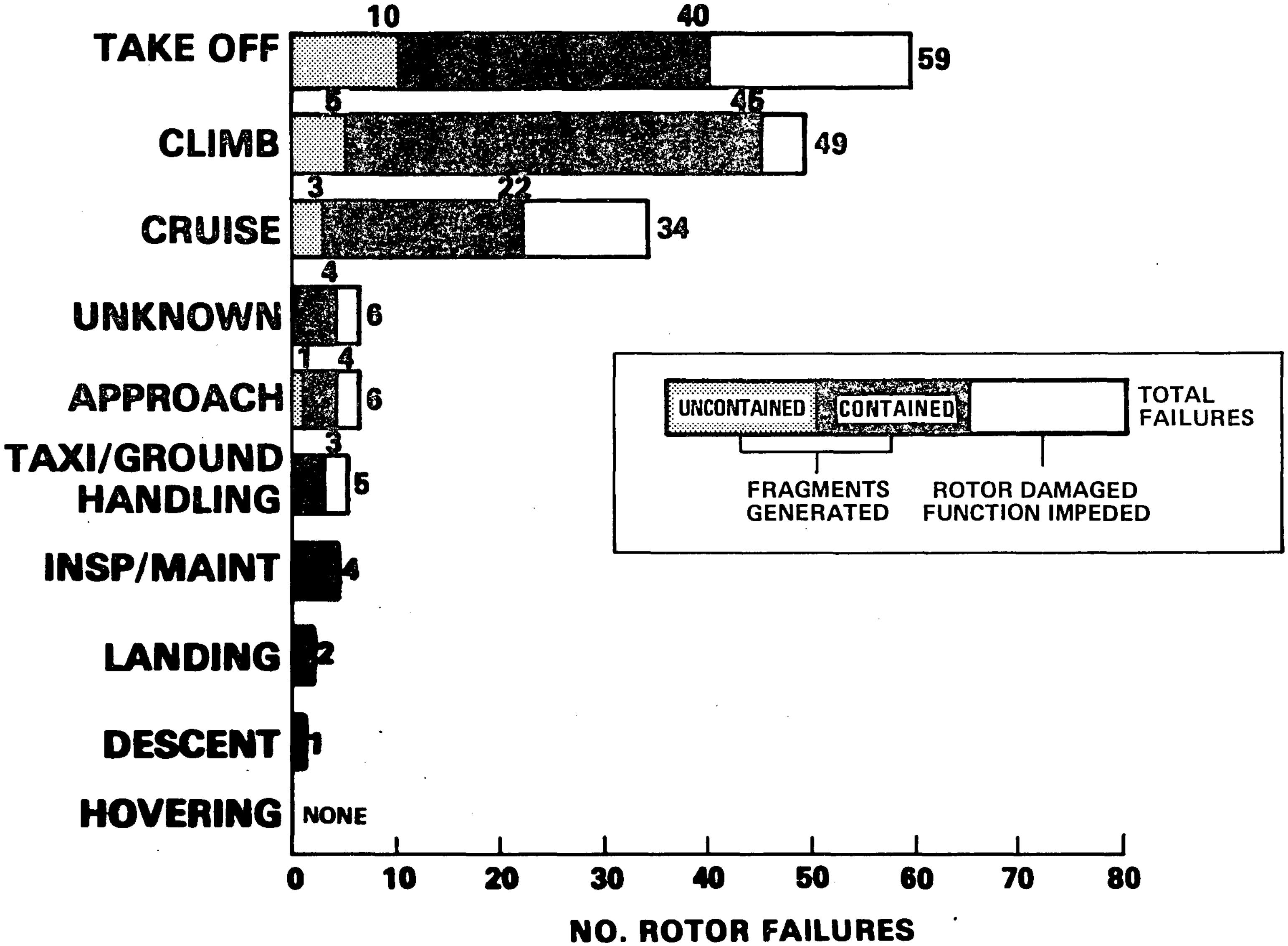


FIGURE 4

NAPC-PE-23

FLIGHT CONDITION AT ROTOR FAILURE — 1978



8

FIGURE 5

NAPC-PE-23

UNCONTAINED ROTOR FAILURE DISTRIBUTIONS ACCORDING TO CAUSE AND FLIGHT CONDITION(1) 1976 — 1978

TYPE OF FRAGMENT GENERATED	ENGINE ROTOR COMPONENT	DESIGN & LIFE PRED. PROBLEMS		SECONDARY CAUSES		FOREIGN OBJECT DAMAGE		QUALITY CONTROL		UNKNOWN		SUBTOTALS		TOTALS
		HIGH POWER	LOW POWER	HIGH POWER	LOW POWER	HIGH POWER	LOW POWER	HIGH POWER	LOW POWER	HIGH POWER	LOW POWER	HIGH POWER	LOW POWER	
DISK	FAN											0	0	
	COMPRESSOR	1										1	0	
	TURBINE		2									0	2	3
RIM	FAN											0	0	
	COMPRESSOR	2								2		4	0	
	TURBINE							1				1	0	5
BLADE	FAN	3	1			3	1	2				8	2	
	COMPRESSOR	3		2						5		10	0	
	TURBINE	1	2	9	1					2	2	12	5	37
SEAL	FAN											0	0	
	COMPRESSOR									1	1	1	1	
	TURBINE			2						1		3	0	5
SUBTOTALS		10	5	13	1	3	1	3	0	11	3	40	10	
TOTALS		15		14		4		3		14		50		50

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

FIGURE 6

THE INCIDENCE OF UNCONTAINED ROTOR FAILURES IN U.S. COMMERCIAL AVIATION 1962 — 1978

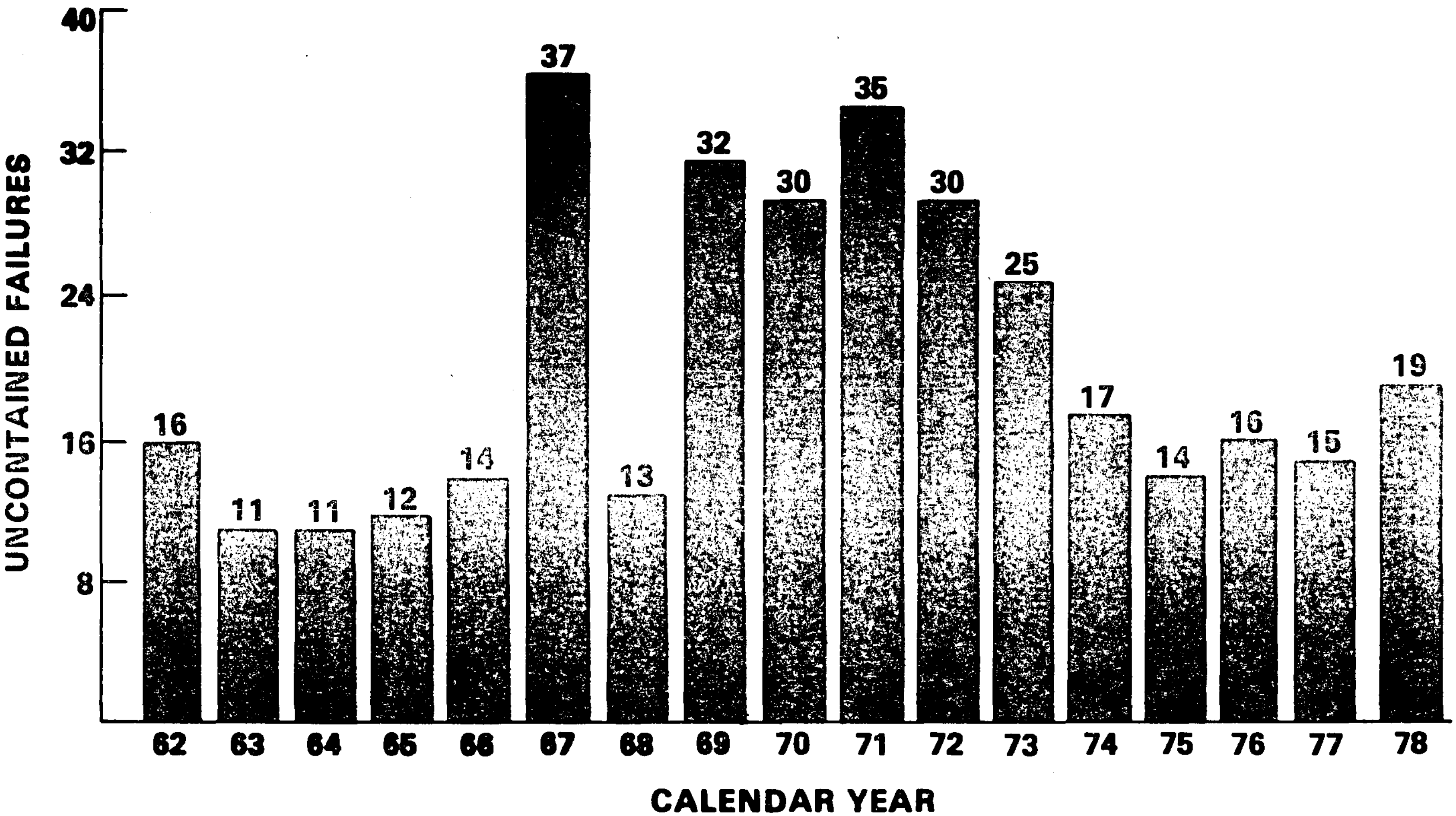


FIGURE 7

NAPC-PE-23

APPENDIX A

Data on Rotor Failures in U. S. Commercial Aviation for 1978. 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 - 1978

SDR NO.	DATE	SUBMITTER	AIRCRAFT	ENGINE	COMPONENT	FRAGMENT TYPE	CAUSE	CONTAINMENT CONDITION	FLIGHT CONDITION
01258018	1/6	TWA	B707	JT4D	T	B	2	C	4
01258019	1/7	OZA	DC9	JT8D	T	B	7	C	2
01258020	1/9	AWI	DC9	JT8D	F	B	7	C	4
01308023	1/6	CAL	DC10	CF6	T	B	7	C	4
01308024	1/30	BNF	B727	JT8D	C	B	3	C	3
02028023	1/14	AAL	DC10	CF6	T	B	1	C	5
0208026	2/2	PSAX	B727	JT8D	T	B	7	C	3
0208025	1/4	AAA	DC9	JT8D	C	B	7	C	8
01308024	1/11	BNF	B727	JT8D	C	B	2	C	3
02038024	2/3	TIAS	DC10	CF6	C	B	2	C	3
02078027	1/19	AAL	B727	JT8D	T	B	7	C	4
02098006	1/23	UAL	B727	JT8D	C	B	3	C	5
02158020	2/15	AWI	DC9	JT8D	C	B	7	C	3
03068028	2/4	NWA	DC10	JT9D	F	B	3	C	5
03078020	2/14	TWA	B707	JT4A	T	B	2	C	4
03088024	2/14	AAL	DC10	CF6	C	B	7	C	3

CHARACTERISTICS OF ROTOR FAILURES - 1978

SDR NO.	DATE	SUBMITTER	AIRCRAFT	ENGINE	COMPONENT	FRAGMENT TYPE	CAUSE	CONTAINMENT CONDITION	FLIGHT CONDITION
03168023	2/22	NAL	DC10	CF6	C	B	2	C	3
03168024	2/26	TWA	B707	JT3D	C	B	2	C	1
03168025	2/18	OZA	DC9	JT8D	T	B	1	NC	3
03178023	2/26	AAL	DC10	CF6	T	B	2	NC	4
03218019	2/27	AAA	BA111	SPEY	T	B	2	C	8
03238023	2/28	AAL	DC10	CF6	T	B	1	C	4
03248023	2/24	APN	CV580	501	T	B	2	C	2
03248024	3/2	TWA	DC9	JT8D	T	B	7	C	3
03318024	3/8	OZA	DC9	JT8D	T	B	2	NC	7
04058023	3/4	PCTC	CV990	CJ805	T	B	7	C	5
04058026	2/26	EAL	L1011	RB211	T	B	7	C	3
04128024	3/19	NWA	DC10	JT9D	T	B	7	C	4
04138023	3/21	NAL	B727	JT8D	C	B	2	C	5
04138024	3/18	NAL	B727	JT8D	T	B	2	NC	3
04138025	3/19	AAA	DC9	JT8D	T	B	7	C	3
04148031	3/27	TXI	DC9	JT8D	T	B	7	C	4

CHARACTERISTICS OF ROTOR FAILURES - 1978

SDR NO.	DATE	SUBMITTER	AIRCRAFT	ENGINE	COMPONENT	FRAGMENT TYPE	CAUSE	CONTAINMENT CONDITION	FLIGHT CONDITION
04188030	3/27	NAL	B727	JT8D	T	B	2	NC	3
04198037	3/27	TXI	DC9	JT8D	C	B	1	C	4
04218038	3/30	AAL	B747	JT9D	C	B	1	C	5
04278029	4/3	HAL	DC9	JT8D	C	D	1	NC	3
05018034	4/4	AWI	DC9	JT8D	T	B	7	C	4
05048032	4/20	NAL	B727	JT8D	T	B	7	C	4
05098036	4/24	OZA	DC9	JT8D	T	B	7	C	3
05108028	4/22	NAL	B727	JT8D	T	B	7	C	4
05108029	4/22	AAA	DC9	JT8D	T	B	7	C	3
05118034	4/2	CAPS	DC8	JT3D	C	B	2	C	5
05118035	4/28	TXI	DC9	JT8D	T	B	2	C	4
05168030	5/1	WAL	DC10	CF6	T	B	7	C	5
05188029	5/1	OZA	FH227	DART	T	B	2	C	10
05188030	5/4	TWA	L1011	RB211	T	B	2	C	4
05268023	5/12	WAL	DC10	CF6	C	B	7	NC	4
05318018	5/18	UAL	DC10	CF6	T	B	1	C	4

CHARACTERISTICS OF ROTOR FAILURES - 1978

SDR NO.	DATE	SUBMITTER	AIRCRAFT	ENGINE	COMPONENT	FRAGMENT TYPE	CAUSE	CONTAINMENT CONDITION	FLIGHT CONDITION
06018025	5/21	AAL	B727	JT8D	T	B	2	NC	3
060288026	5/20	TWA	L1011	RB211	T	B	7	C	4
06078026	5/25	AAA	BA111	SPEY	T	R	7	C	3
06088026	5/30	TWA	L1011	RB211	C	B	2	C	3
06128024	5/26	AAA	DC9	JT8D	T	B	7	C	3
06148023	5/19	NAL	DC10	CF6	T	B	2	C	4
06218024	6/12	AAL	B727	JT8D	T	B	2	NC	3
06268016	6/10	UAL	B747	JT9	C	B	1	C	4
06278020	6/9	WAL	DC10	CF6	T	B	7	NC	5
06298019	6/19	UAL	DC10	CF6	C	B	7	C	5
06298019	6/21	TIAS	DC10	CF6	C	B	1	C	5
06308024	6/21	FAL	CV580	501	C	B	7	C	6
06308025	6/17	EAL	B727	JT8D	T	B	1	NC	5
07038098	7/3	DAL	L1011	RB211	T	R	7	C	10
07058023	7/5	AAL	DC10	CF6	F	B	7	C	5
07078026	6/23	UAL	DC10	CF6	T	B	1	C	3

CHARACTERISTICS OF ROTOR FAILURES - 1978

SDR NO.	DATE	SUBMITTER	AIRCRAFT	ENGINE	COMPONENT	FRAGMENT TYPE	CAUSE	CONTAINMENT CONDITION	FLIGHT CONDITION
07178024	7/3	NAL	DC10	CF6	T	B	7	C	4
07148024	6/27	UAL	B747	JT9D	F	B	3	C	3
07218026	6/27	AAA	DC9	JT8D	T	B	7	C	3
07248018	6/23	CAPS	DC8	JT3D	C	B	7	C	3
07258020	7/6	WAL	DC10	CF6	T	B	7	C	5
07268027	6/17	DAL	L1011	RB211	C	B	2	C	4
07278021	7/7	AAA	DC9	JT8D	T	B	7	C	7
07318019	7/15	TWA	B747	JT9D	T	B	7	C	4
08018023	7/14	UAL	B727	JT8D	C	B	7	C	3
08118020	7/27	AAL	DC10	CF6	C	B	1	NC	4
08178023	7/27	CAL	DC10	CF6	T	B	7	C	4
08178024	7/24	CAL	DC10	CF6	T	B	7	C	4
08308023	8/8	AAA	DC9	JT8D	T	B	7	C	3
08318028	8/17	NAL	DC10	CF6	C	B	7	C	4
08318029	8/17	AAL	DC10	CF6	T	R	4	NC	3
08318030	8/19	UAL	B727	JT8D	T	B	1	C	5
09018029	8/21	TWA	B707	JT4	T	B	2	C	5

CHARACTERISTICS OF ROTOR FAILURES - 1978

SDR NO.	DATE	SUBMITTER	AIRCRAFT	ENGINE	COMPONENT	FRAGMENT TYPE	CAUSE	CONTAINMENT CONDITION	FLIGHT CONDITION
09018031	8/21	FAL	B737	JT8D	T	B	7	C	4
09018117	9/1	EAL	L1011	RB211	C	B	7	C	1
09078027	8/25	AAL	B727	JT8D	C	B	2	C	4
09128024	8/29	UAL	DC10	CF6	C	B	1	C	4
09128026	8/27	WAA	B737	JT8D	T	B	2	C	7
09158022	8/29	FECZ	MD30	CF7	T	B	7	C	4
09158023	8/23	FECZ	MD30	CF7	T	B	7	C	4
09208026	9/7	AAL	DC10	CF6	C	B	1	NC	4
09218020	9/6	DAL	L1011	RB211	C	B	2	C	4
09228019	9/13	ACAX	L188	501	T	B	2	C	3
09198080	9/19	PSAX	Unknown	JT8D	F	B	7	C	1
09288024	9/8	NAL	B727	JT8D	C	S	7	C	4
09298025	9/14	UAL	DC8	JT3D	C	B	2	C	5
10048021	9/22	TWA	B747	JT9D	T	B	7	C	4
10178024	9/27	AAIX	B720	JT3D	C	B	7	C	3
10198020	10/4	TWA	L1011	RB211	T	B	7	C	3
10208025	10/6	TWA	B747	JT9D	T	B	7	C	3

CHARACTERISTICS OF ROTOR FAILURES - 1978

SDR NO.	DATE	SUBMITTER	AIRCRAFT	ENGINE	COMPONENT	FRAGMENT TYPE	CAUSE	CONTAINMENT CONDITION	FLIGHT CONDITION
11038022	10/18	NAL	B727	JT8D	C	B	1	C	4
11078022	10/26	TWA	B727	JT8D	C	B	3	C	3
11098027	10/8	AAA	BA111	SPEY	T	B	7	C	3
11148021	10/26	NAL	DC10	CF6	C	B	1	NC	4
11228022	11/1	DAL	L1011	RB211	C	B	2	C	4
11218025	11/6	TWA	L1011	RB211	C	B	2	C	5
12018027	11/13	OZA	FH227	DART532	T	B	2	C	7
12058026	11/13	AAA	DC9	JT8D	T	B	7	C	4
12058027	11/13	AAA	DC9	JT8D	T	B	7	C	3
12068015	12/1	BNE	B727	JT8D	T	B	2	NC	3
12128023	11/20	TWA	B727	JT8D	C	B	2	C	4
12148024	12/26	UAL	B747	JT9D	C	B	2	C	4
12208017	11/28	UAL	DC10	CF6	T	B	1	C	4
12208018	12/3	UAL	B727	JT8D	C	S	7	NC	3
12218014	11/25	OZA	DC9	JT8D	T	B	2	C	2
12228024	12/5	NWA	B747	JT9D	C	B	3	C	5
12268028	12/4	AWI	DC9	JT8D	T	B	1	C	4

CHARACTERISTICS OF ROTOR FAILURES - 1978

SDR NO.	DATE	SUBMITTER	AIRCRAFT	ENGINE	COMPONENT	FRAGMENT TYPE	CAUSE	CONTAINMENT CONDITION	FLIGHT CONDITION
12298025	12/13	AAL	B727	JT8D	T	B	7	C	4
12298027	12/12	PAI	YS11A	DART	T	B	7	C	3
01039024	12/13	CAL	DC10	CF6	C	B	7	NC	3
01039026	11/30	RAHT	SH3	PT6A	T	B	1	C	1
01059025	12/19	FAL	B737	JT8D	T	B	7	C	5
01099026	12/17	AWI	DC9	JT8D	F	B	4	C	3
01099027	12/18	NWA	DC10	JT9D	F	B	3	NC	5
01159024	12/19	DAL	DC8	JT3D	C	B	2	C	10
01169024	12/23	PCTC	CV990	CJ805	T	B	2	C	10
03029031	12/29	CAPS	DC8	JT4A	T	B	7	C	5
01099025	12/17	OZA	DC9	JT8D	C	N	2	N	3
01258025	1/11	CAIT	SD330	PT6A	C	N	2	N	2
02018025	1/16	TWA	DC9	JT8D	F	N	3	N	3
02038026	1/18	NAL	B727	JT8D	T	N	2	N	3
02088023	1/22	TWA	B727	JT8D	F	N	3	N	5
02098022	1/19	ACAX	L188	501	C	N	3	N	4
02098023	1/23	TWA	B707	JT3D	F	N	3	N	3

CHARACTERISTICS OF ROTOR FAILURES - 1978

SDR NO.	DATE	SUBMITTER	AIRCRAFT	ENGINE	COMPONENT	FRAGMENT TYPE	CAUSE	CONTAINMENT CONDITION	FLIGHT CONDITION
02108026	1/22	SBWS	B747	JT9D	C	N	7	N	4
0308029	2/8	ONAS	DC10	CF6	F	N	3	N	5
03098031	2/2	FWIC	CV880	CJ805	C	N	7	N	10
03108025	3/10	ZIAX	STC340T	DART	T	N	2	N	3
03208026	2/27	AAA	BA111	506	C	N	3	N	5
03278024	3/5	TWA	B707	JT3D	C	N	3	N	5
03308021	2/26	FLAX	L188	501	T	N	6	N	5
04038016	3/12	FAL	B737	JT8D	F	N	3	N	3
03278011	3/21	OZA	DC9	JT8D	F	N	3	N	3
04058021	4/5	FAL	B737	JT8D	F	N	3	N	3
02228030	2/2	WAL	B720	JT3D	C	N	2	N	3
04268015	4/26	HAL	DC9	JT8D	F	N	3	N	3
05098037	4/23	UAL	B737	JT8D	F	N	3	N	3
05108027	4/20	NAL	B727	JT8D	C	N	5	N	5
05188027	4/29	OZA	DC9	JT8D	T	N	2	N	5
05248021	5/6	FECZ	MD20	CF7	C	N	3	N	3
05268024	5/12	WAA	B737	JT8D	F	N	3	N	7

CHARACTERISTICS OF ROTOR FAILURES - 1978

SDR NO.	DATE	SUBMITTER	AIRCRAFT	ENGINE	COMPONENT	FRAGMENT TYPE	CAUSE	CONTAINMENT CONDITION	FLIGHT CONDITION
07078027	6/26	PAI	B737	JT8D	F	N	3	N	10
07268026	7/11	EAL	L1011	RB211	F	N	3	N	3
07318018	7/14	APN	CV580	501	C	N	3	N	2
08038020	7/8	NOMC	CV990	CJ805	T	N	2	N	5
08178022	7/31	TIAS	L382	501	T	N	7	N	5
08218022	8/5	NAL	DC10	CF6	C	N	5	N	4
08218024	8/3	TWA	B707	JT3D	C	N	3	N	5
09158025	8/30	TWA	B727	JT8D	T	N	2	N	5
10038023	8/19	TIAS	L382	501	C	N	3	N	3
11018008	10/15	OZA	DC9	JT8D	F	N	3	N	3
11148024	10/27	FAL	B737	JT8D	F	N	3	N	3
11228020	10/13	FECZ	MD20	CF7	F	N	3	N	5
11298023	11/16	TIAS	L382	501	C	N	3	N	3
12058024	11/13	UAL	DC8	JT3D	C	N	3	N	3
12068018	11/13	OZA	FH227	DART	T	N	2	N	7
01199026	12/27	UAL	B727	JT8D	F	N	3	N	4
02019020	12/30	HAL	DC9	JT8D	F	N	3	N	3

DISTRIBUTION LIST

Activity	Copies
Commander, Naval Air Systems Command (AIR-50174), Department of the Navy, Washington, DC	9
Intra-command Addresses: AIR-330A (1), AIR-530 (1), AIR-536 (1), AIR-5360 (1), AIR-5361 (1), AIR-5362 (1), MAT-03L (1), AIR-330 (1)	
Commander, Naval Air Development Center, Warminster, PA 18974	1
Commanding Officer, Naval Air Engineering Center, Lakehurst, NJ 08733	1
Commanding Officer, Naval Aviation Safety Center, Naval Air Station, Norfolk, VA 23511	1
Director, Applied Technology Laboratory, Army Research and Technology Laboratories, Ft. Eustis, VA 23604	1
Commanding General, U. S. Army Aviation Systems Command (AMSAV-ERP), 12th and Spruce Streets, St. Louis, MO 63166	1
Commander, Air Force Aero-Propulsion Laboratory (AFSC), Wright-Patterson Air Force Base, OH 45433	1
National Aeronautics and Space Administration, Att: R. H. Johns, MS 49-3, Lewis Research Center, 21000 Brookpark Road, Cleveland, OH 44135	12
National Aeronautics and Space Administration (RF, RO(2), RLC), Washington, DC 20546	4
Federal Aviation Administration (RD-723), Washington, DC 20553	1
Defense Documentation Center for Scientific and Technical Information, Building No. 5, Cameron Station, Alexandria, VA 22314	12
Aeroelastic Laboratory, Massachusetts Institute of Technology, Cambridge, MA 02139	4

End of Document