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# Statistics on Aircraft Gas Turbine Engine Rotor Failures that Occurred in U. S. Commercial Aviation During 1984

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Final Report



U.S. Department of Transportation
**Federal Aviation Administration**

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16. Abstract

This report presents statistical information relating to gas turbine engine rotor failures which occurred during 1984 in commercial aviation service use. Two hundred and six failures occurred in 1984. Rotor fragments were generated in 114 of the failures and, of these, 18 were uncontained. The predominant failure involved blade fragments, 90.3 percent of which were contained. Seven disk failures occurred and all were uncontained. Seventy percent of the 206 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 are useful in support of flight safety analyses, proposed regulatory actions, certification standards, and cost benefit analyses.

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## EXECUTIVE SUMMARY

This service data analysis is prepared on a calendar 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 1984.

Two hundred and six rotor failures were reported in 1984. These failures accounted for approximately 12 percent of the 1657 shutdowns experienced by the United States commercial fleet. Rotor fragments were generated in 114 of the failures and, of these, 18 were uncontained. This represents an uncontained failure rate of 1.8 per million gas turbine engine powered aircraft flight hours, or 0.7 per million engine operating hours. Approximately 10.2 million and 24.7 million aircraft flight and engine operating hours, respectively, were logged in 1984.

Turbine rotor fragment-producing failures were approximately two times greater than that of the compressor rotor fragment-producing failures (79 and 32 respectively, of the total). Fan rotor failures accounted for three of the fragment-producing failures experienced.

Blade fragments were generated in 103 of the rotor failures; 10 of these were uncontained. The remaining eleven fragment-generating failures were produced by disk, rim, and seal.

Of the 115 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--48 (41.7 percent); (2) secondary causes--35 (30.4 percent); and (3) design and life prediction problems--32 (27.8 percent). One hundred and forty-five (71.4 percent) of the 206 rotor failures occurred during the takeoff and climb stages of flight. Ninety (78.9 percent) of the 114 rotor fragment-producing failures and 14 (77.8 percent) of the 18 uncontained rotor failures occurred during these same stages of flight.

The incidence of engine rotor failures producing fragments has increased 18.7 percent from 1983 (96 in 1983 and 114 in 1984). The uncontained engine rotor failures has increased 100 percent in 1984 (9 in 1983 and 18 in 1984). The 10-year (1975 through 1984) average of uncontained engine rotor failures has increased to 15.2.

# INTRODUCTION

This report is sponsored and co-authored 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.

The intent and purpose of this report is to present data as objectively as possible on rotor failure occurrences in United States commercial aviation. Presented in this report are statistics on gas turbine engine utilization and failures that have occurred in U.S. commercial aviation during 1984. These statistics are based on service data compiled by the FAA Flight Standards District Office. The National Safety Data Branch of the FAA Aviation Standards National Field Office disseminates this information in a service difficulty data base and the Air Carrier Aircraft Utilization and Propulsion Reliability Report. The FAA service data base contains only a fraction of the actual commercial helicopter fleet operating statistics. The number of turboshaft engines in use with the corresponding engine flight hours given herein are estimates derived primarily from statistics published by the Helicopter Association International in their helicoper annuals. 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) typically 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 analysis are contained in appendix A. The results of these analyses are shown in figures 1 through 7 and tables 1 and 2.

Figure 1 shows that 206 rotor failures occurred in 1984. These rotor failures accounted for approximately 12.4 percent of the 1657 shutdowns experienced by the gas turbine powered U.S. commercial aircraft fleet during 1984. Rotor fragments were generated in 114 of the failures experienced and, of these, 18 (15.8 percent of the fragment-producing failures) were uncontained. This represents an uncontained failure rate of 1.8 per million gas turbine engine powered aircraft flight hours, or 0.7 per million engine operating hours.

Approximately 10.1 million and 24.6 million aircraft flight and engine operating hours, respectively, were logged by the U.S. commercial aviation fleet in 1984. 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 type 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 78 (68.4 percent) and 33 (28.9 percent), respectively, of the total number of fragment-producing failures. Fan rotor failures accounted for three (2.6 percent) of the fragment-producing failures experienced.

2. Blade fragments were generated in 103 (90.3 percent) of the rotor failures; 10 (8.8 percent) of these were uncontained. The remaining 11 (9.6 percent) rotor fragment failures were produced by disk, rim, and seal. All of the seven disk failures were uncontained, one rim failure was contained, and one of the three seal failures was uncontained.

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

Table 1 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/turbojet--8.5, turboprop--11.1, and turboshaft--2.0. Uncontained engine failure rates per million flight hours by engine type were turbofan/turbojet--0.7, turboprop--0.8, and turboshaft--1.0.

Figure 5 shows what caused the rotor failures to occur. Of the 115 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--48 (41.7 percent); (2) secondary causes--35 (30.4 percent); and (3) design and life prediction problems--32 (27.8 percent).

Figure 6 indicates the flight conditions that existed when the various rotor failures occurred. One hundred and forty-five (70.4 percent) of the 206 rotor failures occurred during the takeoff and climb stages of flight. Ninety (78.9 percent) of the rotor fragment-producing failures and 14 (77.8 percent) of the uncontained rotor failures occurred during these same stages of flight. The highest number of uncontained rotor failures, 11 (61.1 percent), happened during takeoff.

Table 2 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 1984. This table 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 30 and 5). For "design and life prediction problems" the number of "high" power uncontained failures was three times greater than "low" power (namely 24 and 8); and for "foreign object damage" the number of uncontained failures was seven times greater at "high" power than "low" power (namely 7 and 1). This tabulation also indicates that of the 138 total uncontained incidences, blade failures accounted for 68.1 percent; disk failures, 20.3 percent; rim failures, 5.1 percent; and seal/spacer failures, 6.5 percent.

Figure 7 shows the annual incidence of uncontained rotor failures in commercial aviation for the years 1962 through 1984. During 1984, the incidence of uncontained rotor failures increased by nine over the previous year, 1983. Over the past 10 years, 1975 through 1984, an average of 15.2 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 1983 (96 in 1983 and 114 in 1984). The uncontained engine rotor failures has increased 100 percent (18 in 1984 and 9 in 1983). The 10-year (1975 through 1984) average of uncontained engine rotor failures is 15.2.

Of the 18 uncontained events that occurred during 1984, 12 (66.7 percent) involved turbine rotors, 5 (27.8 percent) involved compressor rotors, and 1 (5.6 percent) involved fan rotors.

The predominant cause of failure was attributed to foreign object damage (41.7 percent of the known failures), but no uncontained failure occurred in this category. Secondary causes (30.4 percent of the known failures) and design and life prediction problems (27.8 percent of the known causes) had 4 and 3 uncontained failures, respectively. The causes of the remaining 11 uncontained failures (61.1 percent) are unknown.

Uncontained failures occurred in 3 of the 10 known flight modes; i.e., 11 during takeoff (61.1 percent), 3 during climb (16.7 percent), and 3 in cruise (16.7 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.

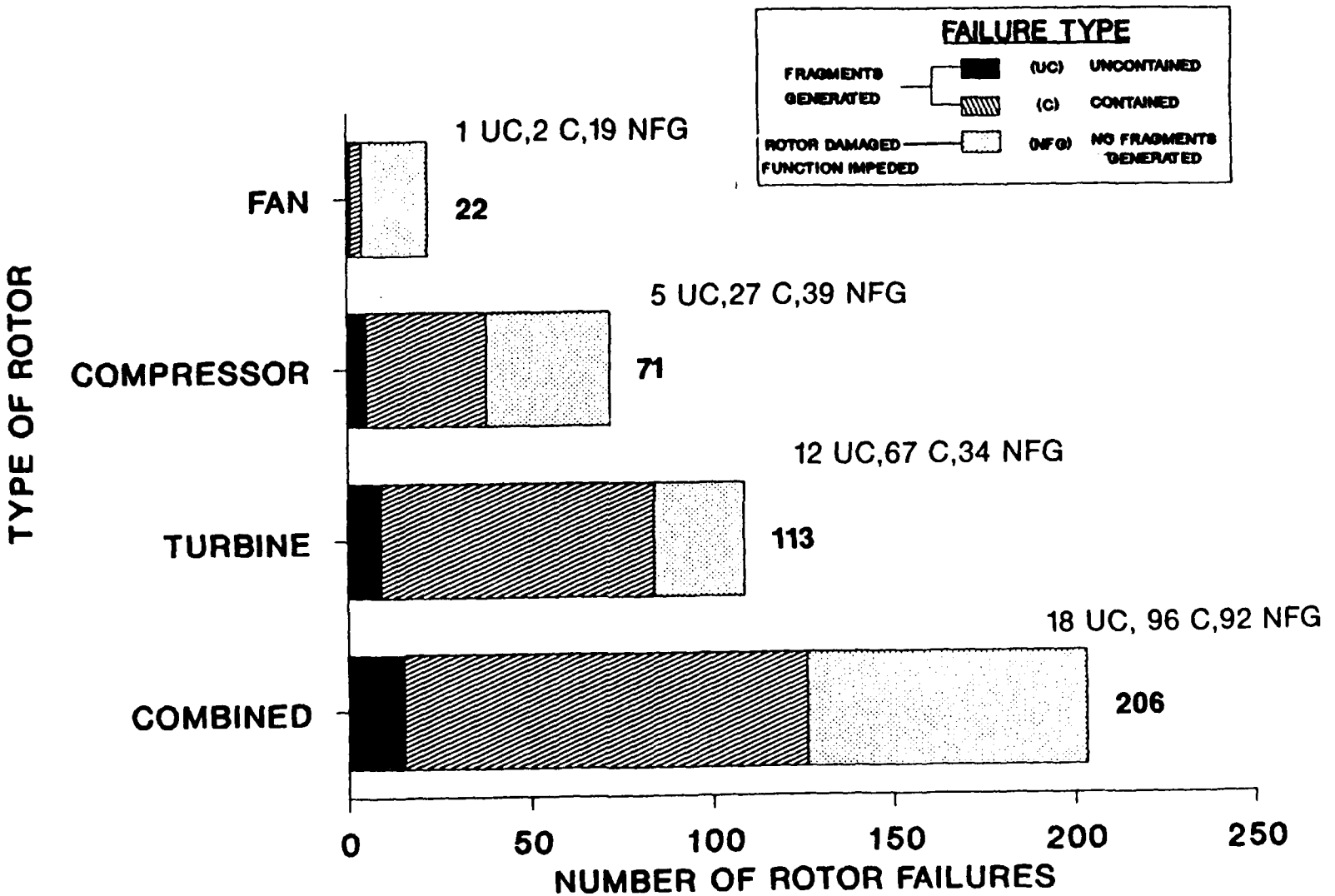



FIGURE 1. INCIDENCE OF ENGINE ROTOR FAILURES IN U.S. COMMERCIAL AVIATION - 1984

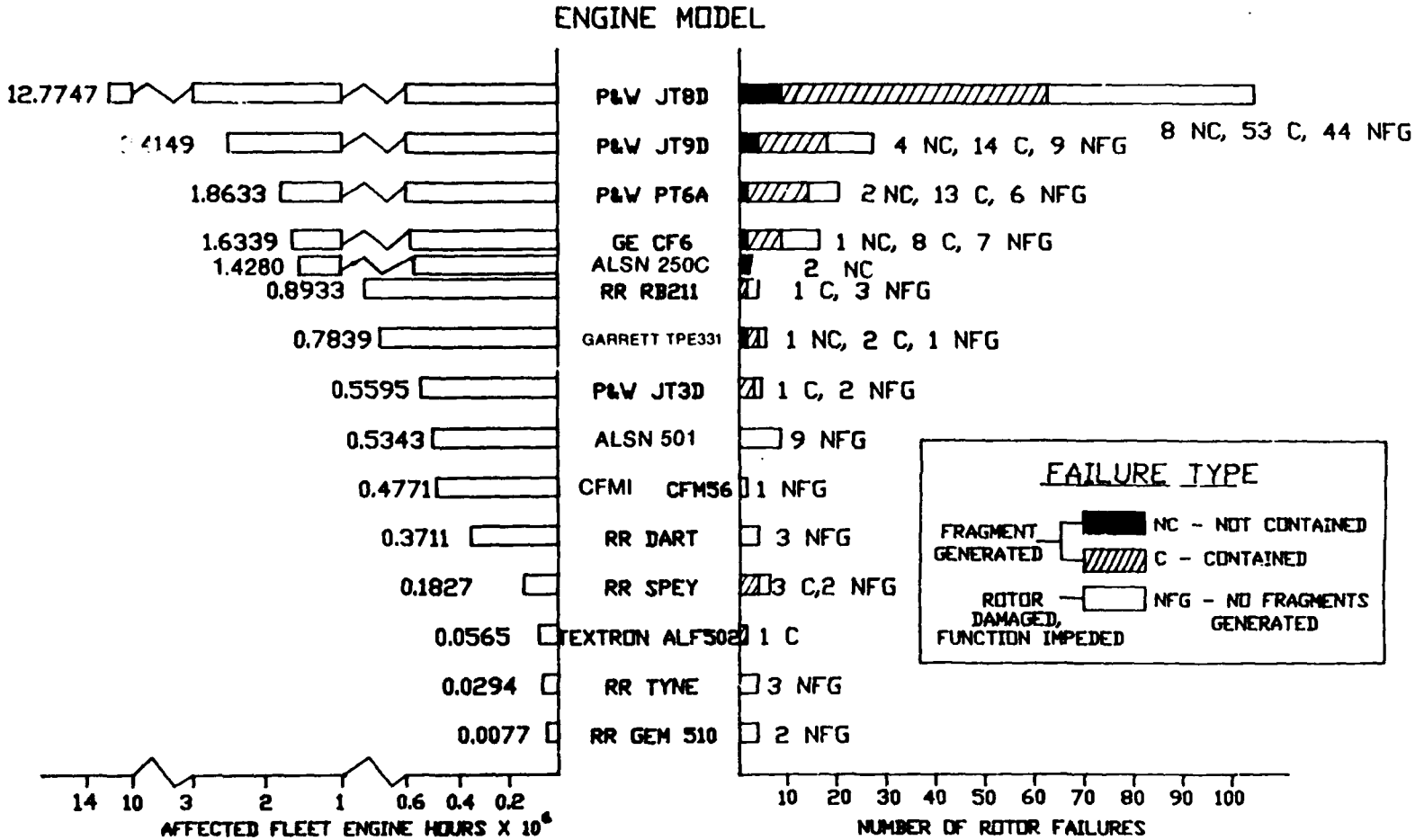



FIGURE 2. INCIDENCE OF ENGINE ROTOR FAILURES IN U.S COMMERCIAL AVIATION ACCORDING TO AFFECTED ENGINE MODEL AND ENGINE FLEET HOURS - 1984

| ENGINE ROTOR COMPONENTS | TYPE OF FRAGMENT GENERATED | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | DISK | | RIM | | BLADE | | SEAL | | TOTAL | |
| | TF | UCF | TF | UCF | TF | UCF | TF | UCF | TF | UCF |
| FAN | 0 | 0 | 0 | 0 | 3 | 1 | 0 | 0 | 3 | 1 |
| COMPRESSOR | 1 | 1 | 0 | 0 | 30 | 4 | 2 | 0 | 33 | 5 |
| TURBINE | 6 | 6 | 1 | 0 | 70 | 5 | 1 | 1 | 78 | 12 |
| TOTAL | 7 | 7 | 1 | 0 | 103 | 10 | 3 | 1 | 114 | 18 |

NOTES:

(1) FAILURES THAT PRODUCED FRAGMENTS

TF - TOTAL FAILURES

UCF - UNCONTAINED FAILURES

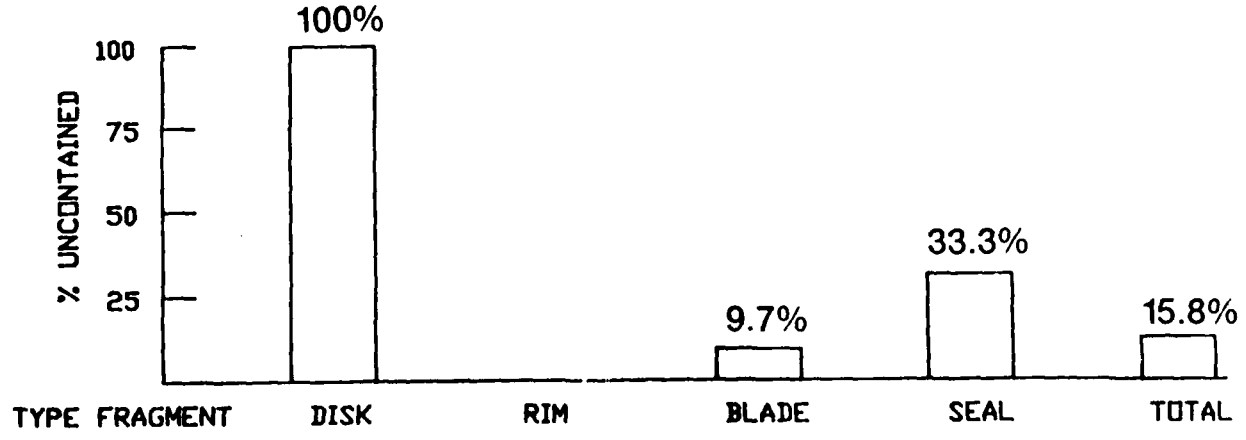
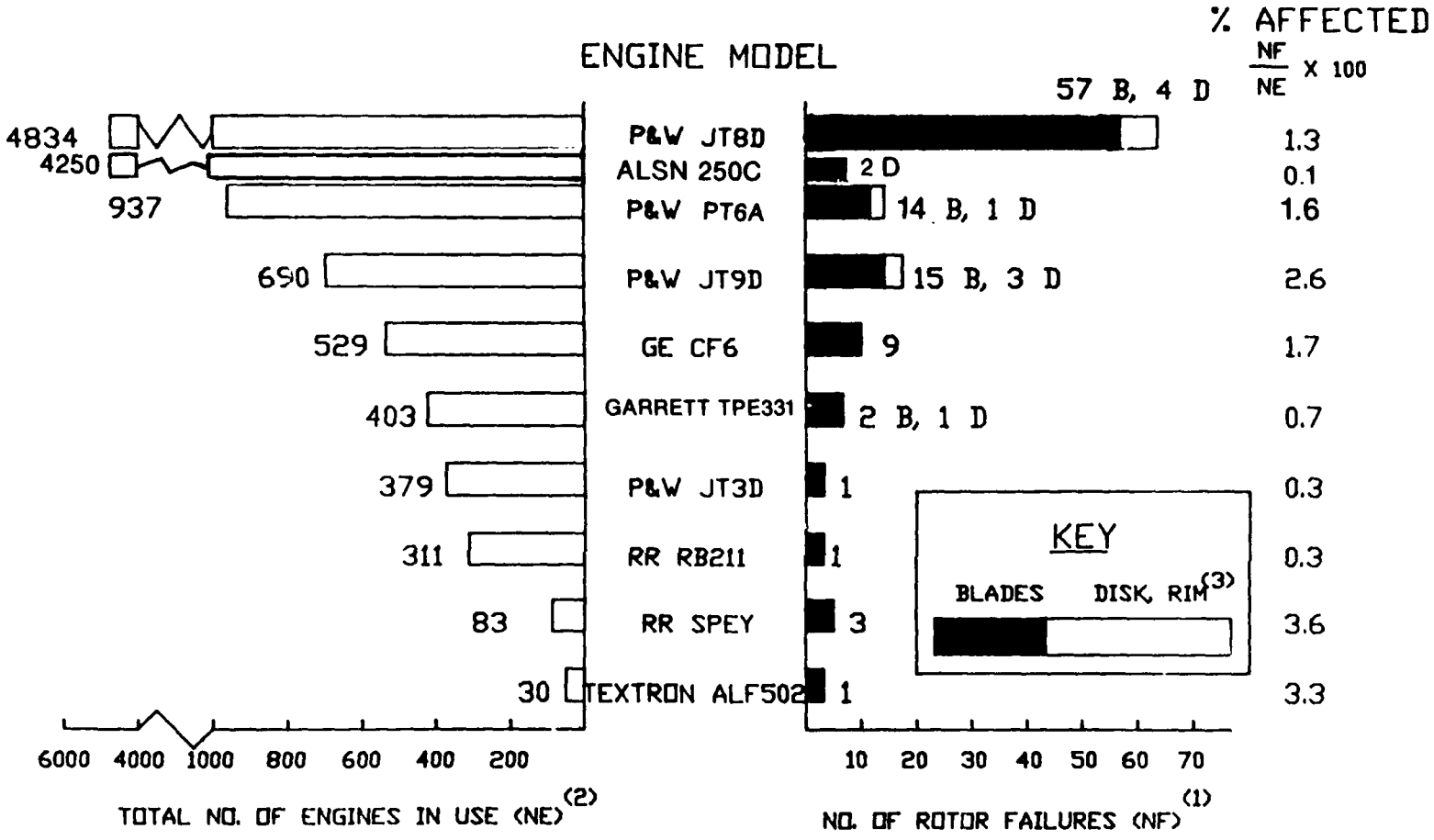



FIGURE 3. COMPONENT AND FRAGMENT TYPE DISTRIBUTIONS FOR CONTAINED AND UNCONTAINED ROTOR ENGINE FAILURES (FAILURES THAT PRODUCED FRAGMENTS) - 1984




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 - 1984

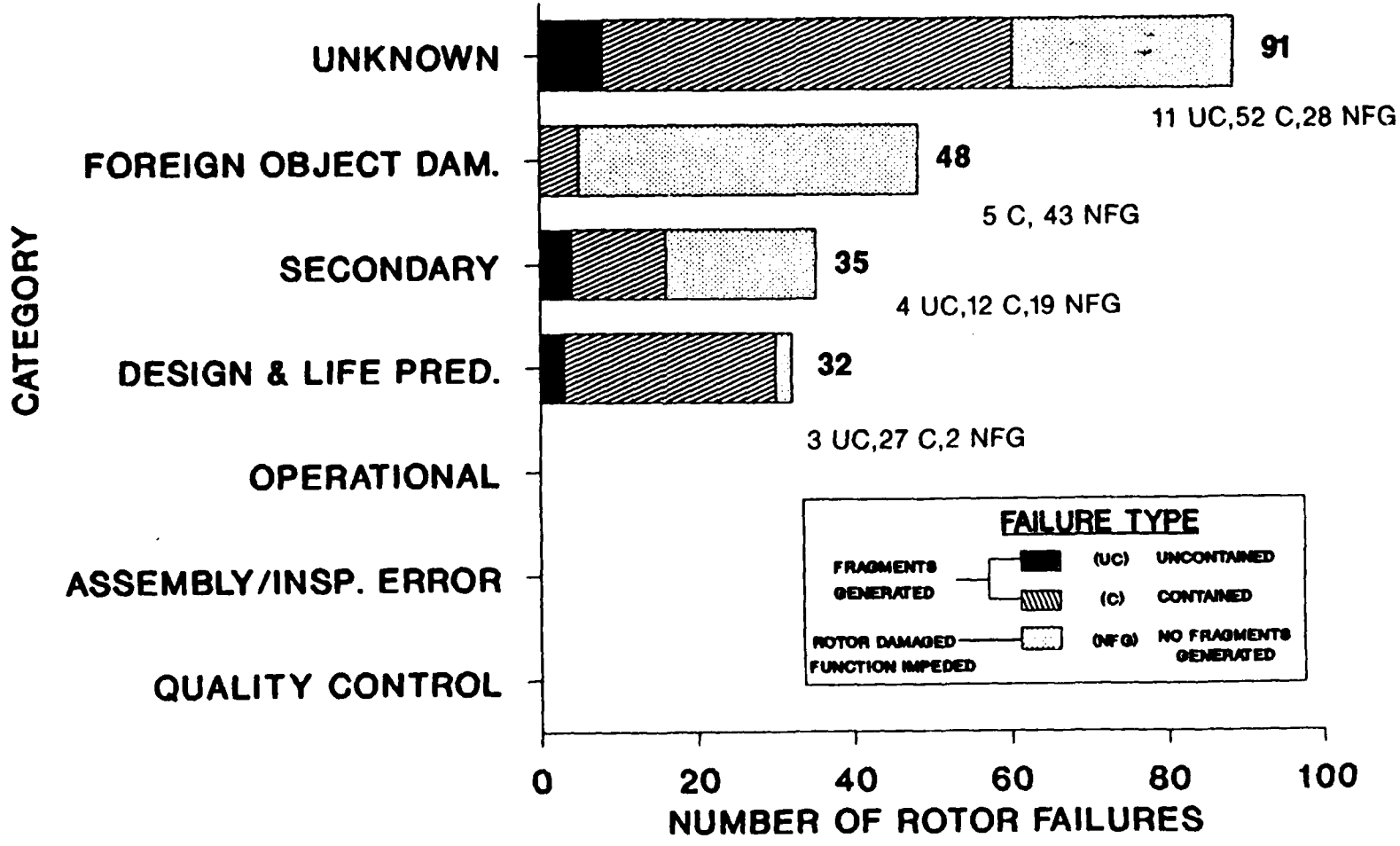



FIGURE 5. ENGINE ROTOR FAILURE CAUSE CATEGORIES - 1984

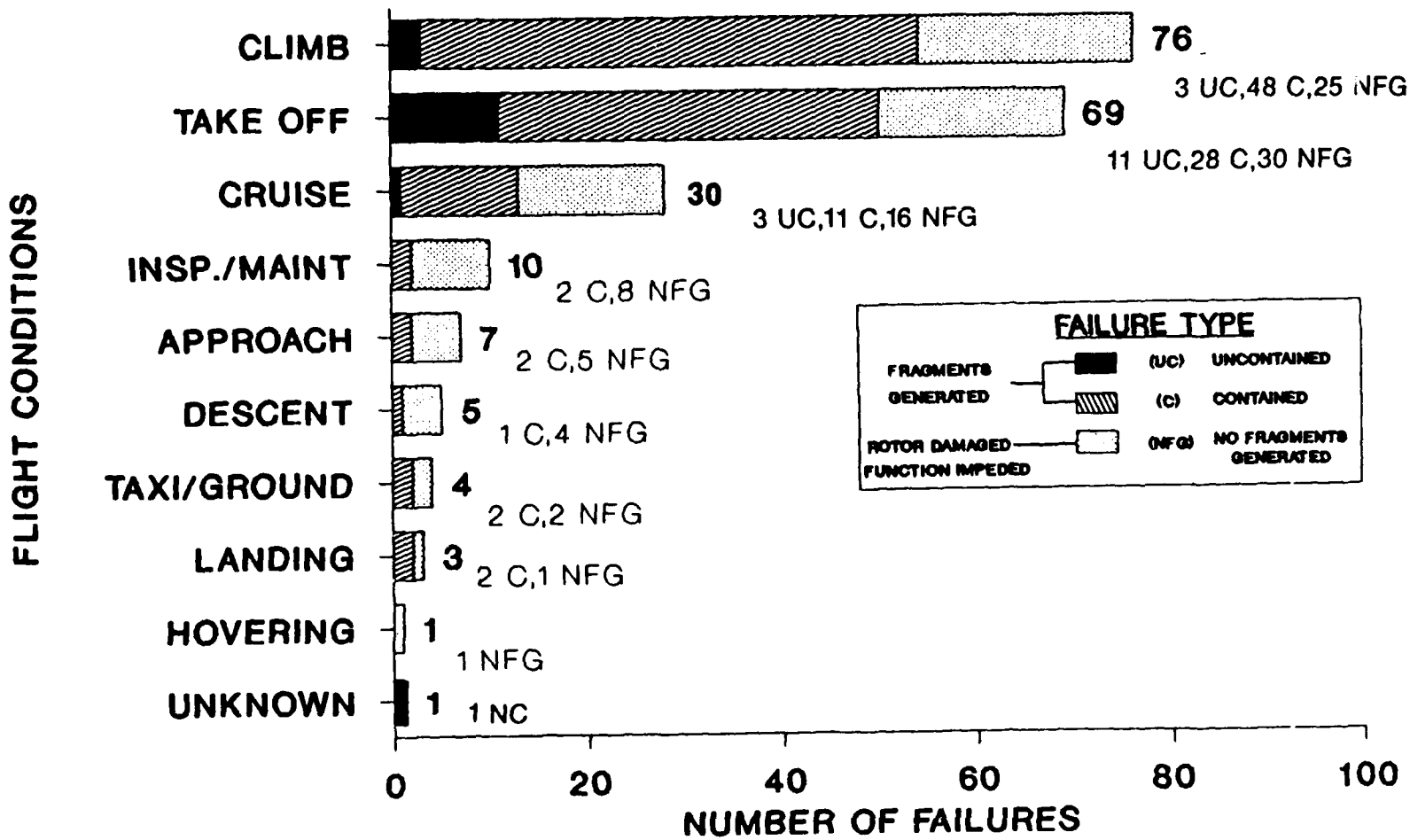



FIGURE 6. FLIGHT CONDITION AT ENGINE ROTOR FAILURE - 1984

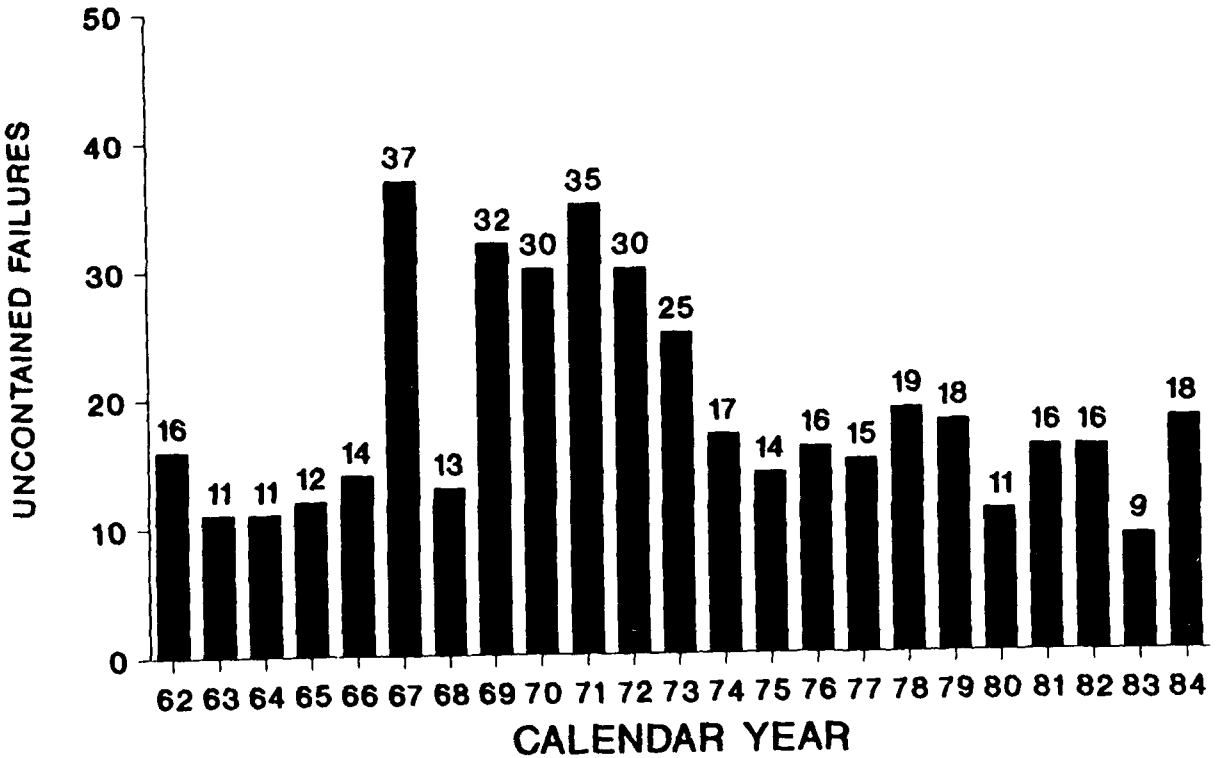



FIGURE 7. THE INCIDENCE OF UNCONTAINED ENGINE ROTOR FAILURES IN U.S. COMMERCIAL AVIATION, 1962 through 1984

TABLE 1. GAS TURBINE ENGINE FAILURE RATES ACCORDING TO ENGINE MODEL AND TYPE - 1984

| TYPE/ MODEL | AVERAGE NUMBER IN USE | ENGINE FLIGHT HRS.x$10^6$ | NO. OF FAILURES | | | | FAIL.RATES / $10^6$ ENGINE FLIGHT HRS. | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | C | NC | N | TOTAL | C | NC | N | TOTAL |
| TURBOFAN/TURBOJET | | | | | | | | | | |
| JT8D | 4834 | 12.7747 | 53 | 8 | 44 | 105 | 4.1 | 0.6 | 3.4 | 8.2 |
| JT3D | 379 | 0.5595 | 1 | 0 | 2 | 3 | 1.8 | 0.0 | 3.6 | 5.4 |
| JT9D | 690 | 2.4149 | 14 | 4 | 9 | 27 | 5.8 | 1.7 | 3.7 | 11.2 |
| CF6 | 529 | 1.6339 | 8 | 1 | 7 | 16 | 4.9 | 0.6 | 4.3 | 9.8 |
| RB211 | 311 | 0.8933 | 1 | 0 | 3 | 4 | 1.1 | 0.0 | 3.4 | 4.5 |
| CF700 | 15 | 0.0052 | 0 | 0 | 0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| SPEY | 83 | 0.1827 | 3 | 0 | 2 | 5 | 16.4 | 0.0 | 10.9 | 27.4 |
| JT15D | 3 | 0.0011 | 0 | 0 | 0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| TFE731 | 9 | 0.0093 | 0 | 0 | 0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| CFM56 | 229 | 0.4771 | 0 | 0 | 1 | 1 | 0.0 | 0.0 | 2.1 | 2.1 |
| ALF502 | 30 | 0.0565 | 1 | 0 | 0 | 1 | 17.7 | 0.0 | 0.0 | 17.7 |
| JT4A | 41 | 0.0250 | 0 | 0 | 0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| CJ610 | 2 | 0.0002 | 0 | 0 | 0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| TOTAL | 7155 | 19.0334 | 81 | 13 | 68 | 162 | 4.3 | 0.7 | 3.6 | 8.5 |
| TURBOPROP | | | | | | | | | | |
| PT6A | 937 | 1.8633 | 13 | 2 | 6 | 21 | 7.0 | 1.1 | 3.2 | 11.3 |
| ALL501 | 353 | 0.5343 | 0 | 0 | 9 | 9 | 0.0 | 0.0 | 16.8 | 16.8 |
| TPE331 | 403 | 0.7839 | 2 | 1 | 1 | 4 | 2.6 | 1.3 | 1.3 | 5.1 |
| DART | 260 | 0.3711 | 0 | 0 | 3 | 3 | 0.0 | 0.0 | 8.1 | 8.1 |
| BASTAN | 13 | 0.0227 | 0 | 0 | 0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| TYNE | 17 | 0.0294 | 0 | 0 | 3 | 3 | 0.0 | 0.0 | 102.0 | 102.0 |
| CT7 | 6 | 0.0008 | 0 | 0 | 0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| TOTAL | 1989 | 3.6055 | 15 | 3 | 22 | 40 | 4.2 | 0.8 | 6.1 | 11.1 |
| TURBOSHAFT | | | | | | | | | | |
| 250C* | 4250 | 1.4280 | 0 | 2 | 0 | 2 | 0.0 | 1.4 | 0.0 | 1.4 |
| GEM510 | 6 | 0.0077 | 0 | 0 | 2 | 2 | 0.0 | 0.0 | 259.7 | 259.7 |
| ALL OTHERS* | 1744 | 0.5860 | 0 | 0 | 0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| TOTAL* | 6000 | 2.0217 | 0 | 2 | 2 | 4 | 0.0 | 1.0 | 1.0 | 2.0 |

C = CONTAINED NC = NOT CONTAINED
N = FUNCTION IMPEDED, NO FRAGMENTS GENERATED

*Estimated total number in use and engine flight hours for entire U.S. commercial fleet.

TABLE 2. UNCONTAINED ENGINE ROTOR FAILURE DISTRIBUTIONS ACCORDING TO CAUSE AND FLIGHT CONDITIONS - 1976 THROUGH 1984

| TYPE OF FRAGMENT GENERATED | | DISK | | | RIM | | | BLADE | | | SEAL | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| ENGINE ROTOR COMPONENT | | FAN | COMP | TURB | FAN | COMP | TURB | FAN | COMP | TURB | FAN | COMP | TURB | SUB TOT | TOTAL |
| CAUSE | FLIGHT COND. | | | | | | | | | | | | | | |
| DESIGN/LIFE | HI | 0 | 5 | 0 | 0 | 2 | 0 | 8 | 7 | 1 | 0 | 1 | 0 | 24 | |
| PREDICTION | LOW | 0 | 1 | 3 | 0 | 0 | 0 | 1 | 0 | 3 | 0 | 0 | 0 | 8 | 32 |
| PROBLEMS | UNK | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | |
| SECONDARY | HI | 0 | 1 | 0 | 0 | 0 | 0 | 4 | 4 | 18 | 0 | 0 | 3 | 30 | |
| CAUSES | LOW | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2 | 3 | 0 | 0 | 0 | 5 | 36 |
| | UNK | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 1 | |
| FOREIGN | HI | 1 | 0 | 1 | 0 | 0 | 0 | 5 | 0 | 0 | 0 | 0 | 0 | 7 | |
| OBJECT | LOW | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 1 | 10 |
| DAMAGE | UNK | 0 | 0 | 0 | 0 | 0 | 0 | 2 | 0 | 0 | 0 | 0 | 0 | 2 | |
| QUALITY | HI | 0 | 1 | 0 | 0 | 0 | 1 | 2 | 0 | 0 | 0 | 0 | 0 | 4 | |
| CONTROL | LOW | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 4 |
| | UNK | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | |
| OPERATIONAL | HI | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | |
| | LOW | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | UNK | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | |
| ASSEMBLY/ | HI | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | |
| INSP. | LOW | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| REPORTS | UNK | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | |
| UNKNOWN | HI | 0 | 1 | 8 | 0 | 3 | 0 | 4 | 8 | 9 | 1 | 2 | 1 | 37 | |
| | LOW | 1 | 0 | 4 | 0 | 1 | 0 | 0 | 2 | 5 | 0 | 1 | 0 | 14 | 56 |
| | UNK | 0 | 0 | 1 | 0 | 0 | 0 | 1 | 0 | 3 | 0 | 0 | 0 | 5 | |
| SUBTOTAL | HI | 1 | 8 | 9 | 0 | 5 | 1 | 23 | 19 | 28 | 1 | 3 | 4 | 102 | |
| | LOW | 1 | 1 | 7 | 0 | 1 | 0 | 2 | 4 | 11 | 0 | 1 | 0 | 28 | 138 |
| | UNK | 0 | 0 | 1 | 0 | 0 | 0 | 3 | 0 | 4 | 0 | 0 | 0 | 8 | |
| TOTAL | | | 28 | | | 7 | | | 94 | | | 9 | | 138 | 138 |

*Takeoff and climb are defined as "High Power" and all other conditions are defined as "Low Power".

APPENDIX A

Data of Engine Rotor Failures in U.S. Commercial Aviation for 1984. 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 - 1984

| SDR NO. | SUBMITTER | AIRCRAFT | ENG/LOC | COMPONENT | FRAGMENT TYPE | CAUSE | CONTAINMENT CONDITION | FLIGHT CONDITION |
|---|---|---|---|---|---|---|---|---|
| 103084067 | PSA | BAE146 | ALF502 | T | B | 1 | C | 4 |
| 011284090 | EAL | DC10 | CF6 | T | B | 2 | C | 4 |
| 091484024 | WRL | DC10 | CF6 | T | B | 7 | C | 4 |
| 080784045 | UAL | DC10 | CF6 | C | B | 3 | C | 3 |
| 042484187 | WAL | DC10 | CF6 UNK | C | B | 1 | NC | 3 |
| 111384057 | AAL | DC10 | CF6 | T | B | 7 | C | 4 |
| 081484087 | AAL | DC10 | CF6 | T | B | 1 | C | 4 |
| 012684114 | PAA | DC10 | CF6 | C | B | 7 | C | 5 |
| 050984079 | CAL | DC10 | CF6 | F | B | 3 | C | 3 |
| 092584028 | AAL | DC10 | CF6 | T | B | 2 | C | 4 |
| 090484117 | WRL | DC10 | CF6 | F | N | 3 | N | 3 |
| 042484200 | UAL | DC10 | CF6 | F | N | 3 | N | 4 |
| 042484198 | EAL | DC10 | CF6 | F | N | 3 | N | 3 |
| 061484036 | PAA | DC10 | CF6 | C | N | 7 | N | 4 |
| 020784203 | PAA | DC10 | CF6 | C | N | 3 | N | 2 |
| 110884043 | UAL | DC10 | CF6 | T | N | 2 | N | 3 |
| 052284165 | AAL | DC10 | CF6 | T | N | 2 | N | 5 |
| 042484195 | UAC | DC8 | CFM562 | C | N | 3 | N | 3 |
| 020684055 | OXE | F27 | DART511 | T | N | 7 | N | 3 |
| 041884031 | BHA | STC24 | DART542 | T | N | 2 | N | 7 |
| 052984133 | WRT | STC24 | DART542 | T | N | 2 | N | 1 |
| 102584003 | ASR | WEST.30 | GEM510 | T | N | 2 | N | 9 |
| 102584004 | ASR | WEST.30 | GEM10 | T | N | 2 | N | 1 |
| 041084004 | AMT | B707 | JT3D | F | B | 7 | C | 5 |
| 071784092 | AMT | B707 | JT3D | F | N | 3 | N | 3 |
| 031584106 | RAY | DC8 | JT3D | T | N | 7 | N | 5 |
| 062684082 | EAL | B727 | JT3D | C | B | 7 | C | 3 |
| 091184052 | PEX | B727 | JT8D No.3 | T | B | 2 | NC | 3 |
| 051584131 | EAL | B727 | JT8D | C | B | 7 | C | 3 |
| 110684020 | DAL | B727 | JT8D No.1 | T | B | 7 | NC | 3 |
| 062984033 | NWA | B727 | JT8D | T | B | 1 | C | 4 |
| 041884025 | EAL | B727 | JT8D | T | B | 7 | C | 4 |
| 041184105 | DAL | B727 | JT8D | T | B | 2 | C | 4 |
| 060584136 | OZA | DC9 | JT8D | T | B | 1 | C | 4 |
| 070384096 | REP | DC9 | JT8D | T | B | 1 | C | 3 |
| 062184023 | REP | B727 | JT8D | T | B | 7 | C | 4 |
| 032884093 | EAL | B727 | JT8D | C | B | 2 | C | 8 |
| 121084050 | HAL | DC9 | JT8D | C | B | 1 | C | 5 |
| 041084032 | HAL | DC9 | JT8D | C | B | 7 | C | 3 |
| 041084031 | HAL | DC9 | JT8D | C | B | 7 | C | 4 |
| 121884064 | HAL | DC9 | JT8D | V | B | 7 | C | 5 |
| 0313B4066 | HAL | DC9 | JT8D | C | B | 7 | C | 3 |
| 031384067 | HAL | DC9 | JT8D | C | B | 1 | C | 3 |
| 050184150 | HAL | DC9 | JT8D | T | B | 1 | C | 3 |

## CHARATERISTICS OF ROTOR FAILURES - 1984

| SDR NO. | SUBM1TTER | AIRCRAFT | ENG/LOC | COMPONENT | FLIGHT TYPE | CAUSE | CONTAINMENT CONDITION | FLIGHT CONDITION |
|---|---|---|---|---|---|---|---|---|
| 030684138 | AAL | DC9 | JT8D | C | B | 7 | C | 4 |
| 061984102 | ACL | DC9 | JT8D | C | B | 3 | C | 1 |
| 102484011 | TWA | DC9 | JT8D | C | B | 1 | C | 4 |
| 052284155 | REP | DC9 | JT8D | C | B | 7 | C | 3 |
| 050984078 | ACL | DC9 | JT8D | T | B | 1 | C | 3 |
| 022884128 | EAL | DC9 | JT8D UNK | C | B | 7 | NC | 3 |
| 121784057 | DAL | DC9 | JT8D UNK | C | B | 1 | NC | 4 |
| 032284121 | ONE | B727 | JT8D | C | B | 3 | C | 4 |
| 032884094 | EAL | B727 | JT8D No.1 | C | B | 2 | NC | 3 |
| 081484089 | NWA | B727 | JT8D | T | B | 1 | C | 4 |
| 100283030 | EAL | DC9 | JT8D | T | B | 1 | C | 3 |
| 052284159 | REP | DC9 | JT8D | C | B | 7 | C | 3 |
| 121884075 | EAL | DC9 | JT8D | T | B | 1 | C | 4 |
| 040484075 | REP | DC9 | JT8D | T | B | 1 | C | 3 |
| 032284112 | REP | DC9 | JT8D | T | B | 1 | C | 3 |
| 020284037 | EAL | DC9 | JT8D | T | B | 2 | C | 4 |
| 111984077 | USA | DC9 | JT8D | T | B | 7 | C | 7 |
| 100484050 | REP | DC9 | JT8D | T | B | 2 | C | 5 |
| 100383042 | REP | DC9 | JT8D | T | B | 7 | C | 4 |
| 070384126 | REP | DC9 | JT8D | T | B | 1 | C | 4 |
| 021084016 | AKB | DC9 | JT8D | T | B | 7 | C | 3 |
| 062684086 | OZA | DC9 | JT8D | T | B | 1 | C | 4 |
| 090484118 | USA | DC9 | JT8D UNK | C | B | 1 | NC | 3 |
| 022884124 | USA | DC9 | JT8D | T | B | 1 | C | 4 |
| 051584139 | NW | B727 | JT8D | T | B | 1 | C | 4 |
| 091884056 | UAL | B727 | JT8D | T | B | 1 | C | 3 |
| 012480467 | USA | DC9 | JT8D | T | R | 1 | C | 4 |
| 090484115 | TBA | B727 | JT8D | T | B | 7 | C | 4 |
| 909484072 | MID | DC9 | JT8D | T | B | 7 | C | 3 |
| 082884127 | MID | DC9 | JT8D No.3 | T | D | 7 | NC | 3 |
| 102484007 | BNF | B727 | JT8D | T | B | 7 | C | 3 |
| 091884047 | REP | DC9 | JT8D | T | B | 7 | C | 4 |
| 121084045 | TWA | B727 | JT8D | C | B | 2 | C | 5 |
| 020784202 | SWA | B737 | JT8D | T | B | 2 | C | 4 |
| 071184010 | OZA | DC9 | JT8D | T | B | 7 | C | 3 |
| 051584138 | SWA | B737 | JT8D | T | B | 2 | C | 4 |
| 060784067 | OZA | DC9 | JT8D | T | B | 1 | C | 4 |
| 062684126 | UAL | B727 | JT8D | T | B | 1 | C | 2 |
| 042484194 | EAL | DC9 | JT8D No.2 | T | D | 7 | NC | 4 |
| 120584086 | CAL | DC9 | JT8D | T | B | 1 | C | 3 |
| 120384021 | CAL | DC9 | JT8D | T | B | 7 | C | 4 |
| 032884128 | TWA | B727 | JT8D | T | B | 7 | C | 4 |
| 012484069 | TWA | B727 | JT8D | T | B | 7 | C | 4 |
| 082184158 | AKB | DC9 | JT8D | C | N | 7 | N | 1 |
| 112684087 | DAL | B727 | JT8D | C | N | 2 | N | 4 |

## CHARACTERISTICS OF ROTOR FAILURES - 1984

| SDR NO. | SUBMITTER | AIRCRAFT | ENG/LOC | COMPONENT | FRAGMENT TYPE | CAUSE | CONTAINMENT CONDITION | FLIGHT CONDITION |
|---|---|---|---|---|---|---|---|---|
| 091884055 | FAL | B737 | JT8D | T | N | 2 | N | 3 |
| 121984058 | EAL | DC9 | JT8D | T | N | 2 | N | 4 |
| 100484045 | REP | B727 | JT8D | C | N | 7 | N | 5 |
| 071184003 | EAL | DC9 | JT8D | F | N | 3 | N | 5 |
| 011284098 | REP | B727 | JT8D | T | N | 2 | N | 3 |
| 032884089 | USA | B727 | JT8D | T | N | 2 | N | 3 |
| 021584007 | HAL | DC9 | JT8D | C | N | 7 | N | 6 |
| 080384017 | AKB | DC9 | JT8D | T | N | 7 | N | 4 |
| 121084042 | ACL | DC9 | JT8D | C | N | 7 | N | 3 |
| 061984110 | ACL | DC9 | JT8D | C | N | 7 | N | 5 |
| 100484046 | TWA | DC9 | JT8D | C | N | 3 | N | 3 |
| 020784208 | UAL | B737 | JT8D | F | N | 3 | N | 7 |
| 120384051 | ACL | B737 | JT8D | C | N | 3 | N | 1 |
| 041884023 | EAL | B727 | JT8D | T | N | 7 | N | 4 |
| 022284151 | REP | DC9 | JT8D | T | N | 2 | N | 5 |
| 122484056 | REP | DC9 | JT8D | T | N | 2 | N | 5 |
| 091884045 | RAY | DC9 | JT8D | T | N | 7 | N | 4 |
| 012684106 | EAL | B727 | JT8D | T | N | 7 | N | 5 |
| 061984115 | NIA | B727 | JT8D | T | N | 7 | N | 3 |
| 071184005 | REP | DC9 | JT8D | T | N | 7 | N | 1 |
| 031384068 | OZA | DC9 | JT8D | F | N | 3 | N | 3 |
| 050184136 | ONE | B727 | JT8D | C | N | 1 | N | 1 |
| 051584140 | NWA | B727 | JT8D | F | N | 3 | N | 4 |
| 072484004 | AER | B727 | JT8D | C | N | 3 | N | 5 |
| 100984024 | CAL | DC9 | JT8D | C | N | 1 | N | 4 |
| 110684050 | REP | DC9 | JT8D | C | N | 2 | N | 3 |
| 111984075 | PAI | B737 | JT8D | T | N | 7 | N | 3 |
| 020284026 | SWA | B737 | JT8D | F | N | 3 | N | 4 |
| 042484192 | WAL | B737 | JT8D | F | N | 3 | N | 4 |
| 120384020 | PEX | B727 | JT8D | C | N | 3 | N | 3 |
| 060584142 | PEX | B727 | JT8D | C | N | 3 | N | 4 |
| 011284104 | SWA | B737 | JT8D | C | N | 3 | N | 6 |
| 050284002 | PEX | B727 | JT8D | C | N | 3 | N | 3 |
| 050184134 | PEX | B727 | JT8D | C | N | 3 | N | 3 |
| 121084043 | AWX | B737 | JT8D | C | N | 2 | N | 1 |
| 073184005 | NYA | DC9 | JT8D | T | N | 7 | N | 4 |
| 051584145 | NYA | DC9 | JT8D | T | N | 7 | N | 4 |
| 050884096 | EAL | DC9 | JT8D | F | N | 3 | N | 4 |
| 122784013 | UAL | B727 | JT8D | F | N | 3 | N | 3 |
| 122484060 | UAL | B727 | JT8D | C | N | 7 | N | 4 |
| 011984103 | EAL | B727 | JT8D | T | N | 7 | N | 3 |
| 061484939 | EAL | DC9 | JT8D | T | N | 7 | N | 5 |
| 031384062 | NWA | DC10 | JT9D | C | B | 2 | C | 4 |
| 091884046 | NWA | DC10 | JT9D | T | B | 2 | C | 3 |
| 111484117 | NWA | DC10 | JT9D | T | B | 7 | C | 4 |
| 110684051 | NWA | DC10 | JT9D | T | B | 7 | C | 4 |

## CHARACTERISTICS OF ROTOR FAILURES - 1984

| SDR NO. | SUBMITTER | AIRCARFT | ENG/LOC | COMPONENT | FLIGHT TYPE | CAUSE | CONTAINMENT CONDITION | FLIGHT CONDITION |
|---|---|---|---|---|---|---|---|---|
| 071184004 | NWA | DC10 | JT9D | T | B | 7 | C | 4 |
| 102484013 | NWA | B747 | JT9D | T | B | 1 | C | 4 |
| 041884024 | NWA | B747 | JT9D | T | B | 7 | C | 4 |
| 121884077 | TWA | B747 | JT9D | T | B | 1 | C | 4 |
| 120484118 | TWA | B747 | JT9D | T | B | 7 | C | 3 |
| 092684024 | FTL | B747 | JT9D | T | B | 7 | C | 4 |
| 011284094 | NWA | B747 | JT9D | C | B | 7 | C | 4 |
| 011284093 | NWA | B747 | JT9D | C | B | 7 | C | 5 |
| 092584073 | NWA | B747 | JT9D | C | S | 7 | C | 4 |
| 102484009 | NWA | B747 | JI9D UNK | T | S | 2 | NC | 4 |
| 061984127 | FTL | B747 | JT9D | T | B | 7 | C | 4 |
| 032884096 | FTL | B747 | JT9D UNK | T | B | 2 | NC | 5 |
| 041084029 | AAL | B747 | JT9D No.2 | F | B | 7 | NC | 3 |
| 120584085 | UAC | B747 | JT9D No.4 | T | D | 7 | NC | 3 |
| 011284108 | AAL | B747 | JT9D | F | N | 3 | N | 3 |
| 110684019 | UAL | B747 | JT9D | F | N | 3 | N | 3 |
| 080384021 | UAL | B747 | JT9D | C | N | 3 | N | 6 |
| 101784042 | PAA | B747 | JT9D | F | N | 3 | N | 4 |
| 011284102 | PAA | B747 | JT9D | C | N | 7 | N | 4 |
| 032884095 | PAA | B747 | JT9D | T | N | 2 | N | 3 |
| 050884103 | TWA | B747 | JT9D | F | N | 3 | N | 8 |
| 012484062 | NWA | B747 | JT9D | F | N | 2 | N | 4 |
| 103084064 | FTL | B747 | JT9D | F | N | 3 | N | 1 |
| 050284033 | MTR | DHC6 | PT6A | T | B | 7 | C | 3 |
| 021084001 | BRI | B99 | PT6A RH | C | B | 2 | C | 7 |
| 080884074 | RIO | DHC6 | PT6A | C | B | 3 | C | 3 |
| 032084032 | MTR | DHC6 | PT6A | C | S | 7 | C | 3 |
| 030984026 | MTR | DHC6 | PT6A | C | B | 7 | C | 6 |
| 112784024 | RAY | EMB110 | PT6A | T | B | 1 | C | 4 |
| 022184003 | IMP | EMB110 | PT6A | T | B | 7 | C | 3 |
| 041284118 | IMP | EMB110 | PT6A | T | B | 7 | C | 1 |
| 121884070 | PCA | SD330 | PT6A | T | B | 7 | C | 5 |
| 121084040 | RMA | DHC7 | PT6A | T | B | 7 | C | 2 |
| 010584005 | HAL | DHC7 | PT6A | T | B | 7 | C | 5 |
| 061984124 | RMA | DHC7 | PT6A | T | B | 7 | C | 4 |
| 101184023 | HAL | DHC7 | PT6A | T | B | 7 | C | 5 |
| 022484011 | BRI | B99 | PT6A UNK | T | B | 7 | NC | 3 |
| 030184055 | MTR | DHC6 | PT6A | C | N | 3 | N | 2 |
| 030184052 | SW99 | 659 | PT6A | T | B | 7 | NC | 10 |
| 111848028 | AIA | EMB110 | PT6A | C | N | 3 | N | 5 |
| 041984022 | CIC | G73 | PT6A | T | N | 7 | N | 4 |
| 112384005 | AWA | B99 | PT6A | T | N | 7 | N | 5 |
| 010484008 | MVA | SD330 | PT6A | T | N | 7 | N | 3 |
| 031584109 | ERA | DHC7 | PT6A | T | N | 7 | N | 4 |
| 102484015 | PAA | L1011 | R8211 | T | B | 7 | C | 5 |
| 011284116 | EAL | L1011 | RB211 | C | N | 3 | N | 3 |

## CHARACTERISTICS OF ROTOR FAILURES - 1984

| SDR NO. | SUBMITTER | AIRCRAFT | ENG/LOC | COMPONENT | FRAGMENT TYPE | CAUSE | CONTAINMENT CONDITION | FLIGHT CONDITION |
|---|---|---|---|---|---|---|---|---|
| 112084027 | EAL | L1011 | RB211 | C | N | 3 | N | 7 |
| 103184024 | EAL | L1011 | RB211 | F | N | 3 | N | 6 |
| 041184102 | USA | BAC111 | SPEY | C | B | 7 | C | 4 |
| 050884097 | FLE | BAC111 | SPEY | T | B | 7 | C | 4 |
| 102984068 | EMP | F28 | SPEY | C | B | 7 | C | 3 |
| 020784210 | USA | BAC111 | SPEY | C | N | 3 | N | 3 |
| 082884121 | PAI | F28 | SPEY | C | N | 7 | N | 3 |
| 111684042 | AMW | SA226 | TPE331 RH | T | D | 7 | NC | 3 |
| 110584116 | EMP | SA226 | TPE331 | T | B | 7 | C | 4 |
| 083184011 | EMP | SA226 | TPE331 | T | B | 7 | C | 4 |
| 011084082 | SWI | SA227 | TPE331 | C | N | 3 | N | 5 |
| 052984126 | WRN | CL44 | TYNF | C | N | 3 | N | 4 |
| 050284040 | WRN | CL44 | TYNE | C | N | 3 | N | 3 |
| 020284028 | AEI | CL44 | TYNE | T | N | 2 | N | 5 |
| 082784010 | SW62 | B206L1 | 250C28 | T | D | 7 | NC | 5 |
| 092784005 | WP07 | B206B | 250C20 | T | D | 7 | NC | 5 |
| 020784211 | FLA | 188C | 501D13 | C | N | 3 | N | 7 |
| 050184146 | CRA | STCAPJC | 501D13 | C | N | 3 | N | 4 |
| 060584145 | CRA | STCAPJC | 501D13 | C | N | 3 | N | 4 |
| 011284113 | CRA | STCAPJC | 501D13 | C | N | 3 | N | 7 |
| 011984119 | REP | STCAPJC | 501D13 | T | N | 7 | N | 3 |
| 103084058 | TIA | 382G | 501D13 | C | N | 3 | N | 4 |
| 100384018 | SRA | 382G | 501D13 | T | N | 2 | N | 5 |
| 100984006 | SRA | 382G | 501D13 | T | N | 7 | N | 5 |
| 082184156 | REP | STCAPJC | 501D13 | C | N | 3 | N | 3 |