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VIBRATION TEST PLAN
FOR
A SPACE STATION HEAT PIPE SUBASSEMBLY

CONTRACT NO. 9-X6H-8102L-1

PREPARED FOR

LOS ALAMOS NATIONAL LABORATORY
LOS ALAMOS, NEW MEXICO

MASTER

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BY
SUNDSTRAND ENERGY SYSTEMS
4747 HARRISON AVENUE
ROCKFORD, ILLINOIS 61125

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APPROVAL SHEET

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PREPARED BY: DATE 10/02/87
(Mahendra B. Parekh)

APPROVED BY: DATE 10-2-87
(G. Heidenreich)

APPROVED BY: DATE 10-5-87
(M. Kershishnik)

APPROVED BY: DATE 10/5/87
(G. Hill)

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HEAT PIPE VIBRATION TEST PLAN

1.0 Introduction

This test plan describes the Sundstrand portion of task two of Los Alamos National Laboratory (LANL) contract 9-X6H-8102L-1.

Sundstrand Energy Systems was awarded a contract to investigate the performance capabilities of a potassium liquid metal heat pipe as applied to the Organic Rankine Cycle (ORC) solar dynamic power system for the Space Station.

This heat pipe is a subassembly of the heat receiver as shown in Figure 1. The heat receiver, the heat absorption component of the ORC, consists of forty liquid metal heat pipes located circumferentially around the heat receivers outside diameter. As shown in Figure 1, the heat pipe contains in addition to the potassium a toluene heater tube and two thermal energy storage (TES) canisters. The TES canisters and the heater tube are held in their proper position by wire retainers. During the launch of the Space Shuttle, the heat receiver will be subjected to high vibrations. In order to verify performance of the heat pipe design, LANL is building and thermally performance testing a heat pipe. Sundstrand will vibration test the same heat pipe after the thermal test.

2.0 Objective

The test objective is to expose the heat pipe subassembly to the random vibration environment which simulates the space shuttle launch condition. The results of the test will then be used to modify as required future designs of the heat pipe.

3.0 Configuration

Figure 2 shows the test article, which will be supplied by Los Alamos National Lab (LANL), LANL Dwg. No. 102Y-231070, Sheet 1 of 7. The physical characteristics are listed below:

Length - 79.8 inches

Weight heat pipe assembly - 90 lbs (calculated)

Weight of TES canisters - total 50.63 lbs (measured)

Weight of LiOH salt - total 20.35 lbs (calculated)

Weight of potassium - 3.5 lbs (calculated)

Figure 3 shows a cross-section picture of the heat pipe with wicks, TES canisters and simulated toluene heater tube installed. Also shown is one of the six spring retainers made from .080 inch diameter 304 SS wire that support the canisters and simulated heater tube.

4.0 Planned Tests

A total of three (3) dynamic tests are planned to determine the dynamic characteristics of the heat pipe subassembly.

The heat pipe subassembly will be exposed to "Level A" requirements for one time for the period of 3 minutes in each of three different test article orientations. The Level A requirements are specified in Figure 4 while the test article orientations are shown in Figure 5.

5.0 Test Procedures

The random vibration tests on the heat pipe subassembly will be conducted in test cell 66. Figure 6 shows the

photograph of Unholtz-Dickie Model T4000 shaker facility which will be used to shake the heat pipe subassembly to the vibration Level A. The shaker is capable of providing 40,000 lbs of force, while 28,000 lbs is required for this test.

The heat pipe subassembly will be installed in a specially designed vibration fixture for this program. The vibration fixture design, Dwg. No. EP5644-2-1, is such that it simulates the structural interface of the heat pipe subassembly with the proposed space station receiver bulkheads. The dynamic characteristics of the fixture will be determined prior to performing the vibration tests on the test article. A dummy heat pipe, Dwg. EP2809-666, shown in Figure 7, will be used in the place of the test article to check out the fixture dynamic characteristics. The test article mass and end conditions are duplicated on the dummy heat pipe. Based upon the checkout vibration test results, the control accelerometer locations on the fixture will be decided for the test article dynamic test.

The test article installed in the vibration fixture will be shaken in each of the three different axis orthogonal to each other. The vibration Level A input to the fixture and test article will be controlled by the control accelerometers. The test duration in each axis will be 3 minutes. The vibration data (G^2/Hz vs Hz) for each axis will be reviewed prior to starting the next test.

Two control accelerometers will be mounted on the vibration fixture to regulate and control the vibration input level to the fixture. Minimum of four triaxial accelerometers will be mounted on the test article to monitor the vibration response, Figure 8. Additional one triaxial accelerometer will be mounted on each end of the heat pipe subassembly/fixture interface area. The locations of the

accelerometers will be based upon the heat pipe subassembly analytical model and the test results obtained from the dummy heat pipe/fixture testing. The recording of accelerometer data is limited to maximum of thirteen (13) channels.

At the end of testing, the vibration fixture with the dummy heat pipe will be shaken to verify that its structural integrity is unchanged during the entire test program.

After completion of the vibration testing, the test article and fixture will be visually examined for structural damage. The test article will also be radiographically examined prior and after completion of the vibration testing to determine if there is any subsurface structural change caused by the testing.

6.0 Data Acquisition System

The existing control system will be used to control the input vibration level to the test article installed in the vibration fixture. The automatic data acquisition systems already in place will be used to monitor and record the responses from the accelerometers. The daily record of testing, including any anomalies, will be logged. Test anomalies, when identified, will be evaluated for its impact on the future testing. The appropriate corrective actions will be taken to minimize the impact due to anomalies on further testing.

7.0 Report

A test report describing the test objective, results and conclusions will be prepared and submitted as part of meeting the contractual requirements.

FIGURE 1

ORC Heat Pipe Receiver

FIGURE 2

LANL HEAT PIPE ASSEMBLY DRAWING

FIGURE 3

ASSEMBLY OF HEAT PIPE PRIOR TO INSTALLATION OF END CAP

FIGURE 4

LEVEL A RANDOM VIBRATION REQUIREMENTS

FIGURE 5

HEAT PIPE VIB TEST FIXTURE SCHEMATIC

- NOTES:
1. SHAKE IN X DIRECTION
 2. ROTATE TEST ARTICLE 90° AND SHAKE (EQUIVALENT TO SHAKING IN Y DIRECTION)
 3. TURN FIXTURE 90° AND SHAKE (EQUIVALENT TO SHAKING IN Z DIRECTION)

FIGURE 7

DUMMY MASS MODEL HEAT PIPE, EP.2809-666

MATERIAL: S.S.

FIGURE 8

ACCELEROMETER LOCATIONS

INPUT ACCL. 2

TRI-AX ACCL.
FOR TEST ARTICLE 6

TOTAL 8

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