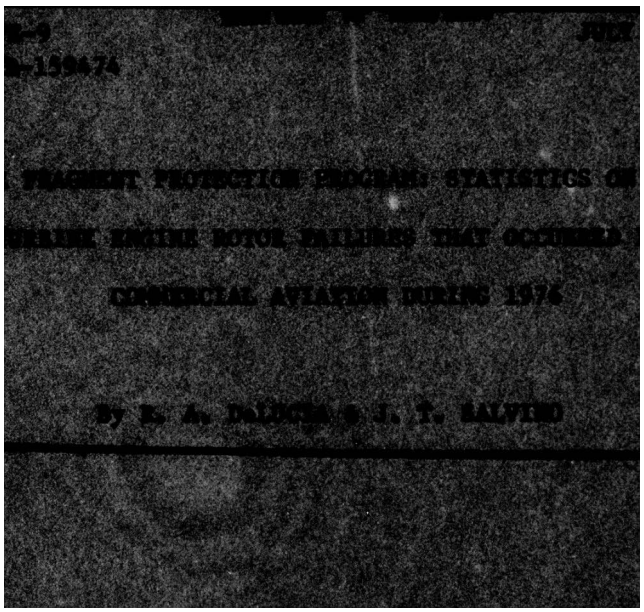
AD-A064 292 NAVAL AIR PROPULSION CENTER TRENTON NJ PROPULSION TE--ETC F/G 1/2
ROTOR FRAGMENT PROTECTION PROGRAM: STATISTICS ON AIRCRAFT GAS T--ETC(U)
JUL 78 R A DELUCIA, J T SALVINO NASA-DPR-C-41581B

UNCLASSIFIED NAPC-PE-9 NASA-CR-159474 NL

1 OF 2
AD
A064 292

END
DATE FILMED
4-79
DDC

X CONT



UNCLASSIFIED

SECURITY CLASSIFICATION OF THIS PAGE *(When Data Entered)*

REPORT DOCUMENTATION PAGE

READ INSTRUCTIONS BEFORE COMPLETING FORM

(14) 1. REPORT NUMBER: NAPC-PE-9

2. GOVT ACCESSION NO.

3. RECIPIENT'S CATALOG NUMBER (9)

(6) 4. TITLE *(and Subtitle)*: ROTOR FRAGMENT PROTECTION PROGRAM: STATISTICS ON AIRCRAFT GAS TURBINE ENGINE ROTOR FAILURES THAT OCCURRED IN U. S. COMMERCIAL AVIATION DURING 1976

5. TYPE OF REPORT & PERIOD COVERED: Final Report, 1975 - 1976

6. PERFORMING ORG. REPORT NUMBER

(10) 7. AUTHOR(s): R. A. DeLucia and J. T. Salvino

8. CONTRACT OR GRANT NUMBER(s): NASA DPR C-41581-B, new Mod. 8

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

(11) 12. REPORT DATE: July 1978

13. NUMBER OF PAGES: 29

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

(12) 31 p. (18) NASA (19) CR-159474

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

(15) NASA-DPR-C-41581B

18. SUPPLEMENTARY NOTES
"Aircraft Safety Office, Lewis Research Center, Cleveland, Ohio 44135, Advisor, A. G. Holms."
Other report designation: NASA-CR-159474

19. KEY WORDS *(Continue on reverse side if necessary and identify by block number)*
Air Transportation and Safety
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 1976 in commercial aviation service use. The predominant failure involved blade fragments, 88 percent of which were contained. Although fewer rotor rim, disk, and seal failures occurred, all were uncontained. Sixty-seven percent of the 186 rotor failures occurred during the takeoff and climb stages of flight.

410 500

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-9 JULY 1978
NASA-CR-159474

ROTOR FRAGMENT PROTECTION PROGRAM: STATISTICS ON AIRCRAFT GAS TURBINE ENGINE ROTOR FAILURES THAT OCCURRED IN U. S. COMMERCIAL AVIATION DURING 1976

Prepared by: R. A. DeLUCIA

J. F. SALVINO

Approved by: J. L. MOSS
Commander, USN
Director, PE

AUTHORIZATION: NASA DPR C-41581-B, MOD.8

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.

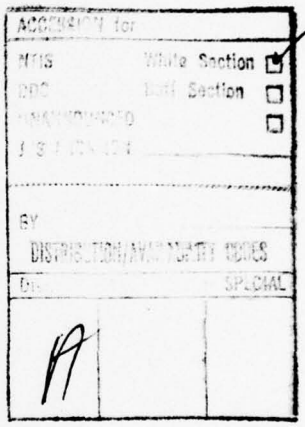


TABLE OF CONTENTS

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 bursts.

Presented in this report are statistics on gas turbine rotor failures that have occurred in U. S. commercial aviation during 1976. 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 6.

a. Figure 1 shows that 186 rotor failures occurred in 1976. These rotor failures accounted for approximately 9.3% of the 2002 shutdowns experienced by the gas turbine powered U. S. commercial aircraft fleet during 1976. Rotor fragments were generated in 109

---

[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.

of the failures experienced and, of these, 20 (18.3% of the fragment producing failures) were uncontained. This represents an uncontained failure rate of 3.2 per million gas turbine engine powered aircraft flight hours, or 1.1 per million engine operation hours. Approximately 6.2 million and 18.9 million aircraft flight and engine operating hours, respectively, were logged by the U. S. commercial aviation fleet in 1976. Because of the potentially catastrophic consequence of the fragment producing failures, these rates are considered to be significantly high.

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 three times greater than that of compressor rotor fragment producing failures; these corresponded to 68.8% and 22.9%, respectively, of the total number of rotor bursts. Fan rotor failures accounted for 8.3% of the uncontained failures experienced.

(2) Blade fragments were generated in 93.6% of the rotor failures; 11.9% of these were uncontained. The remaining rotor fragment failures (6.4%) produced disk, rim and seal fragments, of which 100% 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. It appears that the more recently introduced, larger turbofan engines have experienced the highest rate of rotor failure.

d. Figure 4 shows what caused the rotor failures to occur. Of the known causes of failure*, the dominant causal factors were: (1) Secondary Causes (45.2%); (2) Foreign Object Damage (36.5%); and (3) Design and Life Prediction Problems (14.8%).

e. Figure 5 shows the flight conditions that existed when the various rotor failures or bursts occurred. Approximately 67% of the 186 rotor failures occurred during the takeoff and climb stages of flight. Approximately 70% of the rotor fragment producing failures, and 70% of the uncontained rotor failures, occurred during these same stages of flight. The highest percentage of uncontained rotor bursts (45%) were experienced during takeoff.

f. Figure 6 shows the annual incidence of uncontained rotor failure in commercial aviation for the years 1962 through 1976. During 1976, the incidence of uncontained rotor failure increased over the previous

*Because of the high percentage of unknown causes of rotor failure, the analysis was based on the total number of known causes.

years, 1974 and 1975, by 15 and 30%, respectively. Over the past four years, 1973 thru 1976, an average of 19 uncontained rotor failures per year have occurred. During this same time period, the rate of uncontained rotor bursts has remained relatively constant at an average of approximately 1 per million engine operating hours.

CONCLUSIONS

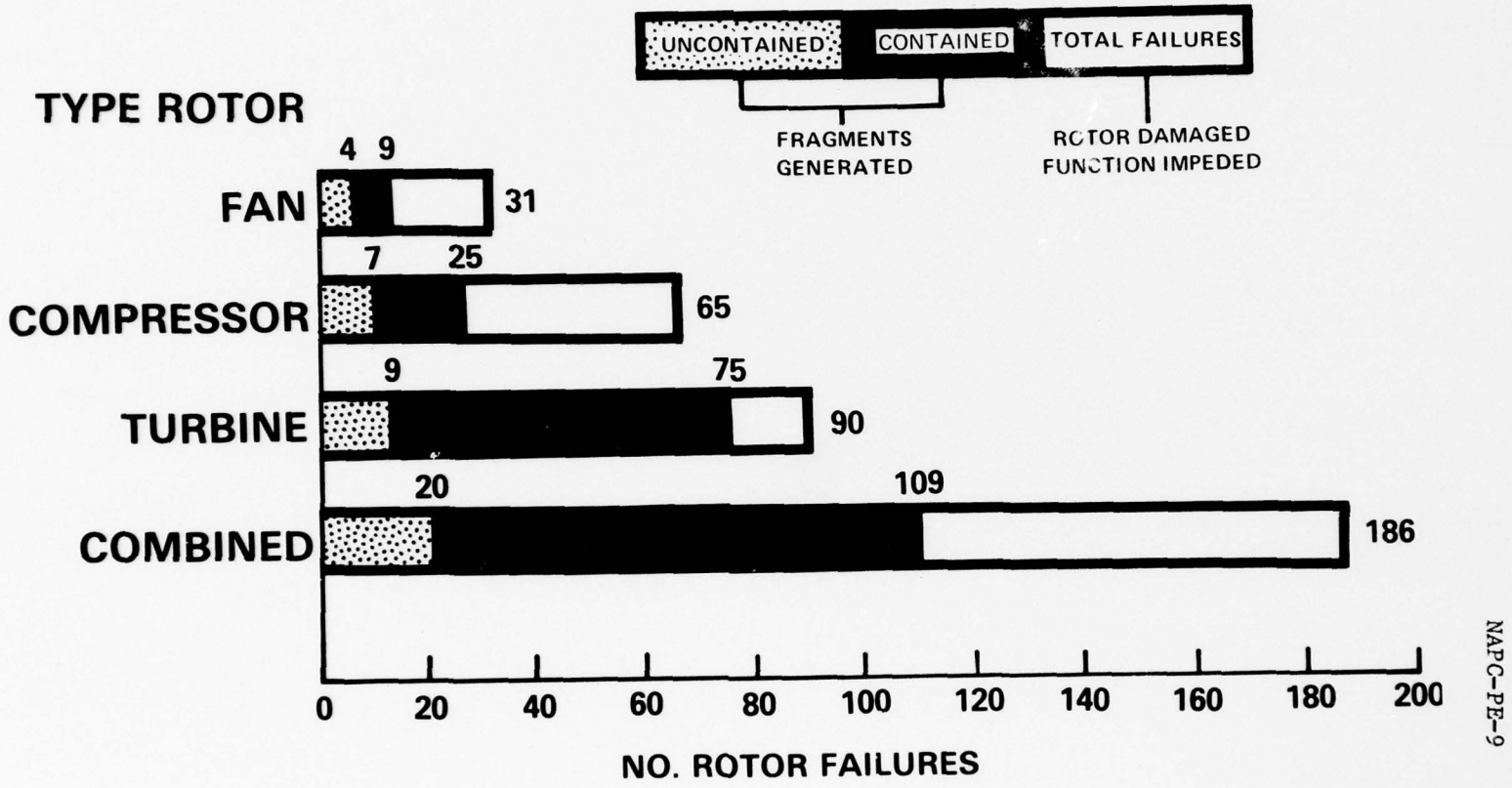
1. The incidence of rotor failure and uncontained failure is significantly high enough to warrant continuation of the experimental and analytical efforts that constitute the Rotor Fragment Protection Program.

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

3. The number of uncontained blade failures that occurred during 1976 is surprisingly high considering that, under FAA regulations, rotor blade containment is required for engine certification.

4. It appears that causes beyond the control or scope of present technology such as FOD, structural life and integrity prediction, and secondary effects, are still primarily responsible for most of the rotor failures that occur.

FIGURE 1
INCIDENCE OF ROTOR FAILURE
IN U.S. COMMERCIAL AVIATION 1976



NAPC-PE-9

FIGURE 2

COMPONENT AND FRAGMENT TYPE DISTRIBUTIONS FOR CONTAINED AND UNCONTAINED ROTOR FAILURES[1] – 1976

ENGINE ROTOR COMPONENT	TYPE OF FRAGMENT GENERATED								TOTALS	
	DISK		RIM		BLADE		SEAL			
	TF	UCF	TF	UCF	TF	UCF	TF	UCF	TF	UCF
FAN	0	0	0	0	9	4	0	0	9	4
COMPRESSOR	0	0	1	1	23	5	1	1	25	7
TURBINE	2	2	0	0	70	4	3	3	75	9
TOTALS	2	2	1	1	102	13	4	4	109	20

(1) FAILURES THAT PRODUCED FRAGMENTS

TF – TOTAL FAILURES
UCF – UNCONTAINED FAILURES

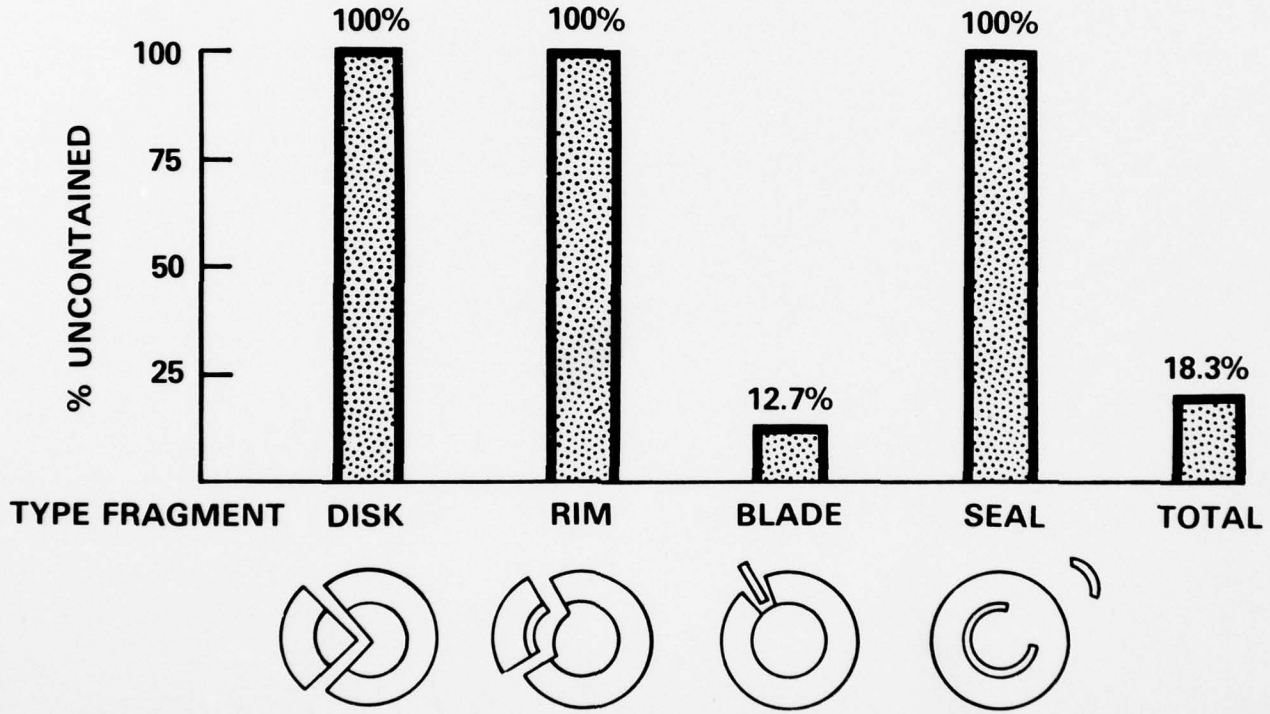
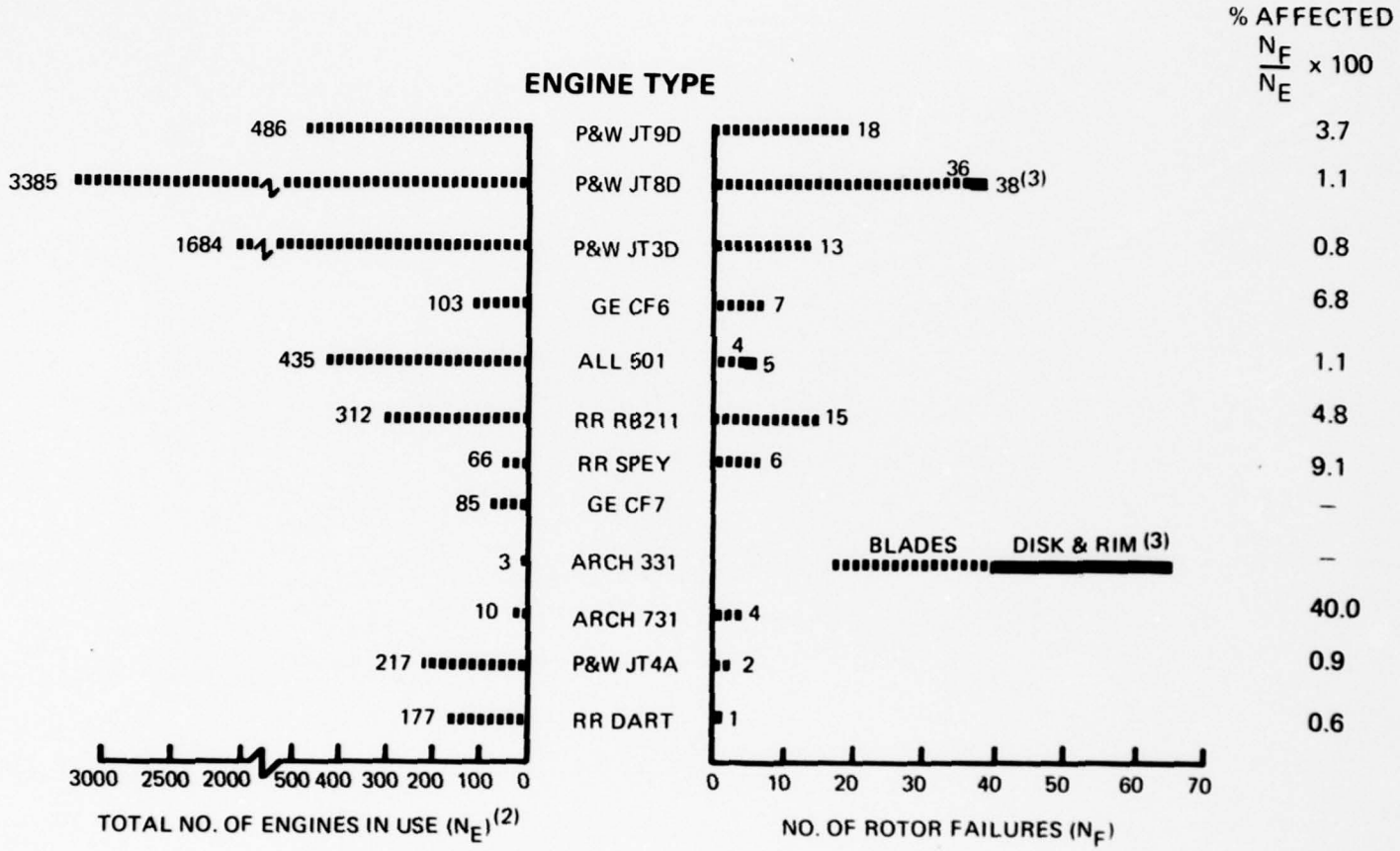


FIGURE 3

THE INCIDENCE OF ROTOR FAILURE(1) IN U.S. COMMERCIAL AVIATION ACCORDING TO ENGINE TYPE AFFECTED – 1976

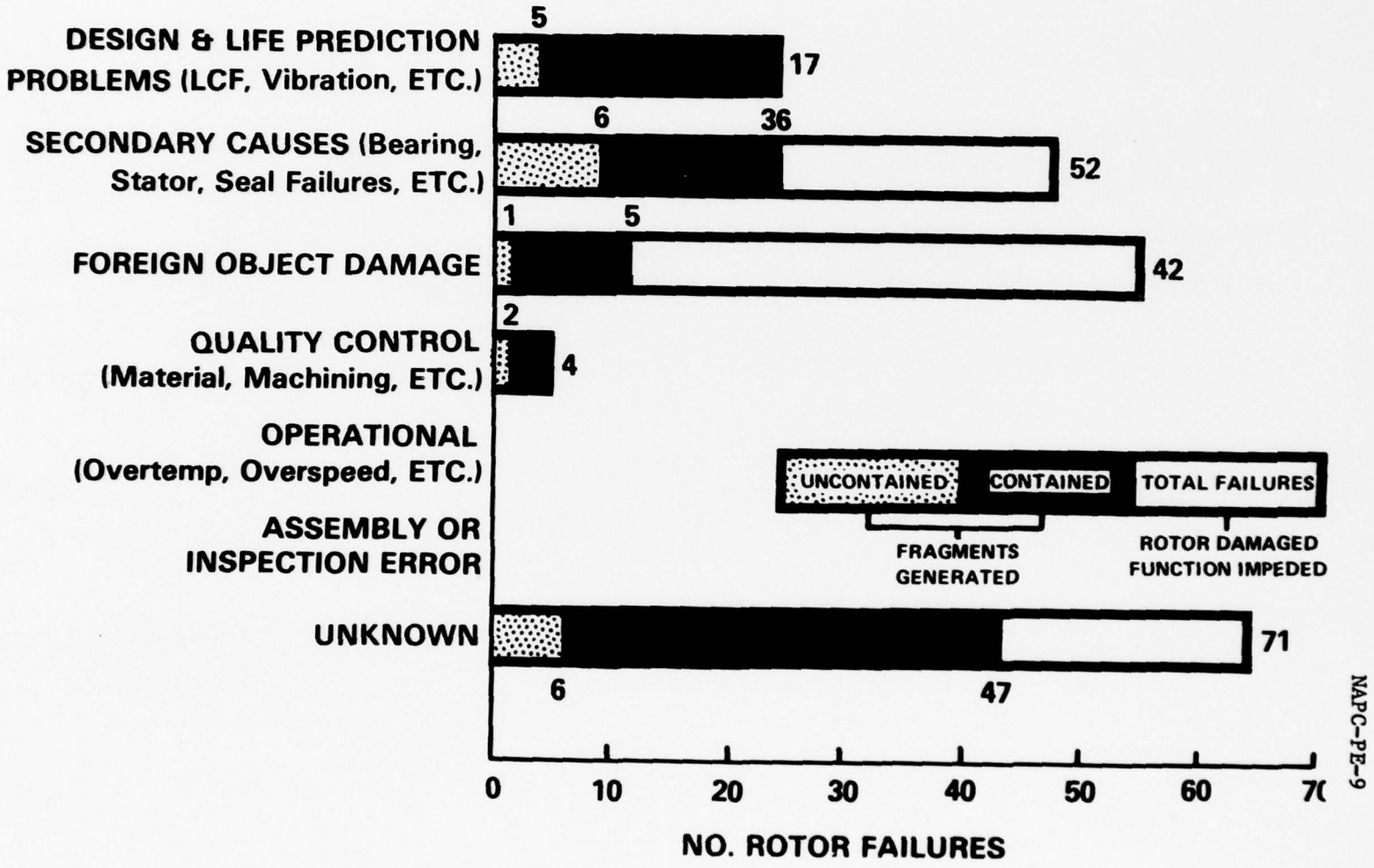


(1) FAILURES THAT PRODUCED FRAGMENTS
(2) YEARLY AVG. OF AIRCRAFT IN USE AT END OF EACH MONTH
(3) 1 SEAL FAILURE INCLUDED IN DISK/RIM COMPILATION

NAPC-PE-9

FIGURE 4

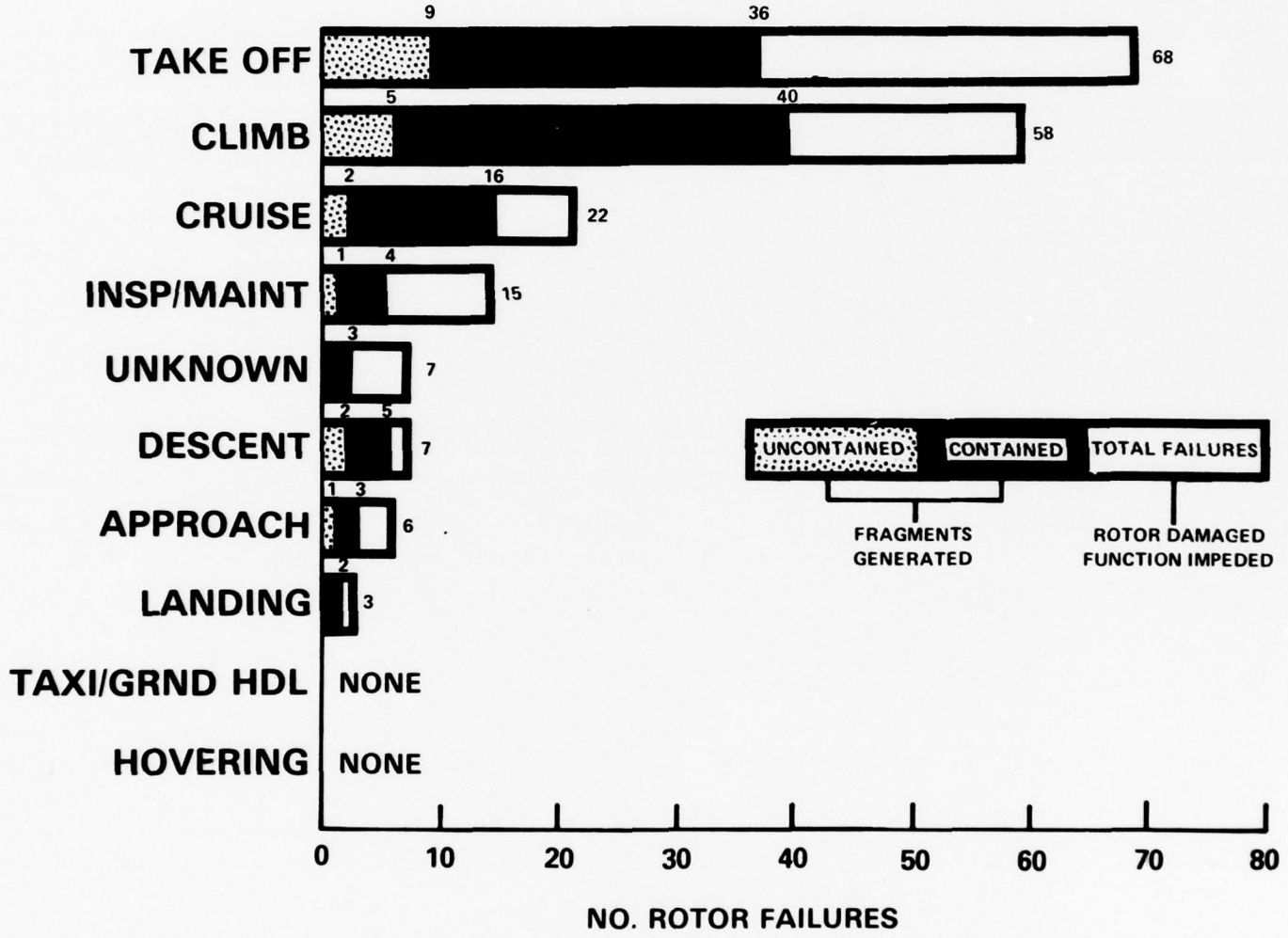
ROTOR FAILURE CAUSE CATEGORIES – 1976



NAPC-PE-9

FIGURE 5

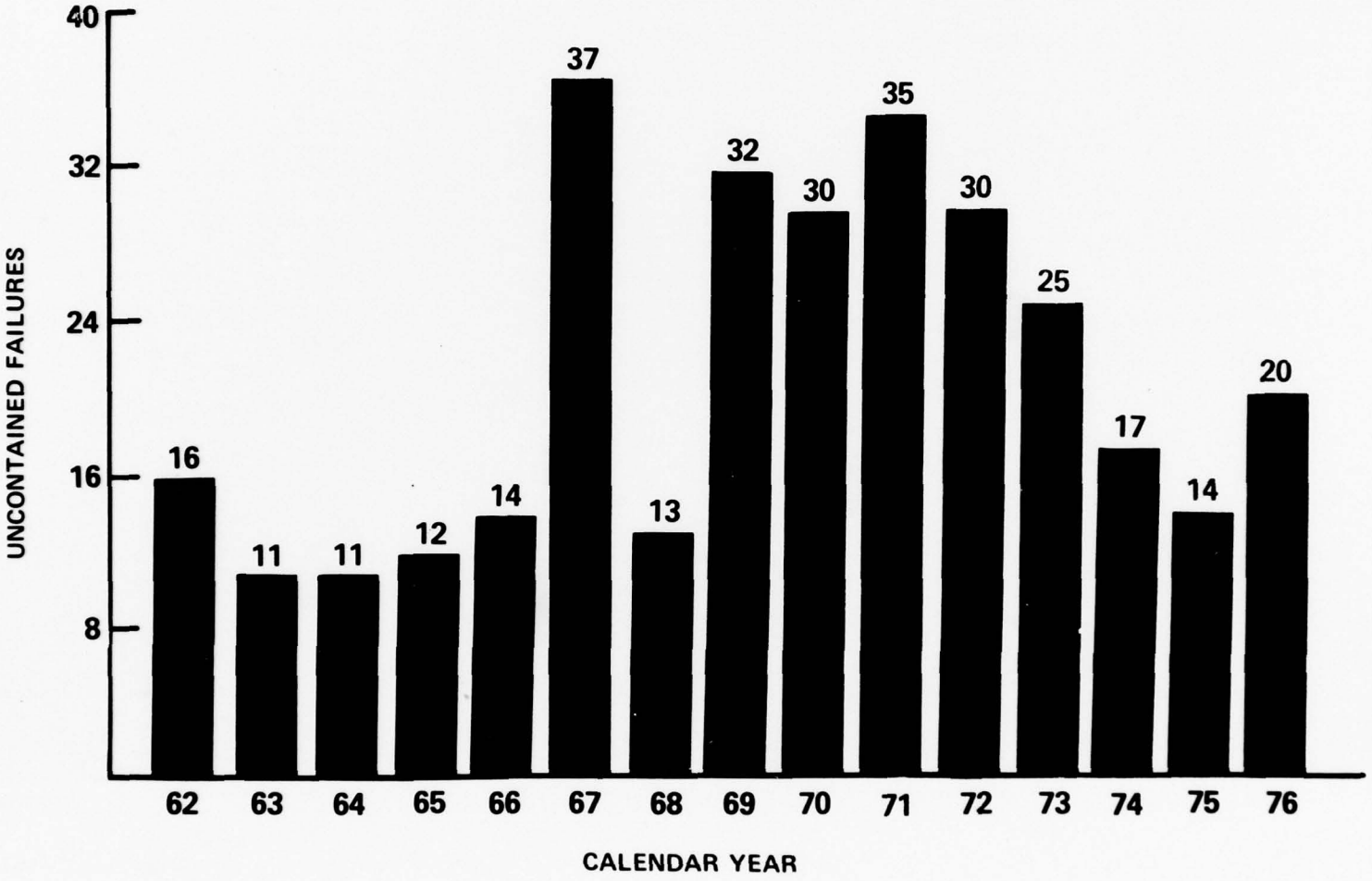
FLIGHT CONDITION AT ROTOR FAILURE – 1976



NAPC-PE-9

FIGURE 6

THE INCIDENCE OF UNCONTAINED ROTOR FAILURES IN U.S. COMMERCIAL AVIATION 1962 – 1976



NAPC-PE-9

APPENDIX A

Data on Rotor Failures in U. S. Commercial Aviation for 1976. 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 - 1976

SDR NO.	DATE	SUBMITTER	AIRCRAFT	ENGINE	COMPONENT	FRAGMENT TYPE	CAUSE	CONTAINMENT CONDITION	FLIGHT CONDITION
01136030	1/13	TXI	DC-9	JT8D	T	B	7	C	4
01136032	1/4	TWA	L-1011	RB211	T	B	7	C	4
01266024	1/13	VAL	DC-10	CF6	T	B	1	NC	5
01266066	1/26	EAL	L-1011	RB211	T	B	7	C	4
01266026	1/26	WAL	UNDET.	JT8D	C	S	7	NC	1
01266049	1/26	EAL	L-1011	RB211	T	B	7	C	4
02036029	1/18	AAA	BA111	SPEY	T	B	7	C	3
02056031	1/27	TWA	B-747	JT9D	T	B	2	C	3
02096030	1/28	SAAX	L-382	501	C	B	2	C	5
02096032	1/26	NWA	DC-10	JT9D	F	B	1	NC	5
02116039	2/1	NCA	DC-9	JT8D	T	B	2	C	6
02186026	2/1	AWI	DC-9	JT8D	T	B	7	C	7
02196035	2/8	TWA	B-747	JT9D	T	B	2	C	4
02266068	2/26	EAL	L-1011	RB211	C	B	2	C	4
02256036	2/6	PAA	B-747	JT9D	F	B	4	NC	4
03016033	2/19	UAL	B-727	JT8D	T	B	2	NC	3

CHARACTERISTICS OF ROTOR FAILURES - 1976 (Continued)

SDR NO.	DATE	SUBMITTER	AIRCRAFT	ENGINE	COMPONENT	FRAGMENT TYPE	CAUSE	CONTAINMENT CONDITION	FLIGHT CONDITION
03036030	2/22	TWA	B-747	JT9D	T	B	2	C	4
03036031	2/20	TWA	B-727	JT8D	T	B	2	C	4
03046029	2/22	SAAX	L-382	501	T	B	2	C	4
03056031	2/25	NCA	DC-9	JT8D	T	B	7	C	4
03236020	3/9	FAL	B-737	JT8A	C	B	3	C	5
03226024	3/4	TWA	B-727	JT8D	T	B	2	C	4
03116039	3/11	EAL	L-1011	RB211	T	B	2	C	4
04126035	3/28	NAL	DC-10	CF6	F	B	4	C	3
04126036	3/28	NAL	B-727	JT8D	T	B	2	C	3
04226029	4/12	TWA	B-707	JT3D	T	B	7	C	4
04016028	3/15	AAA	DC-9	JT8D	C	B	7	C	3
04296037	4/19	TWA	B-747	JT9D	T	S	2	NC	3
04306036	3/31	UAL	DC-10	CF6	T	B	1	C	3
04306037	4/12	TSA	B-737	JT8D	T	B	1	C	3
05056123	5/5	DAL	L-1011	RB211	T	B	2	C	10
05066031	4/20	NWA	DC-10	JT9D	F	B	3	C	1

CHARACTERISTICS OF ROTOR FAILURES - 1976 (Continued)

SDR NO.	DATE	SUBMITTER	AIRCRAFT	ENGINE	COMPONENT	FRAGMENT TYPE	CAUSE	CONTAINMENT CONDITION	FLIGHT CONDITION
05056121	5/5	EAL	L-1011	RB211	T	B	2	C	3
05066029	4/27	PAA	B-707	JT3D	C	B	2	NC	6
05196017	5/9	ONAS	DC-8	JT3D	C	B	2	C	4
05196018	5/7	PAI	B-737	JT8D	T	B	7	C	4
04276027	4/18	AAL	B-747	JT9D	T	B	3	C	4
05146080	5/14	EAL	L-1011	RB211	T	B	7	C	5
05256037	4/27	PSAX	UNDET.	JT8D	T	B	2	C	1
05276042	5/18	AAL	B-747	JT9D	T	S	2	NC	3
06046034	5/13	BCAT	LR-35	TFE731	T	B	1	C	6
06026036	5/19	AAA	DC-9	JT8D	T	B	1	C	3
06016087	6/1	EAL	L-1011	RB211	T	B	2	C	4
06076035	5/21	AAA	BA111	SPEY	T	B	7	C	3
06106024	6/1	TWA	B-747	JT9D	T	B	2	C	7
06116102	6/11	EAL	L-1011	RB211	T	B	7	C	10
06146023	6/2	TWA	B-727	JT8D	T	B	7	C	4
06226024	6/14	ACAX	B-737	JT8D	T	B	7	C	3
06226025	6/9	OZA	DC-9	JT8D	T	B	1	C	3

CHARACTERISTICS OF ROTOR FAILURES - 1976 (Continued)

SDR NO.	DATE	SUBMITTER	AIRCRAFT	ENGINE	COMPONENT	FRAGMENT TYPE	CAUSE	CONTAINMENT CONDITION	FLIGHT CONDITION
06306030 S	6/21	TWA	B-727	JT8D	T	B	7	C	3
07076031	6/26	TWA	L-1011	RB211	T	B	1	C	5
07226032	7/14	AAL	B-707	JT3D	F	B	4	NC	3
07286033	7/18	NAL	B-727	JT8D	C	B	7	NC	3
07306032	7/21	AAL	B-727	JT8D	F	B	7	C	4
08036030	7/21	OZA	DC-9	JT8D	T	B	2	C	4
08036031	7/19	NWA	B-747	JT9D	C	B	2	C	4
08056032	8/1	AAL	DC-10	CF6	C	B	2	NC	4
08096009	7/22	DAL	DC-8	JT3D	F	B	4	C	8
08295030	8/29	FAL	CV-580	501	T	D	1	NC	7
08265034	8/26	TWA	B-747	JT9D	T	S	7	NC	4
08126032	7/29	NWA	B-747	JT9D	T	B	2	C	3
08136028	7/28	NWA	DC-10	JT9D	T	B	1	C	3
08186027	8/8	TWA	B-747	JT9D	T	B	2	C	3
08266033	8/17	AAL	B-727	JT8D	F	B	2	C	3
08206032	8/9	AWI	DC-9	JT8D	T	B	7	C	4
08236032	8/12	PCTC	CV-990	CJ805	F	B	3	NC	3

CHARACTERISTICS OF ROTOR FAILURES - 1976 (Continued)

SDR NO.	DATE	SUBMITTER	AIRCRAFT	ENGINE	COMPONENT	FRAGMENT TYPE	CAUSE	CONTAINMENT CONDITION	FLIGHT CONDITION
08256030	8/13	SOU	DC-9	JT8D	T	B	7	C	3
08276032	8/13	FTLS	DC-8	JT3D	C	R	1	NC	3
08276035	8/18	NCA	DC-9	JT8D	T	B	7	C	3
09026028	8/6	BCAT	LR-35	TFE731	T	B	1	C	5
09096029	8/29	NAL	DC-10	CF6	T	B	7	C	5
09096031	8/30	TWA	B-747	JT9D	T	B	2	C	5
09106036	8/31	ACAX	B-737	JT8D	T	B	7	C	3
09106037	9/1	TWA	L-1011	RB211	T	B	1	C	4
09176028	8/27	CAPS	DC-8	JT3D	T	B	7	C	3
09206030	8/31	CAPS	DC-8	JT4A	T	B	7	C	5
09286024	9/21	TWA	B-707	JT3D	T	B	7	C	4
09286026	9/17	OZA	DC-9	JT8D	C	B	2	C	5
09296020	9/7	DAL	B-727	JT8D	C	B	2	C	5
10016019	9/19	AWI	DC-9	JT8D	T	B	1	C	10
10056025	9/21	AAA	BA111	SPEY	T	B	7	C	4
10066025	9/3	PSAX	B-727	JT8D	T	B	7	C	5
10046023	10/4	PAA	B-747	JT9D	T	B	2	C	5

CHARACTERISTICS OF ROTOR FAILURES - 1976 (Continued)

SDR NO.	DATE	SUBMITTER	AIRCRAFT	ENGINE	COMPONENT	FRAGMENT TYPE	CAUSE	CONTAINMENT CONDITION	FLIGHT CONDITION
10156025	10/1	CAL	DC-10	CF6	T	B	7	C	4
10196019	10/7	TWA	B-707	JT3D	C	B	7	C	3
10196021	10/9	TWA	B-727	JT8D	C	B	7	C	4
10206024	10/11	AAA	BA111	SPEY	C	B	7	C	3
10196019	10/7	TWA	B-707	JT3D	C	B	7	C	4
10305019	10/30	KTS	DC-9	JT8D	T	B	7	NC	3
10196021	10/9	TWA	B-727	JT8D	C	B	7	C	4
10216025	10/12	AAA	BA111	SPEY	C	B	7	C	3
10226026	10/15	TWA	B-707	JT4A	T	B	2	C	4
10276016	10/5	BCAT	LR-35	TFE731	T	B	1	C	4
11176023	11/4	WAL	B-720	JT8D	C	B	7	NC	3
11036027	10/20	FAL	CV-580	501	C	B	7	C	4
11096021	10/21	AAA	BA111	506	T	B	7	C	3
11105026	1/11	WAA	F-27B	DART	T	D	1	NC	6
11236020	1/12	TWA	B-747	JT9D	C	B	2	C	4
11266032	11/13	EAL	L-1011	RB211	T	B	1	C	5
12076025	11/29	TWA	L-1011	RB211	C	B	2	C	4

CHARACTERISTICS OF ROTOR FAILURES - 1976 (Continued)

SDR NO.	DATE	SUBMITTER	AIRCRAFT	ENGINE	COMPONENT	FRAGMENT TYPE	CAUSE	CONTAINMENT CONDITION	FLIGHT CONDITION
12096023	11/30	TWA	B-727	JT8D	C	R	7	NC	4
12146024	11/17	EAL	B-727	JT8D	C	B	2	C	4
12166025	12/8	TWA	B-707	JT3D	T	B	7	C	3
12296026	11/10	BCAT	LR-35	TFE731	T	B	3	C	5
05106030	5/10	UAL	DC-10	CF6	T	B	7	C	1
01107023	12/27	FAL	CV-580	501	T	B	7	C	8
01127031	12/30	BNF	DC-8	JT3D	T	B	7	C	7
01177032	12/23	UAL	B-727	JT8D	T	B	2	NC	4
02017037	1/22	EAL	L-1011	RB211	T	B	7	C	3
04266036	4/26	NCA	CV-580	501	C	N	3	N	3
12016024	12/1	SAAS	1886	501	C	N	3	N	3
05076030	5/7	FECT	FALCON	CF7	C	N	3	N	4
10276018	10/27	MIAS	DC-8	JT4A	C	N	3	N	8
04136037	3/25	AAA	DC-9	JT8D	C	N	3	N	3
06116016	5/30	AAIX	B-720	JT3C	C	N	3	N	1
06106025	5/31	PAA	B-747	JT9D	F	N	3	N	7
05106028	4/29	ACAX	L-188C	501	C	N	3	N	4

CHARACTERISTICS OF ROTOR FAILURES - 1976 (Continued)

SDR NO.	DATE	SUBMITTER	AIRCRAFT	ENGINE	COMPONENT	FRAGMENT TYPE	CAUSE	CONTAINMENT CONDITION	FLIGHT CONDITION
02026023	2/2	SAAS	L-382	501	C	N	3	N	7
05116028	4/19	FECT	FALCON	CF7	C	N	3	N	5
03056030	2/22	PAA	B-707	JT3D	C	N	3	N	3
08106030	8/10	DAL	DC-8	JT3D	F	N	3	N	3
12016026	11/21	TWA	B-707	JT3D	F	N	3	N	3
04266037	4/26	PAA	B-707	JT3D	F	N	3	N	5
07216030	7/9	TIAS	DC-8	JT3D	C	N	3	N	4
10196020	10/7	ONAS	DC-8	JT4	C	N	3	N	6
04146031	3/30	AAA	DC-9	JT8D	F	N	3	N	3
10296013	10/26	SWAX	B-737	JT8D	F	N	3	N	1
02266068	2/26	EAL	L-1011	RB-211	C	N	3	N	4
08266032	8/8	PCTC	CV-990	CJ805	F	N	3	N	1
01166027	1/5	AAA	DC-9	JT8D	C	N	7	N	4
01196031	1/7	AAA	DC-9	JT8D	T	N	7	N	3
04196034	3/22	PSAX	UNDET.	JT8D	T	N	7	N	10
04236036	3/6	FECT	MD-20	CF7	C	N	7	N	4
04236038	3/22	FECT	MD-20	CF7	F	N	7	N	1

CHARACTERISTICS OF ROTOR FAILURES - 1976 (Continued)

SDR NO.	DATE	SUBMITTER	AIRCRAFT	ENGINE	COMPONENT	FRAGMENT TYPE	CAUSE	CONTAINMENT CONDITION	FLIGHT CONDITION
04266037	4/12	PAA	B-707	JT3D	F	N	3	N	5
05136028	5/2	NAL	DC-10	CF6	C	N	2	N	5
05206023	5/9	AAA	DC-9	JT8D	C	N	3	N	3
06236009	6/10	BNF	B-727	JT8D	F	N	3	N	3
06246021	6/14	OZA	DC-9	JT8D	F	N	3	N	3
06306017	6/14	OZA	DC-9	JT8D	F	N	3	N	3
07126008	6/28	TWA	B-727	JT8D	F	N	3	N	3
0708630	6/14	AIAX	L-382	501	T	N	3	N	3
07166014	7/3	OZA	DC-9	JT8D	F	N	3	N	10
07206020	7/5	AAA	DC-9	JT8D	T	N	2	N	1
08136026	6/22	PSAX	UNDET.	JT8D	T	N	2	N	10
08206030	8/20	SAAS	L-382	501	C	N	3	N	3
08266034	8/6	FAL	B-737	JT8D	F	N	2	N	1
10186025	10/10	EAL	L-1011	RB-211	C	N	7	N	3
01277030	1/4	SRAX	L-382	501	C	N	7	N	1
02027038	1/14	AAA	BA-111	SPEY	T	N	3	N	3
02026023	1/17	SAAX	L-382	501	C	N	3	N	7

CHARACTERISTICS OF ROTOR FAILURES - 1976 (Continued)

SDR NO.	DATE	SUBMITTER	AIRCRAFT	ENGINE	COMPONENT	FRAGMENT TYPE	CAUSE	CONTAINMENT CONDITION	FLIGHT CONDITION
05196013	5/5	PCTC	L-188	501	C	N	2	N	4
11016021	10/26	NAL	DC-10	CF6	C	N	7	N	3
09206028	9/6	NAL	DC-10	CF6	F	N	7	N	3
03306023	3/17	NAL	DC-10	CF6	C	N	7	N	3
05076030	5/7	FECT	MD-20	CF7	C	N	3	N	4
11176024	11/17	TWA	B-707	JT3D	C	N	3	N	5
02096030	1/28	PAI	B-737	JT8D	C	N	7	N	4
08276034	8/15	TXI	DC-9	JT8D	F	N	2	N	3
03106030	3/10	CAL	B-727	JT8D	F	N	2	N	1
03306024	3/30	CAL	B-727	JT8D	F	N	2	N	1
09096030	8/27	CAL	B-727	JT8D	C	N	2	N	4
07166030	7/3	TWA	B-727	JT8D	T	N	7	N	4
12296022	12/15	TWA	B-727	JT8D	T	N	7	N	4
11096020	10/19	PSAX	B-727	JT8D	T	N	2	N	5
07096032	7/9	AAA	DC-9	JT8D	T	N	2	N	1
09156026	9/5	TWA	B-747	JT9D	F	N	3	N	3
03246031	3/14	TWA	B-747	JT9D	F	N	2	N	4

CHARACTERISTICS OF ROTOR FAILURES - 1976 (Continued)

SDR NO.	DATE	SUBMITTER	AIRCRAFT	ENGINE	COMPONENT	FRAGMENT TYPE	CAUSE	CONTAINMENT CONDITION	FLIGHT CONDITION
03116031	3/11	FTLS	B-747	JT9D	C	N	2	N	4
0316138	3/31	EAL	L-1011	RB211	C	N	7	N	3
04286087	4/28	EAL	L-1011	RB211	C	N	7	N	4
03176073	3/17	EAL	L-1011	RB211	C	N	7	N	3
04196046	4/19	EAL	L-1011	RB211	C	N	7	N	3
06016090	6/1	EAL	L-1011	RB211	C	N	7	N	3
03056069	3/5	EAL	L-1011	RB211	C	N	7	N	3
01166060	1/16	EAL	L-1011	RB211	C	N	7	N	6
04096102	4/9	EAL	L-1011	RB211	C	N	7	N	3
02066074	2/6	DAL	L-1011	RB211	F	N	3	N	3
02256066	2/25	EAL	L-1011	RB211	T	N	2	N	4
01166063	1/16	EAL	L-1011	RB211	T	N	7	N	3
06246052	6/24	EAL	L-1011	RB211	T	N	2	N	1
02046033	1/22	PAI	B-737	JT8D	C	N	7	N	4
08196030	9/15	NCA	CV-580	501	C	N	3	N	3
10016018	9/22	SAAS	L-188	501	T	N	2	N	10

CHARACTERISTICS OF ROTOR FAILURES - 1976 (Continued)

SDR NO.	DATE	SUBMITTER	AIRCRAFT	ENGINE	COMPONENT	FRAGMENT TYPE	CAUSE	CONTAINMENT CONDITION	FLIGHT CONDITION
01107025	12/26	MIAS	B-720	JT3C	C	N	3	N	3
09106037	9/1	TWA	L-1011	RB211	T	N	7	N	4

DISTRIBUTION LIST

Activity	Copies
Commander, Naval Air Systems Command (AIR-50174), Department of the Navy, Washington, DC 20361 Intra-command Addressees: AIR-330A (1) AIR-5361 (1) AIR-530 (1) AIR-5362 (1) AIR-536 (1) MAT-03L (1) AIR-5360 (1) AIR-330 (1)	9
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, Ohio 45433	1
National Aeronautics and Space Administration, Attn: A. G. Holms, M.S. 100-1, 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

AD-A064 292 NAVAL AIR PROPULSION CENTER TRENTON NJ PROPULSION TE--ETC F/G 1/2
ROTOR FRAGMENT PROTECTION PROGRAM: STATISTICS ON AIRCRAFT GAS T--ETC(U)
JUL 78 R A DELUCIA, J T SALVINO NASA-DPR-C-41581B
UNCLASSIFIED NAPC-PE-9 NASA-CR-159474 NL

2 OF 2
AD A064292

END
DATE FILMED
9-79
DDC

SUPPLEMENTARY

INFORMATION

AD-A064 292

DEPARTMENT OF THE NAVY
NAVAL AIR PROPULSION CENTER
P.O. BOX 7176
TRENTON, NEW JERSEY 08628

IN REPLY REFER TO
PE42:RAD:ml
3900
Ser R392
7 March 1979

From: Commanding Officer, Naval Air Propulsion Center
To: Distribution

Subj: NAPC Formal Report "Rotor Fragment Protection Program: Statistics on Gas Turbine Engine Rotor Failure That Occurred in U.S. Commercial Aviation During 1976" NAPC-PE-9 NASA-CR-159474; by R. A. DeLucia and J. T. Salvino, July 1978; correction to

Encl: (1) NAPC Figure 3 The Incidence Of Rotor Failure (1) In U.S. Commercial Aviation According To Engine Type Affected - 1976 - Page 6 (corrected copy)

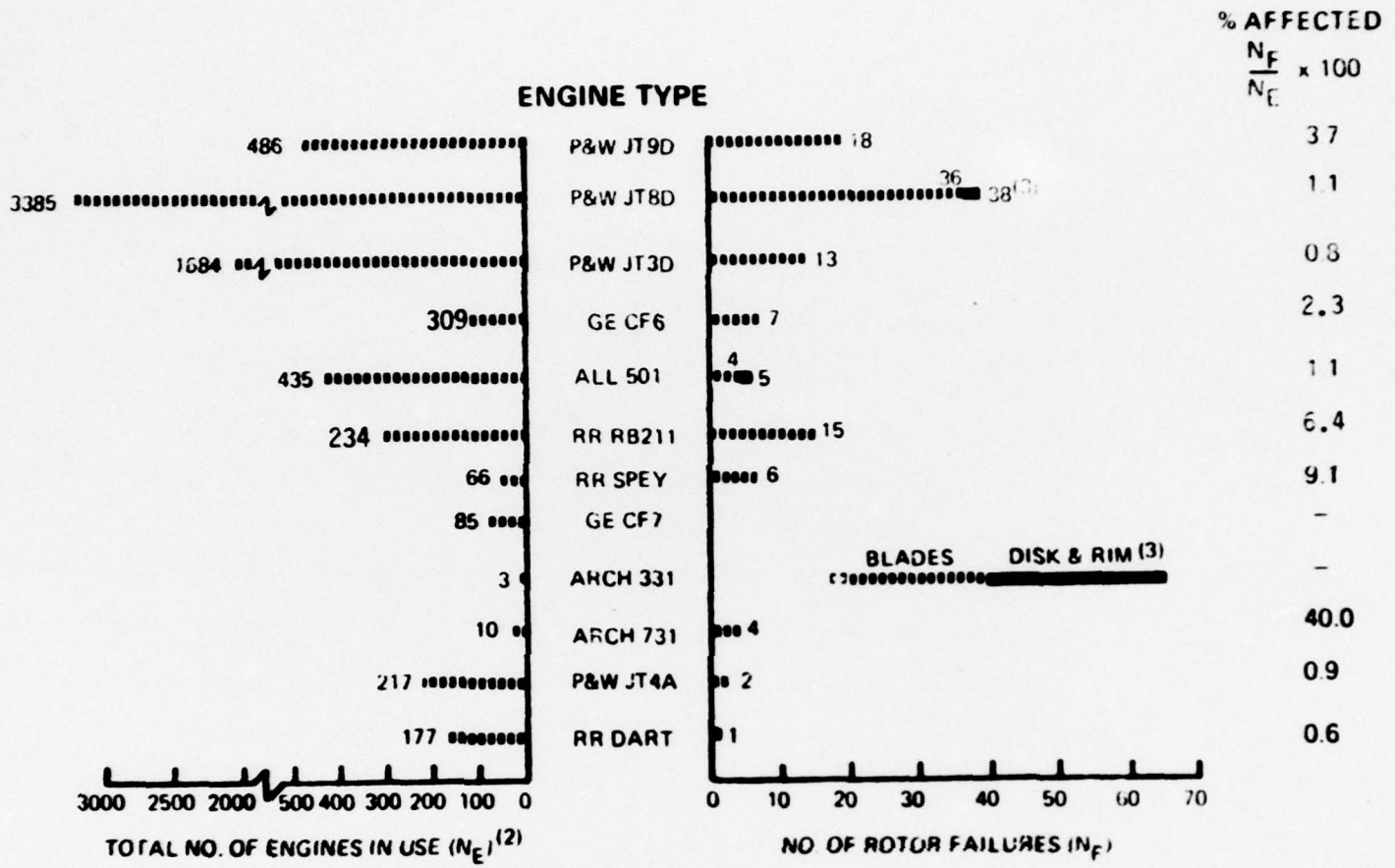
1. Enclosure (1) is being forwarded for replacement of page 6 in subject report.

Jack L. Moss

J. L. MOSS
By direction

FIGURE 3

THE INCIDENCE OF ROTOR FAILURE[1] IN U.S. COMMERCIAL AVIATION ACCORDING TO ENGINE TYPE AFFECTED – 1976



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

NAPC-PE-9

ENCL (1)