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WCAP-13420

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HIGH INERTIA ROTOR TEST PHASE 3
TEST PLAN

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Test Plan for the DOE Phase III High Inertia Rotor Test Program

The Phase III testing will focus on measurement of the drag losses with the high inertia rotor running in water in an annular space, not as a journal bearing. The current test plan for Phase III is divided into six tasks. The test plan will be reviewed periodically by EMD, NATD, and STC. The plan may be changed at such times by mutual agreement, based on the available test results.

TASK 1 - HALF-INCH GAP TEST

Objective - Measure the losses with the radial bearing pads removed and a cylindrical shroud installed to give an annular space with a radial gap of one half inch.

Description - The seven radial bearing pads will be removed from the test housing. A cylindrical shroud, provided by NATD, will be installed in the radial housing to provide a smooth annular space with a radial gap of one half inch. Several improvements in the test rig will be incorporated: two pressure transducers will be replaced by models less sensitive to installation method; an independent digital tachometer will be used to provide accurate speed signals to the data logging computer; the shaft will be leveled by changing the support bearing pivot pins; thermocouples will be installed in the cylindrical shroud at four axial locations; noncontacting displacement gauges will be used to monitor the relative position of the rotor and the housing during operation; and the computer program will be modified to use the displacement gauge information to calculate the radial gap during operation.

Following assembly of the cylindrical shroud into the radial housing, the thrust bearing and the radial housing will be reassembled on the test rotor. A mobile crane will be used to reassemble the housing and rotor onto the test rig. The drive motor controller will be tested and repaired by a factory technician to eliminate the oscillations noted at certain speeds during the earlier testing. Following calibration of the torque measuring system, two sets of test runs will be made, covering the speed range from 600 to 1750 rpm in each direction of rotation. At or near the maximum speed, at least three different thrust loads will be applied. These tests will enable us to measure the losses associated with the use of a half inch radial gap instead of a radial bearing and to determine accurately the effect of thrust load on losses. By comparison with Phase II results we will be able determine what portion of the losses found in Phase II is attributable to the radial bearing.

As soon as results from the testing with half-inch radial gap are available, a review meeting will be held involving EMD, NATD, and STC personnel. The purpose of the meeting will be to decide on the need for additional testing including the start/stop tests.

Schedule for Task 1

Milestones	Dates
Design of Shroud and Fixtures	2-26-92
Rotor Dynamics Calculations	4-21-92
Test Specification	5-22-92
Assembly of Test Facility	5-20-92
Start-up Testing	6-12-92
Half-inch Gap Testing	7-10-92
Letter Report Issued	7-31-92
Review Meeting	8-14-92

TASK 2 - ONE-INCH GAP TEST

Objective - Measure the losses with an annular space having a radial gap of one inch.

Description - The cylindrical shroud with a half-inch radial gap will be removed and replaced by a shroud (provided by NATD) with a one-inch radial gap. Following reassembly and recalibration of the torque measuring system, two sets of test runs will be made, covering the speed range from 600 to 1750 rpm in each direction of rotation. These tests will enable us to measure the losses associated with a second value of radial gap, allowing a determination to be made of the significance of the size of the gap on losses.

Schedule for Task 2

Milestones	Dates
Test Specification	10-30-92
Installation of One-inch Gap Shroud	11-6-92
One-inch Gap Testing	11-30-92
Letter Report Issued	12-31-92

TASK 3 - QUARTER-INCH GAP TEST

Objective - Measure the losses with an annular space having a radial gap of a quarter inch.

Description - The cylindrical shroud with a one-inch radial gap will be removed and replaced by a shroud (provided by NATD) with a quarter-inch radial gap. Following reassembly and recalibration of the torque measuring system, two sets of test runs will be made, covering the speed range from 600 to 1750 rpm in each direction of rotation.

These tests will enable us to determine the optimum value of radial gap by providing a third point on a curve of loss vs. radial gap.

Schedule for Task 3

Milestones	Dates
Test Specification	1-22-93
Installation of Quarter-inch Gap Shroud	1-29-93
Quarter-inch Gap Testing	2-26-93
Letter Report	3-19-93
Final Report Issued	5-14-93

TASK 4 - START/STOP TEST

Objective - Verify the dimensional stability of the enclosed depleted uranium insert and the wear resistance of the thrust bearing by performing 500 starts to 1750 rpm and complete stops.

Description - The rotor and thrust bearing will be removed from the test rig for visual inspection before beginning the start/stop test, after 100 start/stop cycles, and after 500 cycles. Loss measurements will be made periodically at maximum speed to monitor any changes that might occur. The testing will be performed with the cylindrical shroud showing the lowest losses in the prior testing. Full[ ]thrust loading will be maintained on the thrust bearing at each start. a,c

Schedule for Task 4

Milestones	Dates
Test Specification	3-26-93
Inspection	3-26-93
Perform 100 Starts and Full Stops	4-30-93
Inspection	5-14-93
Perform 400 Additional Starts and Full Stops	8-6-93
Inspection	8-20-93
Final Report Issued	10-22-93

TASK 5 - SLOW SPEED WEAR TEST

<u>Objective</u> - Measure the wear of the thrust bearing shoes due to operation at speeds below the film-generation speed.

<u>Description</u> - The drive motor used in the prior testing will be disconnected and replaced by a slow-speed[ ]drive system. Measurements will be made with surface profilometry and/or optical flats before, during, and after testing to determine wear of the thrust shoes. Slow-speed testing will be conducted with full[ ] loading on the thrust bearing. The speed will be selected to be below the speed at which a lubricating film of water will form on the thrust shoes. Following the wear testing an option would be to perform some testing at full speed to show the effect of the wear on full speed performance. After all testing is completed, the high inertia rotor and thrust bearing will be removed from the test rig for dismantling and inspection. The bearing and rotor/shaft assembly will be sent to EMD for Task 6. If no further testing is anticipated, the test rig will be decommissioned and prepared for storage. a,c a,c

Schedule for Task 5

Milestones	Dates
Test Specification	9-24-93
Install Slow Speed Drive	10-1-93
Testing	10-29-93
Final Report Issued	12-31-93

TASK 6 - FINAL EXAMINATION OF TEST BEARING

Objective - Verify that no damage has occurred to the thrust bearing or the enclosed depleted uranium rotor.

Description - The thrust bearing and high inertia rotor will be further disassembled by EMD and visually and dimensionally inspected. The enclosed depleted uranium rotor will be shipped to Martin-Marietta at Oak Ridge for destructive examination of the depleted uranium alloy insert and its stainless steel enclosure. Task 6 will be performed entirely by others and is not included in the STC funding or schedule. It is included here for information only.

GENERAL PROVISIONS

Deliverables - For each task the deliverables will be: Test Specification, Monthly Progress and Financial Reports, and either a Letter Report or a Final Task Report. The Monthly Progress Reports will be furnished by the 1st of each month and the Monthly Financial Reports by the 15th. The other deliverables will be furnished by the dates shown in the task schedules. The dates for Tasks 2 through 5 assume that further funding will be received at STC at least a month in advance of the due date for each Test Specification. At the conclusion of Task 5 all the task reports (including Phases I and II) will be incorporated into a single overall project final report. This report will be issued by 3-31-94.

Engineering Testing Practices at STC - An important milestone in each Task is the submission of a Test Specification. Any changes in the Test Specification must be approved by EMD and AP600 Project Test Engineering. Instrument calibration, data reduction, and recording are described in the following paragraphs.

Temperature measurements will be made by the use of thermocouples, connected either to an automatic data logger or to a manually operated readout device. The choice of readout device depends on the need for continuous versus occasional monitoring. In Phase I each thermocouple was tested for correct output in ambient air and in boiling water before installation in the thrust bearing or support bearings. All agreed to within 1°F with the appropriate temperature. These same thermocouples will be used in Phase III. Because they are mounted in alumina insulating tubes epoxied into locating holes in the bearing pads, they cannot be removed for recalibration. These thermocouples will not be used for design verification measurements. They are used only for monitoring proper operation of the test facility. Similar thermocouples will be mounted in each cylindrical shroud, after calibration in ice water and boiling water. The thermocouple probes, used for measuring water and oil tempreatures, will be removed from the test rig and recalibrated together with their readout equipment using ice water and boiling water.

All the pressure transducers, their signal conditioners, and the data logger will be recalibrated on a rotating-piston dead-weight pressure calibration fixture. The weights used in this fixture will be verified on a balance certified by the STC Standards Laboratory. Electrical shunt calibration will be used before each day's testing to verify that the instrument calibration has not changed.

In Phases I and II radial load measurements were made by calibrated strain gages applied to the thin plate sections of the upper alignment flex plate fixtures. Each flex plate fixture was calibrated a,c

over a full range of loads up to [ ] lb in compression, using a testing machine which itself had been calibrated by certified load-proving rings. Electrical shunt calibrations were made on the strain gage signal conditioning equipment daily before use to ensure that the calibration of the gages had not changed. The same fixtures and shunt calibrations will be used in Phase III.

The torque measuring system will be calibrated by dead weight loading on a temporarily attached lever. The weights will be calibrated by comparison with weights traceable to values certified by the STC Standards Laboratory. Calibration will be performed at 600 and 1200 rpm rotation in both directions every time the test bearing housing is removed from the test rig. Between disassemblies electrical shunt calibration checks will be performed daily before use.

The automatic data logger will be connected directly to a certified high-precision optical tachometer. The flowmeters will be calibrated in place in the water system by the use of an electronic timer and calibrated containers. The timer will be certified by the STC Standards Laboratory. The volume of the containers will be verified by weighing water at room temperature on a certified balance. The displacement transducers, their signal conditioning equipment, and the automatic data logger will be calibrated by use of precision micrometer calibration equipment.

A Hewlett-Packard Model 3497A data logger will be used to read the thermocouples and to take readings from the pressure transducers, the two radial loaders, the torque load cell, the tachometer, the flowmeters, and the displacement transducers. A Hewlett-Packard Model 85 computer will be used to read all the inputs from the data logger, calculate values in engineering units, continually display the most important results on the video monitor (updated every 20 s), print and store all results on demand, and plot selected results during the testing. Readings from other instrumentation will be logged manually at intervals during the testing.

Documentation of Test Procedures and Results. Check lists for all operating procedures will be used before and during each day's operation. Only properly trained personnel will be allowed to operate the test equipment. The check lists will be signed and dated by the designated equipment operators. A check list of test conditions will be used by the designated test engineer for each day's operation. Lists of instrumentation and data recorders will be maintained along with calibration records. Two such lists will be used, one for equipment used to make essential measurements related to the test purposes, and the other for non-essential equipment.

Dated test log sheets containing all the manually-obtained instrument readings will be maintained and initialled by the person designated to make the readings. All computer-generated test data sheets will contain the time and date and will be maintained as part of the test log. For each task the principal investigator will sign a statement indicating that all relevant test documentation has been reviewed, that all test procedures have been followed, and that all test requirements have been met. Any deviations will be noted along with the corrective action to be taken.