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RESULTS OF HELICOPTER FLIGHT TESTS OF A CIRCUMFERENTIAL CARBON OIL SEAL

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Prepared for

EUSTIS DIRECTORATE
U. S. ARMY AIR MOBILITY RESEARCH AND DEVELOPMENT LABORATORY
Fort Eustis, Va. 23604

EUSTIS DIRECTORATE POSITION STATEMENT

The objective of this program was to conduct an in-service flight evaluation of circumferential carbon radial oil seals developed by NASA-Lewis for use on the UH-1 type transmission. The limited test results indicate that this type of seal holds promise for the designed application. Additional testing of this seal is being pursued at the Aviation Test Board, Fort Rucker, Alabama; as of 16 March 1975, 463 hours of operation had been successfully accumulated.

E. Rouzee Givens of the Technology Applications Division served as project engineer for this effort.



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20. ABSTRACT (Continue on reverse side if necessary and identify by block number) Two samples of a circumferential carbon seal design underwent flight tests in UH-1 and AH-1 type helicopters. One sample was tested at Bell Helicopter's flight test facility and one sample was tested at Fort Rucker, Alabama. Both seals operated successfully with no reported leakage for a total of 435 hours. The seal tested at Bell Helicopter accrued 179 hours of successful operation in an AH-1G helicopter, including cold-weather testing down to -65°F. The seal installed at Fort Rucker operated for 256 hours and at the time of this report was still operating satisfactorily.		

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PREFACE

This report summarizes flight test evaluation of two samples of a circumferential carbon radial oil seal developed by the NASA Lewis Research Center in Cleveland, Ohio. The flight tests were conducted under Contract DAAJ02-73-C-0035 with the Eustis Directorate, U. S. Army Air Mobility Research and Development Laboratory, Fort Eustis, Virginia. Technical advice was provided by Mr. Rouzee Givens, Project Engineer, Propulsion Group, Eustis Directorate, USAAMRDL and Mr. Tom Strom, Research Engineer, NASA Lewis Research Center.

Flight tests were conducted at Bell Helicopter Company, Fort Worth, Texas, and at Fort Rucker, Alabama, under control of the U. S. Army Aviation Test Board. All tests at Bell Helicopter were under the direction of Charles Turner, Project Engineer; and all tests at Fort Rucker were under control of Mel Welker, Project Engineer, Civilian Test Board. Testing was performed between January 1, 1973, and December 1, 1974.

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INTRODUCTION

Many helicopter high-speed oil seal applications make use of low-cost elastomeric lip seals to retain transmission and gearbox lubricants. In some cases, this practice has led to excessive seal replacement in service due to the inability of the elastomeric oil seals to operate at high speeds. This report describes flight tests performed on a circumferential carbon oil seal designed to be interchangeable with a present Bell Helicopter elastomeric seal application. Two samples of circumferential carbon seals furnished by the Government were installed in military helicopters and received flight testing over a 2-year time span. This report reviews that flight testing and evaluates test seal performance during the testing.

SEAL INSTALLATION AND TEST

Figure 1 depicts the basic type of circumferential carbon seal evaluated under Contract DAAJ02-73-C-0035 with the Eustis Directorate, Fort Eustis, Virginia. Two test seals were provided by NASA Lewis Research Center, Cleveland, Ohio. Both test seals were designed to be interchangeable with a present UH-1 type elastomeric lip seal that operates at the input from the engine to the main transmission of the Bell UH-1 type helicopter. Sealing by the test seal takes place at a carbon ring-wear sleeve interface as seen in Figure 1. The wear sleeve employed with the test carbon seal remains the same as the sleeve used with the UH-1 type elastomeric lip seal. One basic difference occurred in the main sealing lip area of the test seals. The first seal (hereafter referred to as Type I) contained machined grooves in the main sealing lip. These grooves are shown in Figure 2 and served to provide a pumping action at the seal lip. The second seal (hereafter referred to as Type II) contained no machined grooves in the main sealing lip.

Upon receipt of the test seals, two UH-1 type main transmission input quill assemblies (Bell Helicopter part number 204-040-263-3) were drawn from GFAE stock. These GFAE quills were reworked by installing the two test carbon seals in place of the production lip seals. Figure 3 depicts the input quill assembly and the area of the quill containing the test seal.

Following installation of the test carbon seals in the quill assemblies, a buildup verification bench test was performed on each quill assembly to check for seal leakage. Table 1 gives a summary of the buildup verification runs for each quill assembly of the Bell UH-1 type helicopter. Minimal leakage occurred during these runs and based on the runs, the quill assemblies were approved for installation in UH-1 or AH-1 type helicopter flight test aircraft.

After the quill assemblies containing the test carbon seals were approved for flight, they were transported to the Bell Helicopter flight test group. The flight test group was instructed to install the quill assemblies in available UH-1 or AH-1 military aircraft in order to accumulate actual flight time on the test seals. Figure 4 represents a typical UH-1 type transmission with the test seal location highlighted.

During April 1973, the quill assembly containing the Type I carbon seal was installed in an AH-1G helicopter undergoing a rotor system test program. During the next 8 months, the Type I carbon seal accumulated 70 hours of successful flight test time. Of this 70 hours, 11.1 hours was ground run time in a cold-weather test cell located at Eglin AFB, Florida.

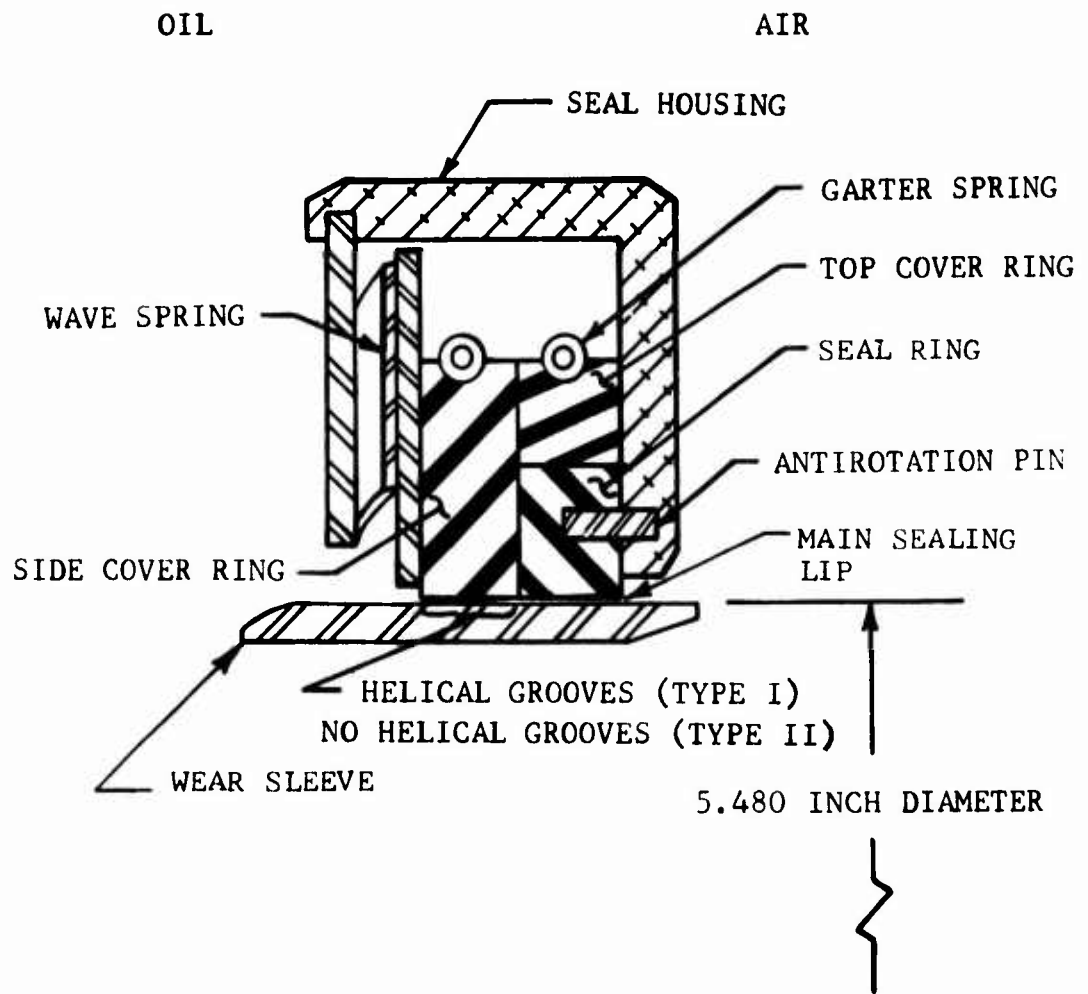


Figure 1. Circumferential Carbon Oil Seal.

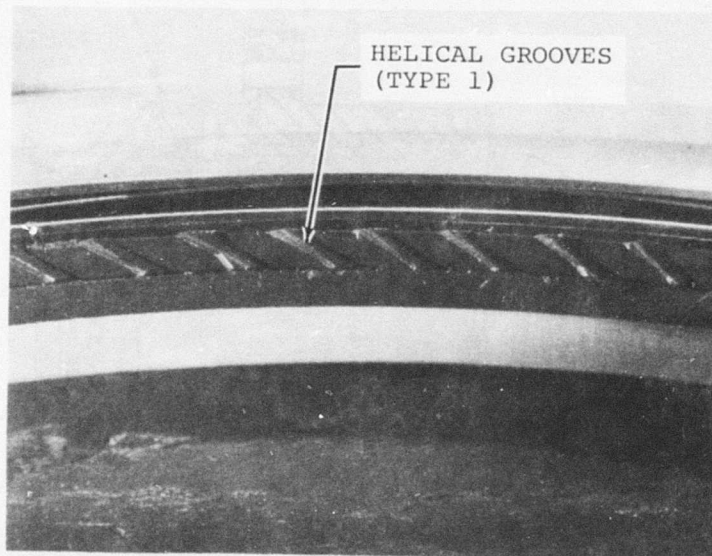


Figure 2. Type I Circumferential Carbon Oil Seal.

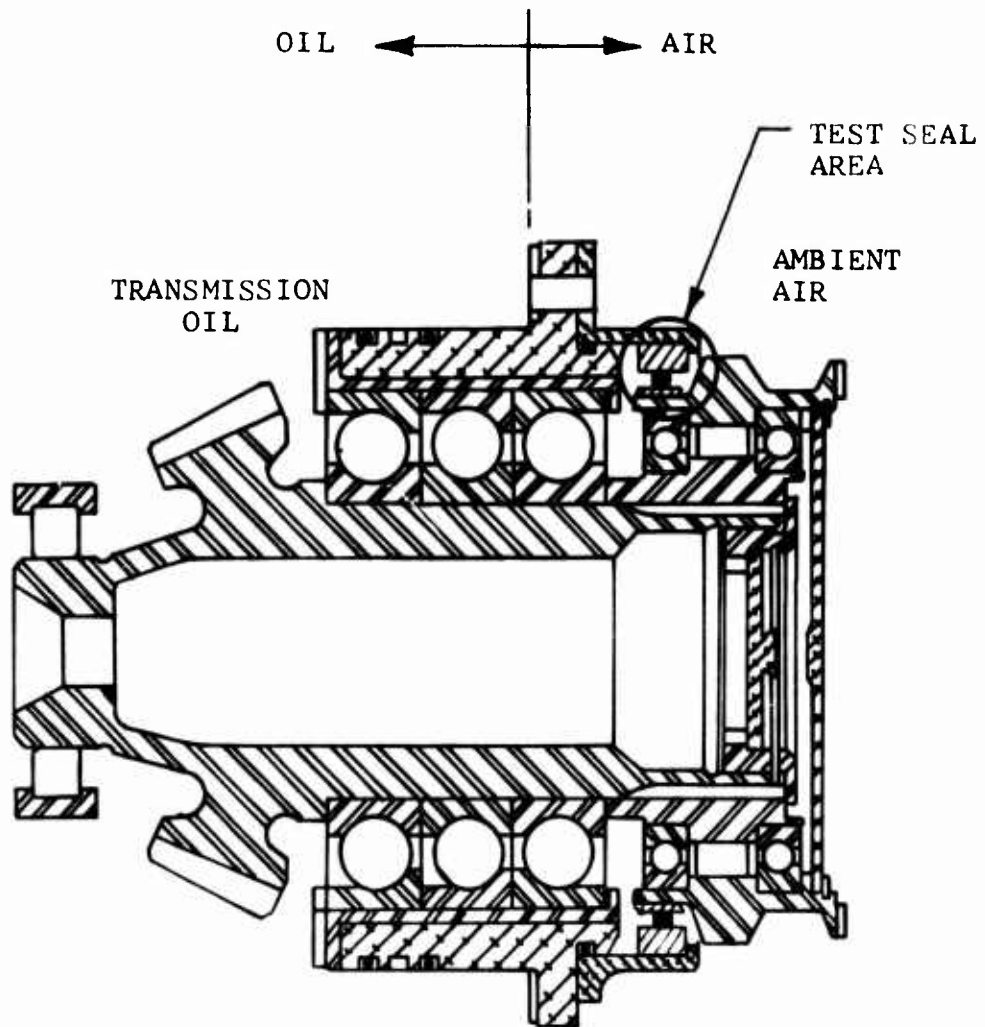


Figure 3. UH-1 Type Main Input Quill Assembly.

TABLE 1. BUILDUP VERIFICATION RUN CYCLE FOR 205-040-263-3 INPUT
QUILL ASSEMBLY

Time (hr)	Accum. Time (hr)	Speed (rpm)	Torque (ft - lb)	Approx. Horsepower
0.1	0.1	4000	Min	Min
0.1	0.2	4800	1,860	141
0.1	0.3	5800	1,860	171
0.1	0.4	6400	4,335	440
0.1	0.5	7040	7,600	827
0.1	0.6	6600	7,400	775
0.1	0.7	6400	8,275	840
0.1	0.8	6400	9,750	990
0.1	0.9	6400	10,601	1077
0.2	1.1	6600	10,781	1129
0.2	1.3	6600	10,924	1144

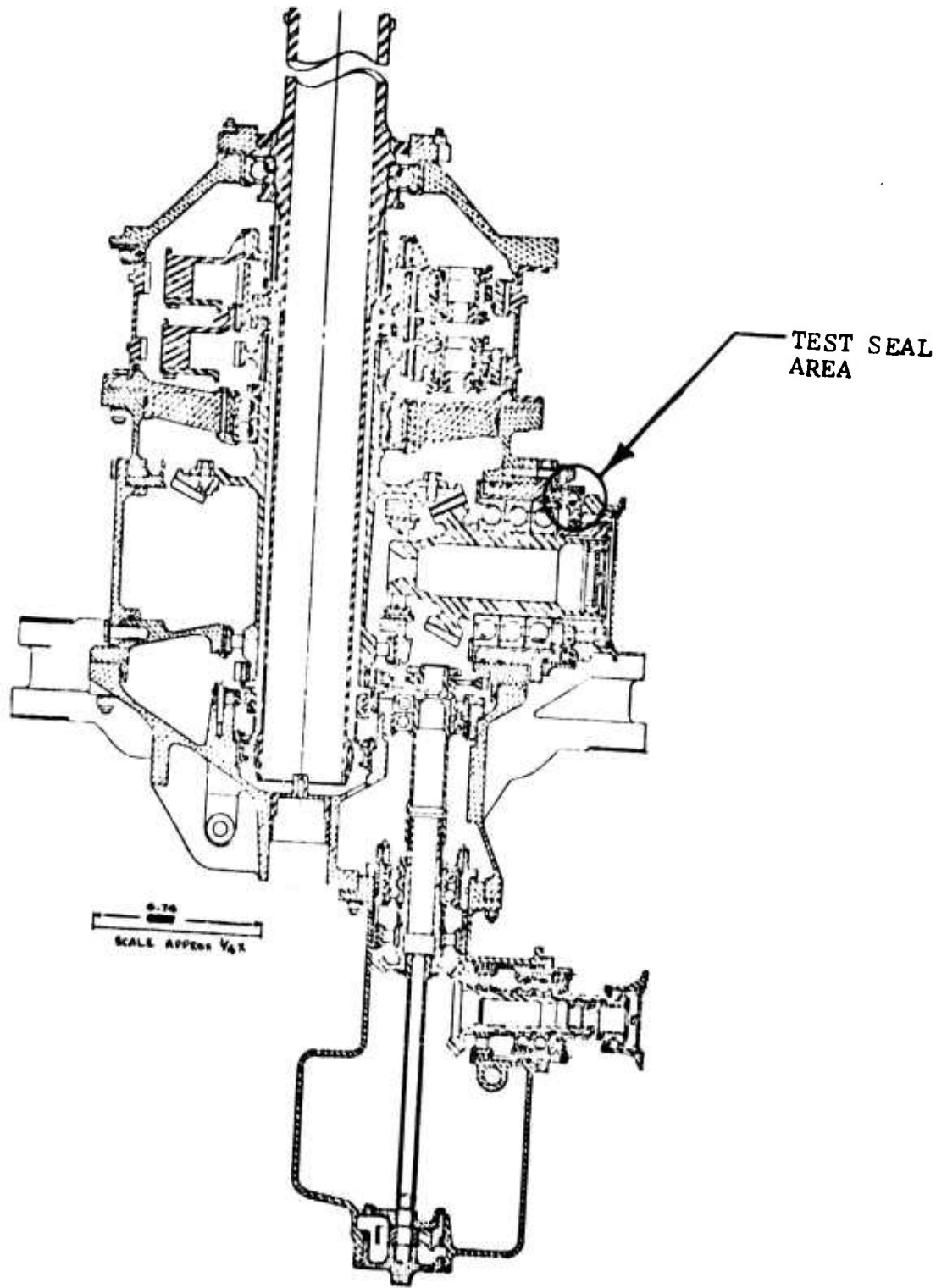


Figure 4. UH-1 Type Main Transmission.

Table 2 reflects the conditions of the cold-weather tests.

The second quill assembly containing the Type II carbon seal remained inactive during 1973 due to lack of available military flight test aircraft. Based on a projected continued lack of available military aircraft at Bell, the quill assembly containing the Type II carbon seal was shipped, in early 1974, to Fort Rucker, Alabama, for installation in a test aircraft under the control of the U. S. Army Aviation Test Board. Thus, by February 1974, both test carbon seals were accumulating flight time in helicopters. Throughout 1974, both test seals received flight testing. In addition to regular flight testing, the Type I seal accumulated 10.5 hours in Alamosa, Colorado, during high-altitude tests. By November 1974, the Type I carbon seal installed at Bell had been tested in an AH-1G helicopter for 175 hours and the Type II seal had received 256 hours of flight testing at Fort Rucker. Throughout all flight tests, no reports of leakage of either type of carbon seal were received.

In December 1974, based upon contract requirements, the quill assembly containing the Type I seal was removed from the flight test aircraft at Bell Helicopter after a total accumulation of 179 hours of flight testing. The quill containing the Type II seal remained at Fort Rucker for further evaluation.

After removal, the Type I carbon seal was inspected by NASA Lewis Research Center personnel. Figures 5 and 6 show the seal and wear sleeve after removal from the quill assembly. The seal and the wear sleeve were considered to be in excellent condition. Approximately 50 percent of the width of the side cover ring and the seal ring made no visible wear marks on the wear sleeve. The wear marks that are visible have no depth and appear only as buffed areas. Following inspection, the Type I seal was reinstalled in the quill assembly. The quill assembly then underwent a buildup verification run (reference Table 1) and was approved for further flight testing. Additional testing of the Type I carbon seal is expected to occur at Fort Rucker, Alabama, under the control of the U. S. Army Aviation Test Board.

TABLE 2. COLD-WEATHER TEST CONDITIONS

Run Temperature (°F)	Run Time (min)	Accum. Time (hr & min)
+70	59	0:59
+70	54	1:53
-25	44	2:37
-45	43	3:20
-65	51	4:11
+70	45	4:56
0	53	5:49
-25	46	6:35
-45	48	7:23
-65	66	8:29
-65	52	9:21
-65	31	9:52
-55	61	10:53
-65	15	11:08

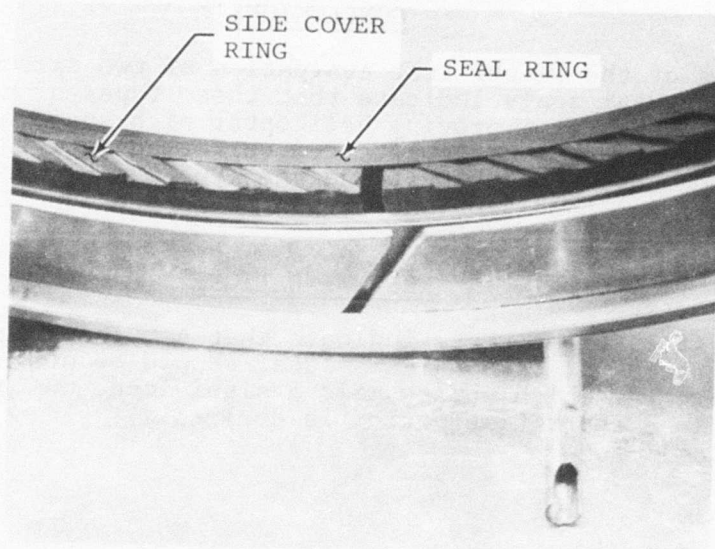


Figure 5. Type I Carbon Seal After 179 Hours of Flight Test.

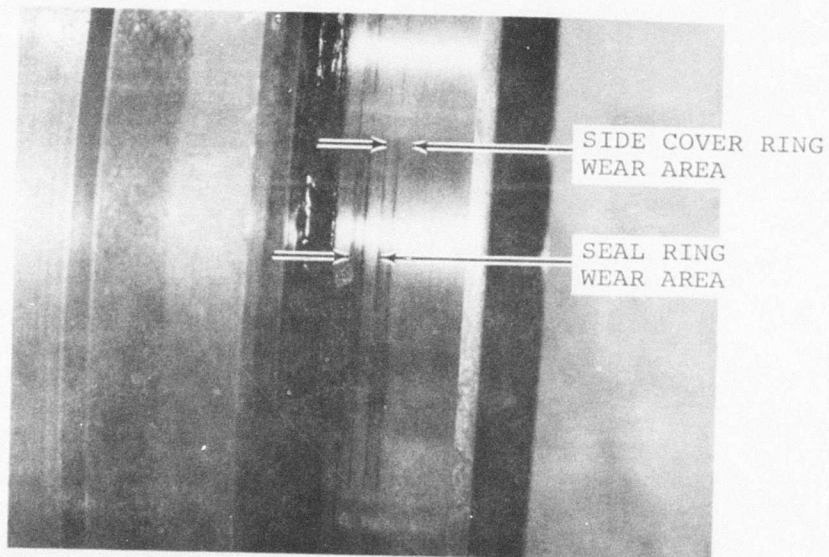


Figure 6. Type I Carbon Seal Wear Sleeve After 179 Hours of Flight Test.

CONCLUSIONS

Results of the flight test evaluation of two circumferential carbon radial seals indicate that these types of seal designs hold promise for improving helicopter high-speed seal applications. Both seal designs tested performed satisfactorily under the test conditions, and the Type I seal appeared to be in excellent condition based upon an inspection after flight tests.

RECOMMENDATIONS

Successful flight tests indicate that continued testing of the circumferential carbon radial seal should be undertaken. A test program which would build a significant number of flight hours in a short time period is desirable.