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THERMAL VACUUM TEST RESULTS FOR THE EO-1 CARBON-CARBON RADIATOR

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INTRODUCTION

The Earth Orbiter - 1 (EO-1) is the spacecraft platform for the Advanced Land Imager (ALI) instrument and will fly in a sun-synchronous orbit 705 kilometers above the Earth. The launch date is scheduled for May 1999 aboard a Delta 7320 ELV. Though the ALI is the primary instrument aboard the EO-1, the spacecraft will also be used to test a number of new technologies, one of which is the carbon-carbon radiator. The C-C radiator is made of carbon fibers in a carbon matrix. It is being built by the Carbon-Carbon Spacecraft Radiator Partnership (CSRP) and will undergo environmental testing at GSFC. The testing consisted of three parts. First the radiator underwent four thermal cycles with four hour soaks at 50°C and -10°C. Second, the radiator underwent thermal balance testing for a variety of conditions. And third, the survival heaters were turned on with five different voltages.

TEST SETUP

Objective

This test is designed to meet the thermal requirements specified in the EO-1 ICD for the C-C radiator and to test the performance of the radiator for a variety of conditions.

Test Facility

The cryo-pumped Thermal Vacuum Facility located in Building 4, Room 183, of Goddard Space Flight Center will be used for this test.

Test Fixture

Two aluminum plates were bolted to the radiator to simulate the LEISA and PSE electronics boxes that will be there during the flight. A CHOTHERM thermal interface was placed between the plates and the radiator. The bolts were torqued to the recommended flight values of 38 in-lbs and re-torqued after 24 hours. The PSE plate had attached heaters capable of generating at least 50 Watts of power, and the LEISA plate heaters had at least 30 W of power capacity. The heaters were attached by two-sided adhesive tape. The power to the two heaters was capable of being adjusted independently. The radiator also had a support frame which bolted to the radiator at the spacecraft attachment points. The purpose of the support frame was to simulate the spacecraft interface during environmental testing. The bolts which attach the radiator to the support frame were torqued to the recommended flight values of 38 in-lbs. There were no heaters on this frame, but Swales supplied two survival heaters which were placed on the radiator. In addition, two strain gauges were placed on the frame to monitor mechanical forces. The radiator was suspended vertically in the chamber by stainless steel wire. During the thermal balance and survival heater tests, MLI was used to insulate the side with the heaters (see Figure 2).

The test fixture temperatures was recorded by a data acquisition system connected to a PC using Labview software. The temperatures were recorded throughout the entire test. The chamber pressure and the actual heater power were recorded in the log book. Type "T" thermocouples were used to monitor test temperatures. Thirty eight were on the radiator and frame, and several were on the chamber wall, shroud, and platten. Two strain gauges were placed together on the outside surface of the support frame. See Figure 1 for rough thermocouple and strain gauge locations. Because the front side of the radiator was covered with silver teflon, the thermocouples were place on the heads of the attachment screws at the four corners and on screws in four of the GSE insert holes.

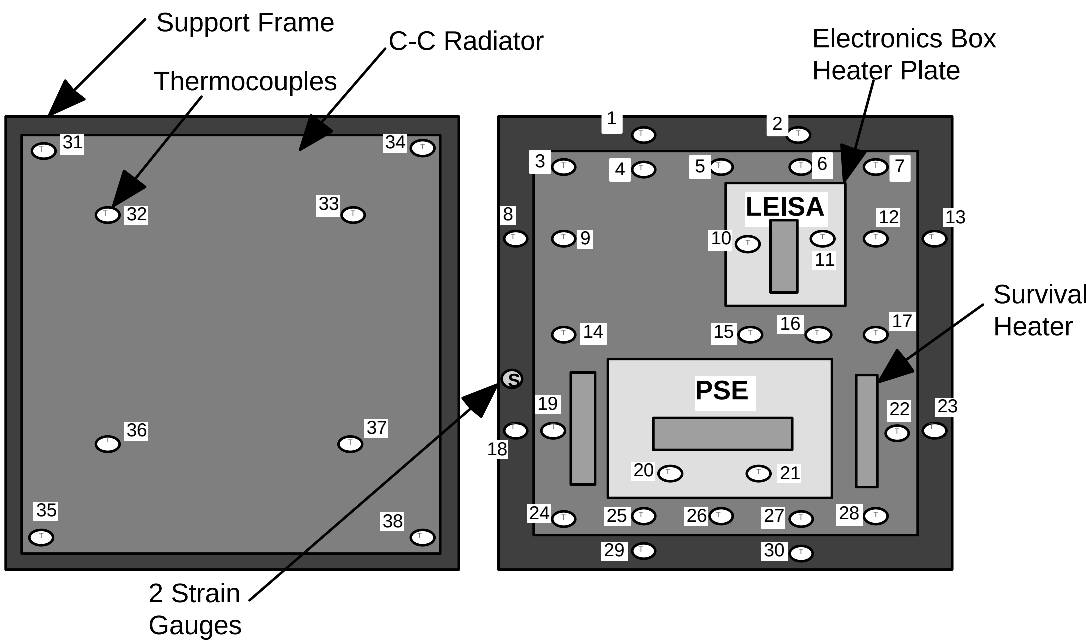

Figure 1: Thermocouple & Strain Guage Locations for C-C Radiator Thermal Vacuum Test

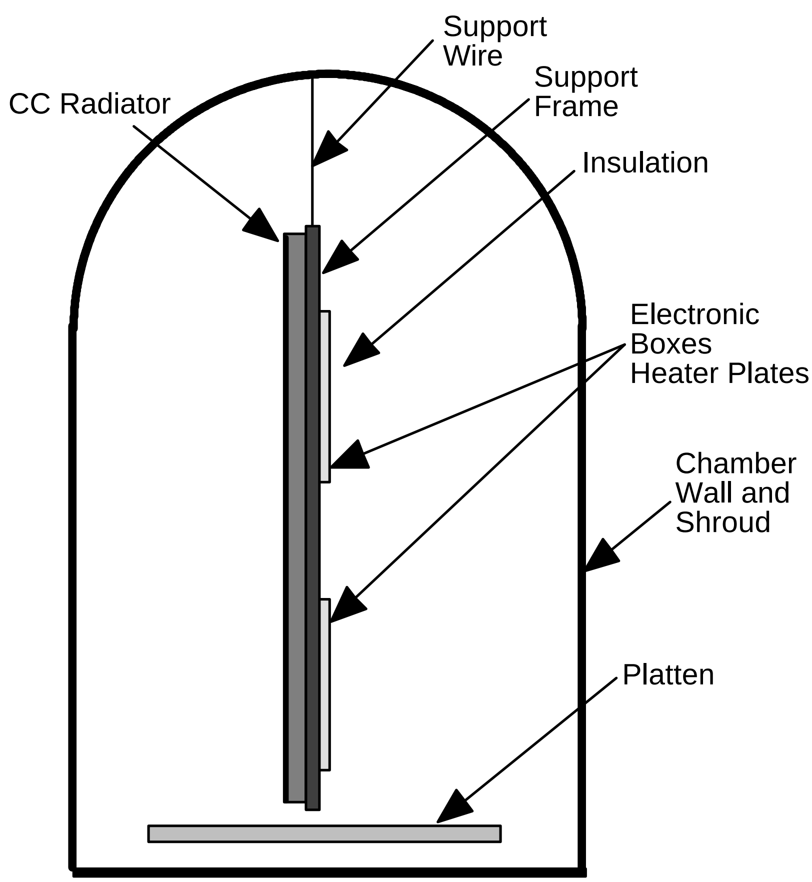

Figure 2: Carbon-Carbon Radiator Thermal Vacuum Setup for Thermal Balance Test
[not to scale]

Heater power was monitored continuously by measuring the voltage directly across the heater and by measuring the actual current flowing through the heater. When steady state was reached, the voltage and current were measured and recorded in the log.

TEST RESULTS

Prior to the first test, the emissivities of the front and back of the radiator were measured. On the front (silver teflon), the emissivity was measured in five areas and averaged 0.81 overall. On the back side (box side), the emissivity was measured in three areas and averaged 0.80 overall.

Thermal Cycle Test

The C-C radiator was subjected to four cycles each consisting of a hot soak at 50°C for four hours and a cold soak at -10°C for four hours. The chamber wall, shroud, and platten were controlled to a temperature that attained and sustained these desired conditions. The temperatures of the front (TC 36) and back (TC 15) of the radiator, the platten (TC 56), and the shroud (TC 84) are shown in Figure 3. Figure 4 shows the output of the two strain gauges and the temperature of the frame nearest the gauges (TC 18).

Thermal Balance Test

Table 1 is a list of the test conditions for the thermal balance test.

Table 1: Thermal Balance Test Conditions

No.	PSE Power(W)	LEISA Power(W)	Platten(C)	Shroud(C)
1	10	0	-20	-20
2	30	0	-20	-20
3	50	0	-20	-20
4	0	10	-20	-20
5	0	30	-20	-20
6	20	10	-20	-20
7	40	20	-20	-20
8	50	30	-20	-20

The results of this test are shown in Figures 5 and 6. Figure 5 is a plot of the radiator front (TC 36) and back (TC 15), and the LEISA and PSE heater powers versus time. Figure 6 is a plot of the LEISA (TC11) and PSE (TC 20) temperatures and the heater powers.

Survival Heaters Test

Table 2 shows the test conditions for the survival heater testing, and Figures 7 and 8 show plot of the temperatures of the back and front of the radiator and the survival heaters' power. The power to both heaters was measured as a single voltage and current.

Table 2: Survival Heater Test Conditions

No.	Heater Voltage	Platten(C)	Shroud(C)
1	21	-20	-20
2	26	-20	-20
3	30	-20	-20

4	35	-20	-20

Figure 7 has the temperatures of the upper left (TC 3), upper right (TC 7), center (TC 15), lower left (TC 24) and lower right (TC 28) of the back or box side of the radiator. Figure 8 has the upper left (TC 31), upper right (TC 34), center (TC 36), lower left (TC 35) and lower right (TC 38) of the front or silver teflon side of the radiator

Figure 3: Thermal Cycles Test - Temperatures

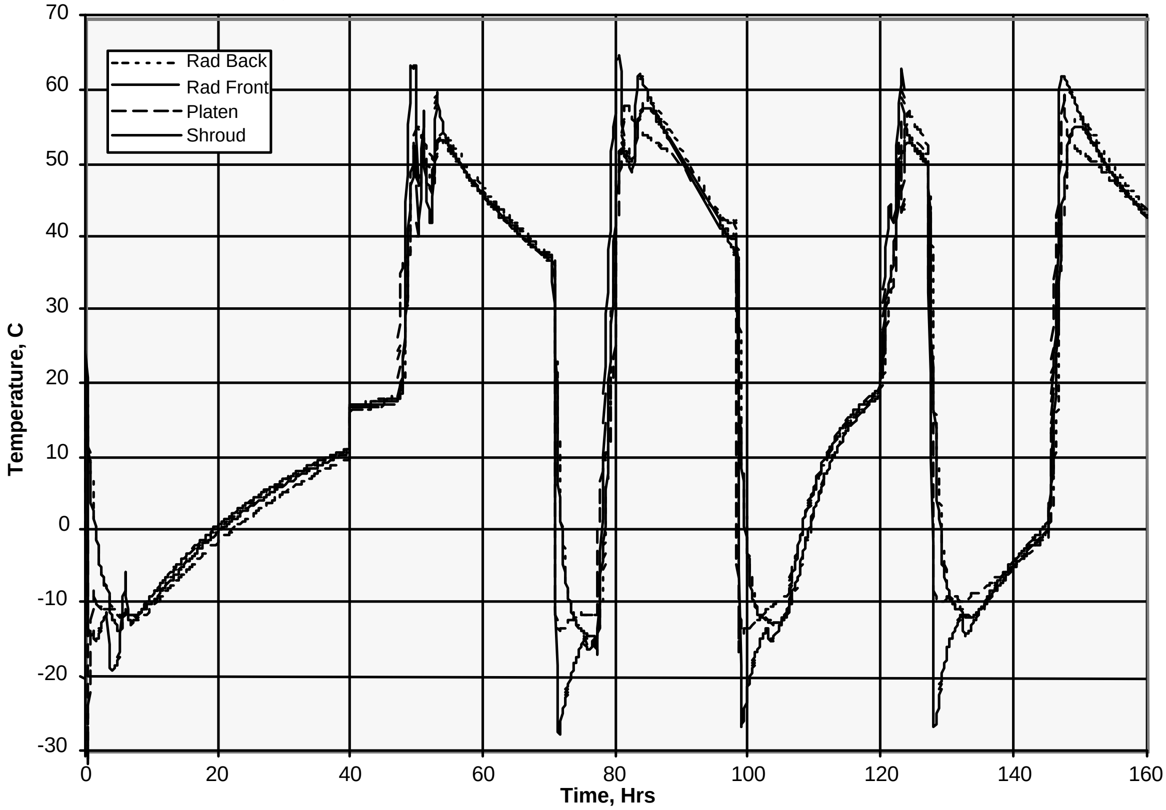

Figure 4: Thermal Cycles Test - Strain Gauges

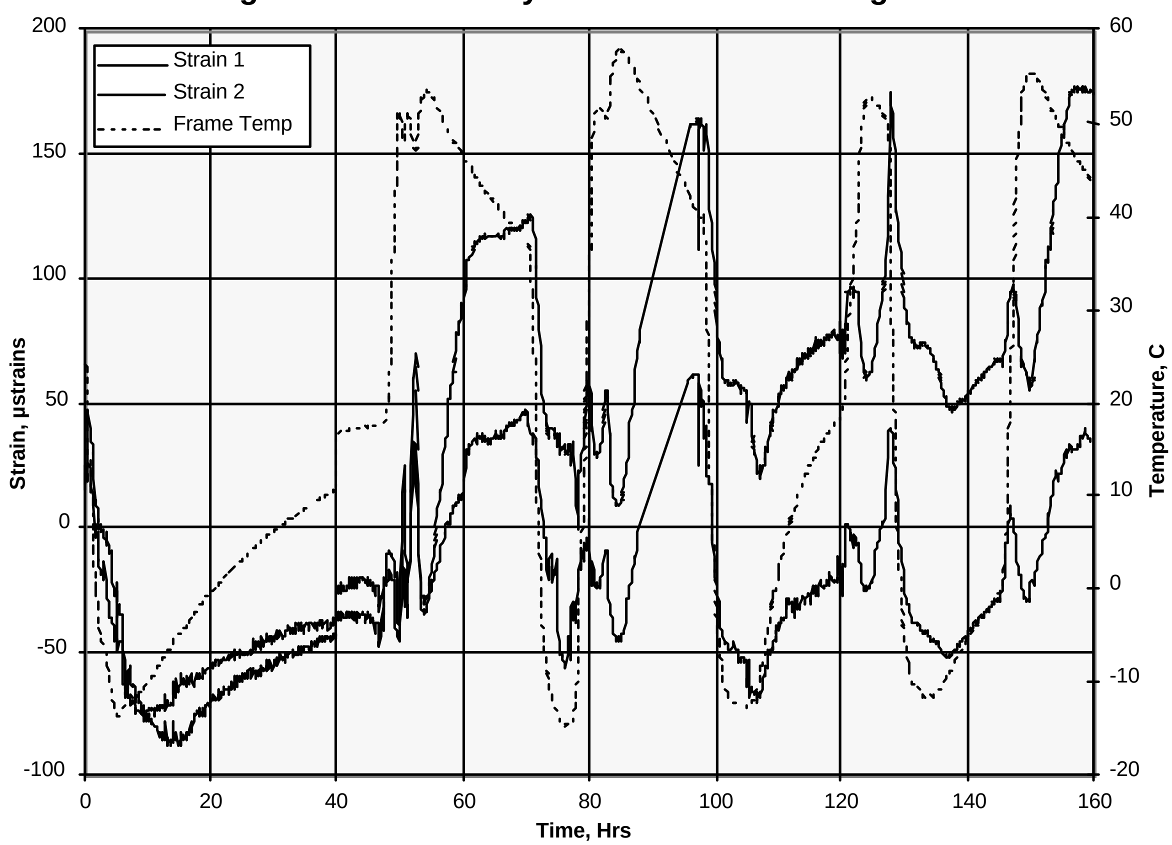

Figure 5: Thermal Balance Test - Radiator Temps & Heater Powers

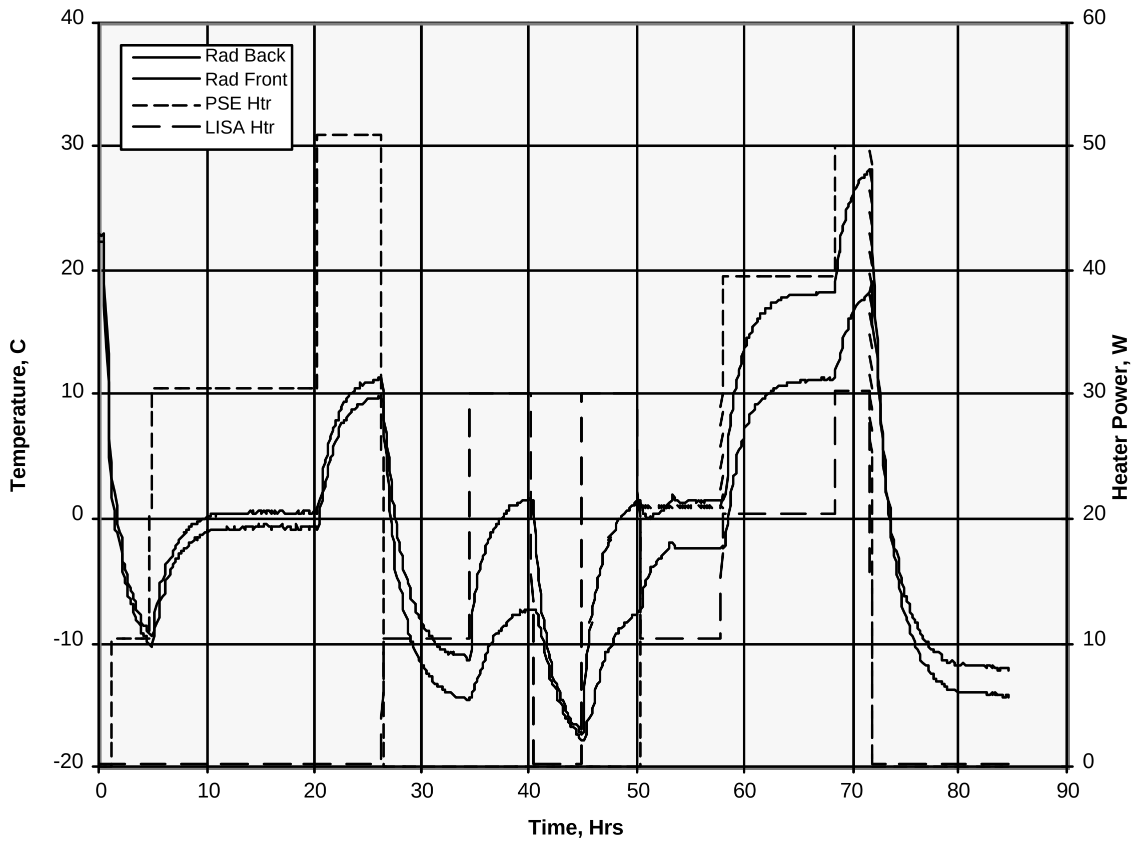

Figure 6: Thermal Balance Test - Plate Temps & Heater Powers

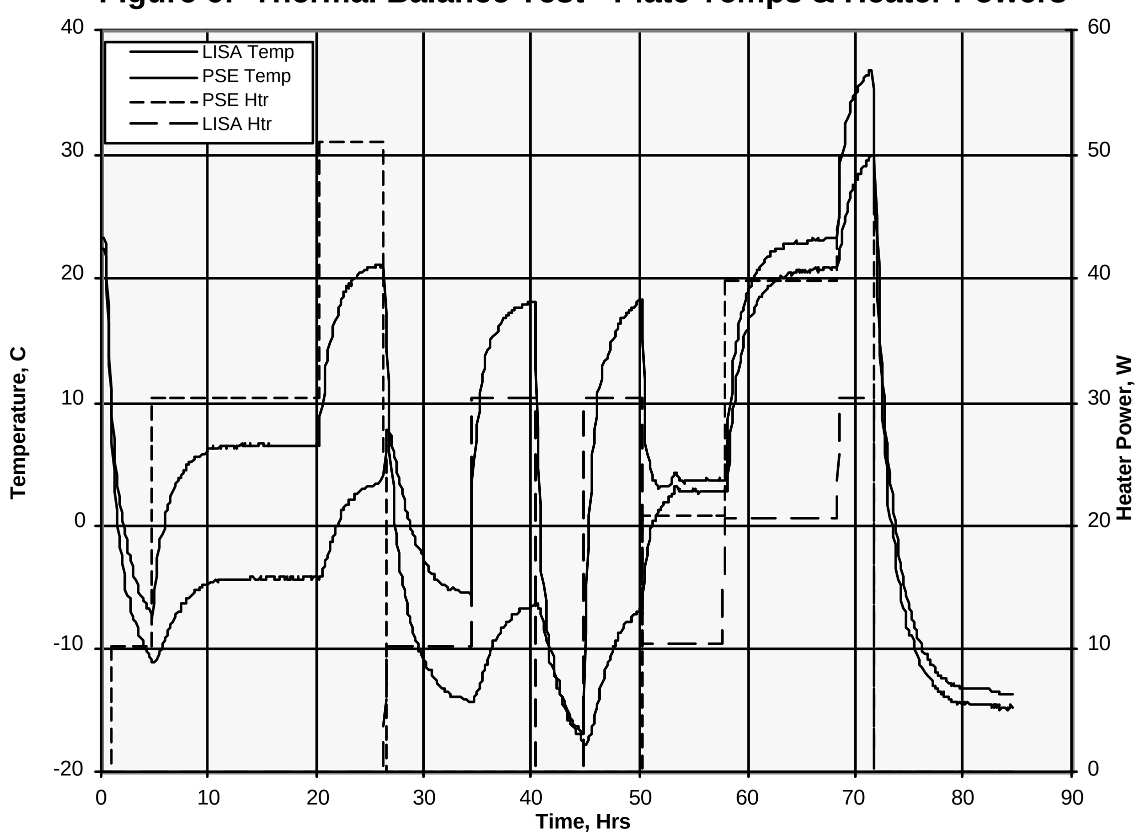

Figure 7: Survival Heater Test - Radiator Back

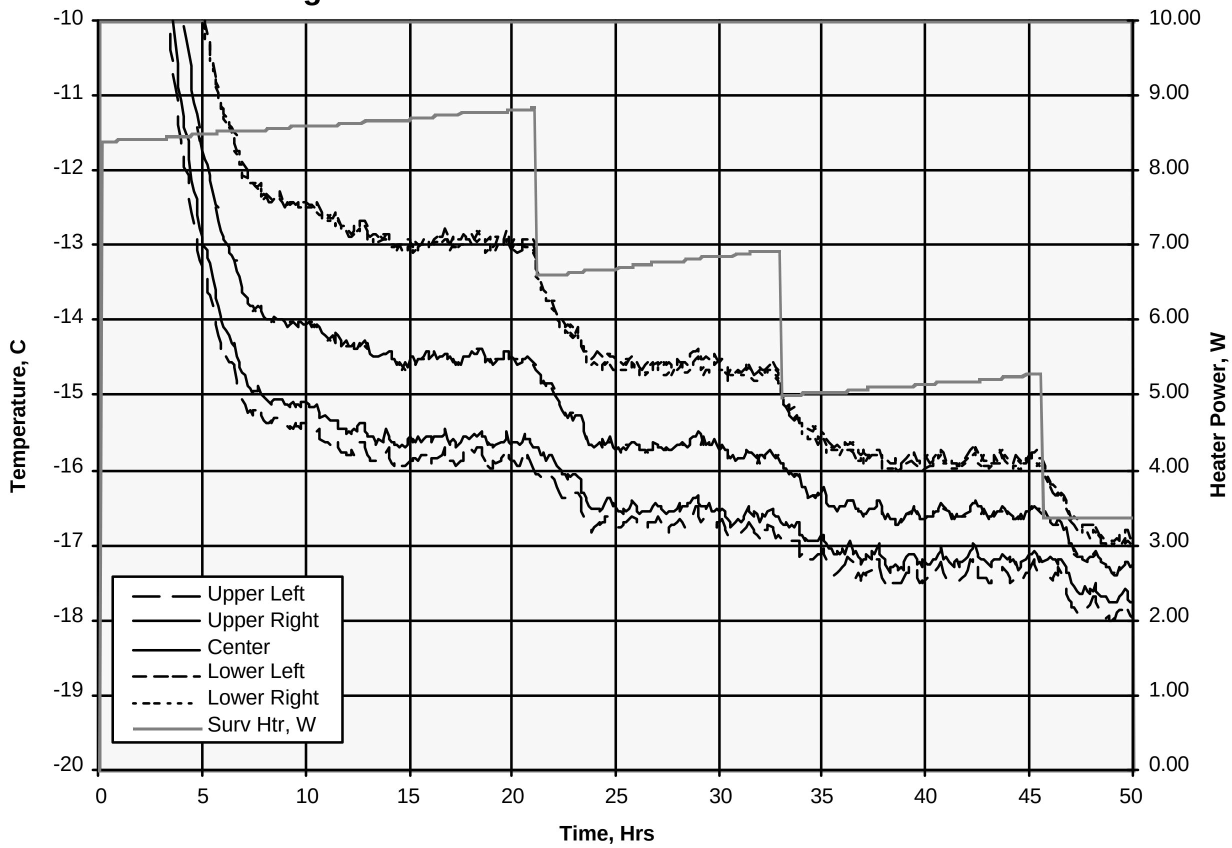

Figure 8: Survival Heater Test - Radiator Front