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LIQUID ROCKET PLANT

TEST PLAN AND SPECIFICATIONS FOR THE
PRESSURE VESSEL-NOZZLE-SEAL ASSEMBLY
CONFIRMATION TEST

Test 1070 N

Report 8207-64-5

5 May 1964

MASTER

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**Contract No. SNP-1
LRO NERVA Rocket Operations**

The work specified in this document is being performed as part of sub-subtask 1.4.3, Pressure Vessel.

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TEST PLAN AND SPECIFICATIONS FOR THE
PRESSURE VESSEL-NOZZLE-SEAL ASSEMBLY
CONFIRMATION TEST

Test 1070 N

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I. INTRODUCTION

This document describes the pressure vessel - nozzle - seal assembly confirmation tests. The purpose of the testing described herein is to demonstrate the compatability of two possible NRX nozzles (AGC-347 stainless steel nozzle S/N 008, P/N 285950-9 and Rocketdyne - Inconel X RN-6 stubby nozzle, P/N 99205795) with NRX 6061-T6 aluminum pressure vessel, S/N 005. These tests will prove the structural integrity of the nozzles for use in NRX test programs with the functional capability demonstrated by acceptance chemical firings. In addition, a seal evaluation will be performed using AGC 6061-T4 aluminum pressure actuated seals with the forementioned hardware.

To gain the desired data and satisfy the test objectives the test, designated 1070N, will be subdivided into four parts:

Test 1070 N-1

An instrumented hydrostatic structural test composed of three (3) cycles to 100% ambient proof pressure utilizing AGC pressure vessel S/N 005 and AGC steel nozzle S/N 008.

Test 1070 N-2

A seal evaluation at the aft pressure vessel joint. Three (3) NERVA pressure actuated seals, P/N 702154, will be tested utilizing AGC pressure vessel S/N 005 and AGC nozzle S/N 008.

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Test 1070 N-3

An instrumented hydrostatic structural test composed of three (3) cycles to 100% proof pressure utilizing AGC pressure vessel S/N 005 and Rocketdyne RN-6 stubby nozzle.

Test 1070 N-4

A seal evaluation at the aft pressure vessel joint. Three (3) NERVA pressure actuated seals, P/N 702154, will be tested utilizing AGC pressure vessel S/N 005 and Rocketdyne RN-6 stubby nozzle.

Due to the security classification of the test pressures, the values will be supplied under separate cover and for the purposes of this report all pressures will be expressed in terms of percentages of proof pressure. The test will be conducted with only the test director and a limited group of technicians cognizant of the actual pressures.

II. OBJECTIVES

Test 1070 N will be performed at ambient temperature to attain the following objectives:

Tests 1070 N-1 and -3:

- a. Evaluate the pressure vessel and nozzle compatability at ambient proof pressure.
- b. Measure the deflections and rotations of the aft pressure vessel and nozzle flanges.
- c. Measure strains at critical areas.

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Tests 1070 N-2 and -4:

- a. Evaluate the ability of the aluminum seal at the pressure vessel-nozzle joint to contain ambient helium gas.

III. RESPONSIBILITIES

A. NERVA Thrust Systems - Department 8200

- 1. Prepare, along with Department 4655, a combined test specifications and test plan report.
- 2. Establish test pressures.
- 3. Provide pressure vessel, seals and nozzles.
- 4. Provide nozzle and closure bolts and washers.
- 5. Follow component assembly.
- 6. Determine test instrumentation locations.
- 7. Coordinate activities of all concerned groups.
- 8. Follow component assembly and provide technical direction.
- 9. Analyze and evaluate test data.
- 10. Correlate analytical and experimental data.
- 11. Prepare, approve, and submit a final test evaluation report. (To be prepared and approved jointly with Department 4655).

B. NERVA Structures - Department 8200

- 1. Perform the required stress analysis.
- 2. Review and approve the test plan and specifications and the final test evaluation report.
- 3. Provide structural consultation during the test.
- 4. Assist in analyzing and evaluating test data.
- 5. Assist in correlating experimental and theoretical data.
- 6. Report results of analyses.

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C. Structural Test Laboratory - Department 4655

1. Prepare, along with Department 8200, a combined test specification and test plan report.
2. Make minor modifications to existing test tooling.
3. Establish a detailed test schedule.
4. Provide test facilities (test cell, pressurizing equipment and instrumentation).
5. Instrument test hardware per AGC Test Plan.
6. Perform testing.
7. Evaluate accuracy of data.
8. Reduce and evaluate test data.
9. Prepare and approve, jointly with Department 8200 (NERVA Thrust Systems), a final test evaluation report.

IV. TEST OPERATIONS

A. TEST SETUP

1. Test 1070 N-1 and -2:

The pressure vessel and AGC nozzle will be assembled in a test cell as illustrated in Figure 1. An internal thrust reaction fixture (T-417188) will be installed in the test assembly to divide the unit into two pressure zones. One pressure zone will be in the nozzle cavity and the other will be in pressure vessel, simulating operational pressure distribution. A nozzle plug, T-603221, and thrust reaction structure, T-417211, will be used to transfer the thrust load to the forward closure. A third pressure zone will be in

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the nozzle plug to ensure that the plug remains seated to the nozzle. For Test 1070 N-1, all three zones will be filled and pressurized with oil. For Test 1070 N-2, the O-ring seal between the nozzle and pressure vessel cylinder will be replaced with a metallic seal and the seal cavity of the pressure vessel zone will be pressurized with helium gas.

2. Test 1070 N-3 and -4:

The pressure vessel and RN-6 stubby nozzle will be assembled as shown in Figure 2. The internal thrust reaction fixture will also be utilized for both of these tests. A hydraulic actuator will be installed between the RN-6 nozzle and the thrust reaction structure to simulate the thrust reaction. Both test unit pressure zones and the actuator will be filled and pressurized with oil for test 1070 N-3. The differences between test 1070 N-1 and -3 are identical to those between test 1070 N-2 and -4.

B. TEST UNIT MEASUREMENTS

Dimensions of the pressure vessel cylinder and both nozzles will be measured before the test as illustrated in Figures 3 through 5. Measurements will be taken at 90° intervals. The seals will be measured after the test. Wall thickness measurements will be taken at each strain gage location.

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C. INSTRUMENTATION

1. Tests 1070 N-1 and -3

The test unit components will be instrumented with strain gages as shown in Figures 7 through 9. The strain gages on the pressure vessel will be used for the entire test series. Deflection transducers will be mounted to the test assembly as shown in Figures 10 and 11. A total of 167 channels of instrumentation for each test will be utilized as follows:

<u>MEASUREMENT</u>	<u>TYPE TRANSDUCER</u>	<u>LOCATION</u>	<u>NO. OF CHANNELS</u>
Deflection	Variable Inductance	Nozzle Joint	24
Strain	Biaxial Strain Gage	Forward Closure	24
Strain	Biaxial Strain Gage	Cylinder	56
Strain	Biaxial Strain Gage	Nozzle	56
Pressure	Strain-Gaged Diaphragm	Pressure Vessel	2
Pressure	Strain-Gaged Diaphragm	Nozzle	2
Pressure	Strain-Gaged Diaphragm	Nozzle Plug or Hydraulic Actuator	2
Thrust	Strain Gaged Load Cell		1

Data acquisition will be accomplished utilizing CEC type 5-123 Recording Oscillographs and SR-4 Digital Readout Instruments.

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2. Tests 1070 N-2 and -4

Pressures will be monitored on Bourdon type gages. Gas leakage, if any, past the nozzle-cylinder seal will be collected in an inverted graduated cylinder filled with water and measured as a function of time.

D. TEST PROCEDURES

Test 1070 N-1 will be conducted first. All three zones will be pressurized with oil simultaneously, maintaining a constant ratio between the zones. The test assembly will be pressurized to 100% ambient proof pressure in 20% increment levels. At each pressure increment, instrumentation and pressure will be allowed to stabilize before proceeding to the next level. A total of three 100% proof pressure cycles will be conducted.

The nozzle and nozzle plug will be drained of oil and removed from the pressure vessel. All instrumentation will be disconnected. The nozzle-cylinder O-ring will be removed from the seal gland and replaced with one of the metallic seals after the seal gland has been thoroughly cleaned and polished. A small portion of the oil will be drained from the pressure vessel to ensure that no oil will contaminate the gland during Test 1070 N-2. The nozzle, nozzle plug, and associated tooling will then be reassembled to the cylinder. The nozzle and nozzle plug will be filled with oil.

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Three nozzle-cylinder seals will be tested in Test 1070 N-2. Each seal will be subjected to three cycles of 100% ambient proof pressure. The nozzle and nozzle plug will be pressurized with oil and the pressure vessel with helium gas. For each 10% increment, the pressure vessel will be pressurized first, and then the nozzle plug and nozzle. At each 10% increment level the pressure ratio between the three zones will be constant. Leakage, if any, past the seal will be measured at each 20% increment level. The test unit will have to be disassembled and assembled as described in the preceding paragraph for each seal tested.

Following the completion of Test 1070 N-2, the AGC nozzle, the nozzle plug, and associated tooling will be removed from the test assembly. The O-ring will be replaced in the nozzle-cylinder seal. The RN-6 stubby nozzle, hydraulic actuator, and associated tooling will be installed on the pressure vessel and instrumentation will be rewired. All three zones will be filled with oil. Test 1070 N-3 will be conducted in the same manner as Test 1070 N-1, and following the completion of Test 1070 N-3, Test 1070 N-4 will be conducted in the same manner as Test 1070 N-2.

V. PHOTOGRAPHIC COVERAGE

Black and white photographs will be taken to provide documentation of the test unit, test setup and assembly, instrumentation and interesting details of the test.

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VI. REPORTS

A. Preliminary Data Report

A preliminary data report for internal use will be submitted to Department 8200 by Department 4655 within five (5) working days following test completion. The report (a blueline or ditto reproduction) shall include the following:

1. Data requested in each cycle of test.
2. Location of instrumentation as placed.

B. Structural Evaluation Report

A final structural evaluation test report will be prepared within twelve weeks of test completion. This report will be prepared jointly by Departments 8200 and 4655 and will include:

1. Report abstract.
2. Test objectives.
3. Test descriptions.
4. Test results.
5. Discussion of results, including a comparison of strain and deflection data with nominal stress analysis.
6. Conclusions and recommendations.
7. Appendices
 - a. Test data.
 - b. Theoretical analysis.

FIGURE 1

TEST 1070N-1 AND -2
SETUP

FIGURE 2

TEST 1070N-3 AND -4
SETUP

NOTES:

1. The nozzle will be measured at 90° intervals.
2. Measurements will be taken before test only.

FIGURE 3
MEASUREMENT OF
AGC NOZZLE

NOTES:

1. The nozzle will be measured at 90° intervals.
2. Measurements will be taken before test only.

FIGURE 4
MEASUREMENTS OF
RN-6 NOZZLE

NOTES:

1. The cylinder will be measured at 90° intervals.
2. Measurements will be taken before test only.

FIGURE 5

MEASUREMENTS OF
PRESSURE VESSEL
CYLINDER

NOTES:

1. The seal will be measured at 90° intervals
2. Measurements will be taken after test only

FIGURE 6
MEASUREMENTS
OF
METALLIC SEAL

NOTES:

1. Inside gages will be directly opposite outside gages.
2. Gages will be at two meridional locations.
3. Wall thickness measurements will be taken at each strain gage location.

FIGURE 7

STRAIN GAGE LOCATIONS
FOR
PRESSURE VESSEL

NOTES:

1. Inside gages will be directly opposite outside gages.
2. Gages will be at two meridional locations.
3. Wall thickness will be taken at each strain gage location.
4. Dimensions given are to be measured along the surface.

FIGURE 8

STRAIN GAGE LOCATIONS
FOR
A.G.C. NOZZLE

NOTES:

1. Inside gages will be directly opposite outside gages.
2. Gages will be at two meridional locations.
3. Wall thickness will be taken at each strain gage locations.
4. Dimensions shown by curved arrow are to be measured along the surface.

FIGURE 9
STRAIN GAGE LOCATIONS
FOR
RN-6 NOZZLE

NOTES:

1. All deflection transducers will be variable inductance type.
2. Instrumentation will be at three meridional locations.

FIGURE 10
DEFLECTION INSTRUMENTATION
FOR
AGC NOZZLE JOINT

NOTES:

1. All deflection transducers will be variable inductance type.
2. Instrumentation will be at three meridional locations.

FIGURE 11
DEFLECTION INSTRUMENTATION
FOR
RN-6 NOZZLE JOINT