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**KILOWATT ISOTOPE
POWER SYSTEM
TEST PROCEDURE FOR THE RADIATOR
LONG AND SHORT PANELS**

**PREPARED BY
TELEDYNE ENERGY SYSTEMS
UNDER
SUBCONTRACT 282566**

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KIPS TEST PROCEDURE

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			RADIATOR PANEL TESTS				
			SIZE A	CONFIDENT NO. 30856	KIPS1010300		
			SCALE	SHEET 1 OF 18			

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1.0 OBJECTIVE AND SCOPE

1.1 Objective - The objective of this document is to outline the procedure for conducting development tests of sections of the KIPS space radiator. The results of these tests will be utilized to determine the final design and anticipated performance characteristics of the full size ground demonstration system (GDS) radiator.

1.2 Scope - This procedure is applicable to the tests planned for the short panel radiator test assembly (KIPS104000-009) and for the long panel radiator test assembly (KIPS104000-019). The test data to be obtained include the pressure drop across the header and individual radiator tube, the temperature profile on the panel and an estimation of the heat rejection capability. The short panel test will be performed under vacuum and $-200 \pm 10^\circ\text{F}$ environment. Tests on the long panel will be conducted under room conditions.

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2.0 APPLICABLE DOCUMENTS

2.1 KIPS1040000 - Radiator Test Section
-009 - Short Section
-019 - Long Section

2.2 PS0700001 - Handling of Dangerous and Toxic Materials

2.3 Dowtherm Heat Transfer Fluids Handbook

2.4 KIPS1040007 Tubing Schematic Radiator Panel Test

2.5 KIPS1040008 Thermocouple Arrangement for Radiator Panel Test

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3.0 FACILITIES, EQUIPMENT AND MATERIALS

3.1 Facilities - The test setup will consist of a thermal vacuum chamber, a thermostat, the radiator panel and associated accessories.

3.2 Equipment - Equivalent or better equipment may be substituted.

3.2.1 Thermal Vacuum Chamber

3.2.2 Thermostat - Haake HT22 and associated equipment.

3.2.3 Flow Meters - Fischer and Porter Model 10A1152A Brooks. Sho-Rate Model #1355, tube #R-2-15-B with tantalum float.

3.2.4 Differential Pressure Gauge - Ashcroft Gauge Model 1125.

3.2.5 Pump - Procon Rotary Vane Type Model 2504.

3.2.6 Graduated Beakers - Two (2) 1000 ml capacity.

3.2.7 Weighing Machine - 0-10 lbs (accuracy 0.1% of full scale)

3.2.8 Digital Thermometer - Type K United System 590 KF

3.2.9 Thermocouple Switch - Thermoelectric Type K, 32 positions

3.2.10 Spirit Level - Standard machinist equipment.

3.2.11 Pressure Gauge - U.S. Gauge Model No. 19003 (100 psig)

3.2.12 Stop watch

3.2.13 Potentiometer (four positions) and ice bath.

3.3 Materials

3.3.1 Dowtherm "A" - reagent grade Biphenyl and phenyl ether (a eutectic mixture of 73.5% phenyl ether, 26.5% biphenyl).

3.3.2 Copper/constantan thermocouple wire (type T) No. 24 gauge.
Chromel/alumel thermocouple wire (type K) No. 28 gauge.

3.3.3 Tap water for thermostat cooling coil.

3.3.4 Insulation - fiberglass

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4.0 WARNINGS AND CAUTIONS

- 4.1 Avoid bodily contact with the heated flow loop components.
- 4.2 Special care must be exercised to make sure that the radiator panel is level (horizontal).
- 4.3 Maximum coolant temperature should not exceed 300°F.
- 4.4 Pressure must be applied to high pressure connection of Differential Pressure Gauge before low pressure is connected.
- 4.5 Absolute care must be exercised in avoiding any leaks.
- 4.6 Call the test engineer if unable to maintain the flow rates or temperatures as prescribed.
- 4.7 Maintain integrity and cleanliness of emissive coating by proper handling. Use protective cover during installation.
- 4.8 Avoid any contact between the wall of the TV chamber and the radiator panel.
- 4.9 Properly insulate all thermocouple wires and tubings.
- 4.10 Check the panels before installation for any obstructions in the flow passages.
- 4.11 At the end of each test cover the long panel to avoid the accumulation of dust. At the beginning of test dust may be removed by vacuum cleaning or blowing.

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5.0 PRE-TEST PROCEDURES

5.1 Physical Measurements

- 5.1.1 Measure (if not available) and record the following in Table 3.
- 5.1.2 Radiator tube inside diameter.
- 5.1.3 Radiator tube overall length (between the center of the inlet and the center of the outlet from the tube).
- 5.1.4 Location of radiator tube pressure taps relative to the inlet and outlet headers (see Figure 2).
- 5.1.5 Location of the inlet header and outlet header pressure taps relative to the radiator tube (see Figure 2).

5.2 Setting the Flow System in Operation

- 5.2.1 Connect the flow circuit as shown in KIPS1040007, except the differential pressure gauges.
- 5.2.2 Using a spirit level, make sure that the radiator panel is completely horizontal.
- 5.2.3 Close tee handle cocks near the pressure gauges.
- 5.2.4 Open valve #3 and adjust valve #1 and #4, for fluid to pass through desired rotameter and the radiator panel.
- 5.2.5 For operation at room temperature bypass the thermostat by adjusting the valve #5.
- 5.2.6 For operation at temperatures higher than the room temperature initially set the thermostat temperature regulator at the desired temperature.
- 5.2.7 Turn on the thermostat preheating system. After the thermostat liquid has reached the desired temperature turn on the thermostat motor.
- 5.2.8 Turn on the pump motor.
- 5.2.9 Open the tee handle cocks to bleed the air out of the flow circuit. After all the air has been removed close the cocks and connect the differential pressure gauges.
- 5.2.10 Bleed the air out of differential pressure gauges.
- 5.2.11 Gradually open the flow control valve (#2) until the rotameter float stabilizes at the desired graduation. (If necessary adjust valve #3.)
- 5.2.12 Allow thirty (30) minutes for temperature to get stabilized such that it remains constant within $\pm 1^\circ$ (if necessary make fine adjustments by controlling the cooling water flow rate through the thermostat).

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5.2.13 See that the system pressure does not rise above approximately 50 psi.

5.3 Flow Meter Calibration

5.3.1 Connect the flow circuit as shown in KIPS1010007.

5.3.2 Make sure that there is no leakage at any point along the flow circuit.

5.3.3 Initially keep valves #3 and 2 closed.

5.3.4 Calibration of Rotameter II

5.3.4.1 Open valve #1 so that flow would pass only through rotameter II (tube No. R-2-15-B with tantalum float)

5.3.4.2 With the Dowtherm "A" fluid at room temperature set the rotameter float at a particular graduation by gradually opening the valve #2 and if necessary adjusting the valve #3.

5.3.4.3 When ready for measurements adjust valve #4 to collect and weigh the amount of fluid passing through the rotameter for a fixed period of time (minimum 30 seconds) measured by stop watch.

5.3.4.4 For each graduation repeat the procedure in para. 5.3.4.3 for at least three (3) times.

5.3.4.5 Record the measured quantities on "Flow Meter Calibration Data" sheet (Table 1).

5.3.4.6 Determine flow rate for at least seven (7) of the graduations on the flow tube.

5.3.4.7 Allow at least 10 minutes for flow to get stabilized at each graduation.

5.3.4.8 Repeat procedures in para. 5.3.4.2 through 5.3.4.7 for four different thermostat temperatures in the range of 165 to 215°F. Each temperature must be maintained within $\pm 1^\circ\text{F}$.

5.3.5 Calibration of Rotameter I

5.3.5.1 Open valve #1 so that flow would pass only through rotameter I (Fischer and Porter Model No. 10A1152A).

5.3.5.2 Repeat procedures in para. 5.3.4.2 through 5.3.4.8.

5.3.6 Using a "linear regression fit," convert flow rate measurements into working calibration curves (flow rate (lbs/sec) vs rotameter reading and Reynolds No. vs rotameter reading) for each rotameter and float combination and for each thermostat control temperature.

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6.0 SHORT RADIATOR PANEL (34" x 48")6.1 Pressure Drop and Temperature Measurement

- 6.1.1 With the radiator panel and the flow circuit connected as shown in the KIPS104000S make sure that there is no leakage in the system.
- 6.1.2 Check all the thermocouples to make sure that they are in proper position. They must read room temperature under room conditions.
- 6.1.3 Using spirit level, adjust the radiator panel so that it lies in a horizontal plane.
- 6.1.4 Maintain the temperature of the thermal vacuum chamber at $-200^{\circ} \pm 10^{\circ}\text{F}$.
- 6.1.5 Evacuate the thermal vacuum chamber to 2.8×10^{-5} torr or slightly less and maintain it at that pressure.
- 6.1.6 Use Rotameter II (Brooks tube number R-2-15-B) for flow rates up to 2000 cc/min. Above this flow rate use Rotameter I (Fischer and Porter).
- 6.1.7 Set the rotameter at the desired graduation and allow at least five (5) minutes for flow to get stabilized.
- 6.1.8 Set the thermostat temperature regulator at the desired temperature.
- 6.1.9 Monitor the temperature of the fluid at the inlet to the header tube (thermocouple A). If this temperature is lower than the desired temperature adjust the thermostat regulator gradually, such that the desired temperature is achieved at the header inlet.
- 6.1.9.1 Record the temperature at the inlet to the header tube (thermocouple A) every two (2) minutes until the set temperature does not change more than $\pm 1^{\circ}\text{F}$. (If necessary make fine temperature control by adjusting the cooling water flow rate through the thermostat.)
- 6.1.10 After the temperature has stabilized at the desired value within $\pm 1^{\circ}\text{F}$ allow ten (10) minutes before taking the various readings.
- 6.1.11 Record the flow rate, all the thermocouple readings, system pressure and differential pressure on the Short Radiator Panel Data Sheet (Table 2).
- 6.1.12 Repeat the procedures in para. 6.1.7 through 6.1.11 for each of the rotameter graduations that lie in the range of Reynolds Number from about 500 to 15,000 (see the Reynolds Number vs Rotameter reading plot).
- NOTE: If the pressure drop across the tube increases beyond the range of the DPG, replace the DPG by a higher range DPG.
- 6.1.13 Repeat the procedures in para. 6.1.7 through 6.1.12 for three different temperatures at the thermostat temperature regulator (168°F , 190°F and 212°F).
- 6.1.14 Repeat the procedures in para. 6.1.7 through 6.1.12 three (3) times.

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- 7.0 FULL LENGTH RADIATOR PANEL (34" x 111")
- 7.1 Attach the full length radiator panel as in Figure 1 except that it should be mounted outside the thermal vacuum chamber.
- 7.2 Make certain that there is no leakage in the system.
- 7.3 Check all the thermocouples to make sure that they are in proper position.
- 7.4 Using spirit level, adjust the radiator panel so that it lies in a horizontal plane.
- 7.5 Repeat procedures in para. 6.1.6 through 6.1.14.

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FIGURE 1
SCHEMATIC TEST SETUP

Location of
Radiator Tube Inlet
Pressure Tap

Location of
Radiator Tube Outlet
Pressure Tap

Location of Outlet
Header Pressure
Tap Relative to
the Radiator Tube

-Location of Inlet Header Pressure Tap Relative to the Radiator Tube

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Sheet 1-1

FLOW METER CALIBRATION DATA SHEET

Diameter of the radiator tube (ft):
Rotameter Tube No. and float:

Date:

[illegible]

RADIATOR TEST DATA

Date:

Panel Type:

Flow Parameters				Pressure Readings PSI			Comments
Rotameter Type	Scale Reading % of Full Scale	Flow Rate lbs/sec	Reynolds Number	System Pressure	Pressure Drop Across Tube	Pressure Drop Across Header	

RADIATOR TEST DATA

Date:

Panel Type:

Flow Parameters				Pressure Readings PSI			Comments
Rotameter Type	Scale Reading % of Full Scale	Flow Rate lbs/sec	Reynolds Number	System Pressure	Pressure Drop Across Tube	Pressure Drop Across Header	

TABLE 2 (Continued)

[illegible]

TABLE 3
MEASURED FIXED PARAMETERS FOR RADIATOR PANEL TESTS

Type of Panel	Room Temperature (°F)	Thermal Vacuum Chamber Shroud Temperature (°F)	Thermal Vacuum Chamber Pressure (torr)	Barometric Pressure (in Hg)	Radiator Tube Inside Diameter (in.)	Radiator Tube Overall Length (in.)	Location of Radiator Tube Pressure Taps		Location of Header Pressure Taps Relative	
							Inlet (in.)	Outlet (in.)	Inlet (in.)	Outlet (in.)

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