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GLAST Tracker Tray Assembly Thermal Test Plan

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Abstract

This report presents the test plan and procedure for the GLAST Tracker Tray Assembly Thermal Test. A thermal test is required to ensure the survivability of the tracker tray assembly when subject to the mission environment. Thermal test results will be used to validate FE models that will be used to design/analyze actual tray design principles. The Science Instrument – Spacecraft Interface Requirements Document (SI-SC IRD) defined the temperature parameters, which the tray assembly would be subjected to in the mission environment.

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Revision Log

Revision	Date	Author	Summary of Revisions/Comments
OI	February 17, 1999	R. Baer, S. Ney, M. Steinzig, E. Swensen	Initial release.
A	April 12, 2000	R. Baer	Updated document number, added Revision log
B	October 30, 2000	E. Swensen	Updated document to incorporate changes made to the test plan during the actual test to ensure the test could be easily reproduced. Improper strain gages were called out in this plan and corrected here. Modifications were made to Sec. 6.2, Paragraph 1, Sec. 8.1, Step 4, Sec. 8.2, Step 4, and Sec. 8.3, title & added Step 4.

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1. Scope

This test procedure describes the thermal test to be conducted on the Tracker Tray Assembly for the Gamma-ray Large Area Space Telescope (GLAST). This document encompasses all of the pertinent information to set-up and carry out the thermal testing. The following sections will include test objectives, test and instrument set-ups, input levels and procedures to carry out the thermal tests efficiently.

2. Test Objective

The objective of the thermal test is to subject the Tracker Tray Assembly to temperatures that are typical to the mission environment. The Tray Assembly will be subjected to temperature ranges specified in the GLAST Science Instrument – Spacecraft Interface Requirements Document (SI-SC IRD), and the structural response will be measured. The response measurements will be used to evaluate the Tray Assembly with regards to the quality of workmanship, reliability of the design, and survivability to the missions thermal environment. The test is also meant to validate finite element models (FEM) and evaluate the current instrumentation and setup for accuracy and reliability.

3. Test Article

Single tray assembly from the GLAST Tracker Tower

The tray is a mechanical prototype of the proposed flight unit. The prototype consists of an aluminum tray closeout with 2-mil wall aluminum honeycomb core and 2-mil aluminum face sheets. Twenty-five 8-mil thick lead squares were bonded to one side of the prototype tray and Kapton circuit sheets were bonded to both sides. One complete ladder of silicon detectors was bonded to the center position on the lead side of the tray. Silicon detector squares were also bonded in the first detector position closest to the side mounted electronics boards in each of the remaining ladder positions on both sides of the prototype tray. Aluminum mass simulators were bonded in the remaining detector positions to form the detector field. The aluminum mass simulators were not edge bonded like the silicon detectors in the actual full ladder. Printed circuit boards without the components were glued into place on two sides of the tray closeout.

4. Test Environment

4.1 Facility

The thermal tests will be conducted at HYTEC Inc. in a clean room environment with temperature control and foreign particle filtration.

4.2 Equipment

The equipment used in conducting the thermal test will include the following:

1. Sun Systems Environmental Chamber – Model EC02
2. Liquid Nitrogen
3. National Instruments Lab VIEW Software
4. Strain Gages
5. Resistance Temperature Detectors (RTDs)
6. Analog Devices backplane with A/D modules

5. Test Configuration

Strain gages will be bonded to the top and bottom of the prototype tray (See Appendix A). Specific strain gage locations are selected by identifying high strain locations using FEA results. Resistance Temperature Detectors (RTDs) will be bonded to the tray at locations nearest the strain gages.

Thermal loads will be produced in a temperature-controlled oven. Tracker Tray Assembly will be initially subjected to temperatures ranging from -10 °C to +40 °C, followed by additional tests over an extended range from -55 °C to +60 °C. Further temperature extremes will be performed should the tray survive previous testing. The oven can achieve temperatures of ±100°C.

6. Instrumentation

6.1 Resistance Temperature Detectors

RTDs will be bonded to the tray at locations nearest the strain gages (See Appendix B for locations).

Readout from RTDs is to be done using an Analog Devices 6BP16-1 backplane with twelve 6B13 A/D modules configured for an input range of ±100°C with a coefficient of thermal expansion constant for platinum, $\alpha = 0.00385$. Typical accuracy of the 6B13 modules is ±0.02°C with a maximum error of ±0.15°C and a peak-to-peak noise of 0.03°C. The RTDs have a range of -70°C to +500°C.

6.2 Strain Gage Sensors

Strain gage sensors are selected to satisfy the needs of the experiment. Use Vishay linear gages, types CEA-XX-250UN-350 or CEA-XX-250UW-350 (Narrow or Wide gages will be satisfactory), and rosettes, type CEA-XX-250UR-120, in the quantities necessary. Here, XX used in the strain gage number represents the self-temperature-compensation (S-T-C) value and comes in a variety of values. The S-T-C number is the approximate linear thermal expansion coefficient of the gage, given in ppm/°F. It is important to use gages with identical S-T-C numbers on both the reference and test pieces to minimize errors. It is also important to use gages from the same manufacturing lots to avoid erroneous errors that will results from material property and manufacturing variations between lots. The lot #'s are listed on the strain gage data sheets.

The strain gages will be connected to a P3500 strain gage measurement unit through a SB-10 switching and balancing unit also from Vishay Measurements Group. Configure the strain gage bridge as a ¼ bridge circuit.

Strain gages sensors are susceptible to damage during handling and must be handled with some caution to avoid damage during installation. Both unidirectional and rosette type strain gages are used, all purchased from the Micro-Measurements Division of Measurements Group. Unidirectional gages have a resistance of 350 ohms ±0.3%. The rosettes have a resistance of 120 ohms ±0.4%

7. Test Levels

Use the following temperature levels for all testing:

- Reference Temperature: +24°C
- Operating Environment Temperature Range: -10°C to +40°C
- Extreme Environment Temperature Range: -55°C to +60°C
- Allowable Oven Temperature Range: -100°C to +100°C

8. Test Samples/Tray Assembly Preparation

The following paragraphs outline the test sequence to prepare test samples and the *Tracker Tray Assembly* for thermal testing.

8.1 6061 Aluminum Test Specimen Preparation

The following is a procedure for preparing the Aluminum test specimens.

1) Turn on air filter housing fan and lights in clean room and allow room to come to equilibrium temperature before beginning strain gage preparation of aluminum test specimen. (+24°C is desirable)
2) Prepare aluminum test specimen for strain gage application using instruction bulletin B-137-16 from Micro-Measurements division of Measurements Group Inc. (or equivalent from selected strain gage vendor)
3) Select strain gages of the same type and lot #. The lot # is not as critical as the type, however errors will result from using gages from different lot's.
4) Bond strain gages to the aluminum test specimen in the locations denoted in Appendix C using instruction bulletin B-137-16 for M-bond AE-10 adhesive system. Use Vishay CEA-00-250UN-350 or CEA-00-250UW-350 (or similar) strain gages. Record the gage factor and transverse sensitivity at +24°C.

8.2 Silicon and Titanium Silicate Preparation

The following is a procedure for preparing the Silicon and Titanium Silicate test specimens.

1) Turn on air filter housing fan and lights in clean room and allow room to come to equilibrium temperature before beginning strain gage preparation of Silicon and Titanium Silicate samples. (+24°C is desirable)

2) Prepare Silicon and Titanium Silicate samples for strain gage application using instruction bulletin B-137-16 from Micro-Measurements division of Measurements Group Inc. (or equivalent from selected strain gage vendor)
3) Select strain gages of the same type and lot #. The lot # is not as critical as the type, however errors will result from using gages from different lot's.
4) Bond strain gages to the Titanium-Silicate and Silicon samples in the locations denoted in Appendix C, using instruction bulletin B-137-16 for M-bond AE-10 adhesive system. Use Vishay CEA-00-250UN-350 or CEA-00-250UW-350 (or similar) strain gages. Record the gage factor and transverse sensitivity at +24°C.

8.3 <u>Tracker Test Tray & Reference Preparation</u>

The following is a procedure for preparing the Tracker test tray.

1) Turn on air filter housing fan and lights in clean room and allow room to come to equilibrium temperature before beginning strain gage preparation of Tracker Test Tray. (+24°C is desirable)
2) Prepare Tracker Test Tray for strain gage application using instruction bulletin B-137-16 from Micro-Measurements division of Measurements Group Inc. (or equivalent from selected strain gage vendor)
3) Bond strain gages to the locations denoted in Appendix A, using instruction bulletin B-137-16 for M-bond AE-10 adhesive systems. Use Vishay CEA-06-250UN-350 or CEA-06-250UW-350 (or similar) strain gages and CEA-13-250UR-120 rosettes. Record the gage factor and transverse sensitivity at +24°C.
4) Bond two strain gages to the silicon reference piece, using instruction bulletin B-137-16 for M-bond AE-10 adhesive systems. Use two Vishay CEA-06-250UN-350 or CEA-06-250UW-350 (or similar) strain gages and one CEA-13-250UR-120 rosette. Record the gage factor and transverse sensitivity at +24°C.

8.4 <u>Lead Wire Attachment</u>

The following is a procedure for attaching lead wires to the strain gages.

1) After bonding strain gages to test pieces, prepare equal lengths (appr. 5') of lead wire sets. Each strain gage will require three conductors, soldered to the twocontact pads. Use 26 gage - 3 conductor wire when available, or build 3 conductor wire sets using 26 gage single conductor wires of different colors. Mark the wires at about 2'6" from the instrument with a permanent ink pen for later use. Attach the leads to the strain gages per the instructions in Micro Measurements bonding kit, insuring that the same color wires are attached to the same junction for each gage.
Note: Alternate gage wires can be used (i.e. using 30 gage lead wire), however the wire gage must remain constant for each strain gage of the same type.
2) Label each set of leads and prepare a diagram that correlates the label to a specific location on the specimen/tray. The labels should be attached approximately 1 foot from the end of the lead farthest from the gage.
3) Line up all the pen marks and attach the leads in sequential order to a piece of tape. Attach another piece of tape to the top of the leads so they cannot come loose.

4) Prepare the RTD leads using the same techniques described above.

8.5 Test Setup (For Samples and Tray Assembly)

The following is a procedure for setting up tests.

1) Place article(s) on supporting fixture inside the Thermal Oven.
2) Route lead wires for strain gages and RTDs out through one of the openings along the side of the thermal oven, and insert the plug so the leads are held at about the location of the tape applied in section 8.4.3 above. This insures that each gage has equal lengths of lead wire inside the oven, minimizing variations in resistance. All the leads from a particular type of instrument (RTD, unidirectional or rosette) should have the same length of wire inside the oven.
3) Connect lead wires from the strain gages to the SB-10 Balance & Switching unit, in quarter-bridge configuration, and connect the SB-10 to the P3500 strain gage readout unit. In the event that more than 10 strain gages are being used, it may be useful to tape the leads near the label in groups of 10 to facilitate switching. Additional SB-10 units can be daisy chained to facilitate additional channels greater than 10.
4) Connect lead wires from the RTDs to the 6B13 A/D modules (or similar) on the 6BP16-1 backplane (or similar). Turn on the 68B driver and backplane and initialize the RTD program using the local computer and the "6Bwin" directory.
5) Start the oven and set to T_{ref}, +24°C. Once the nominal temperature has been reached, allow the system to "soak" for a period of at least 20 minutes. Ensure that the RTD temperature readings are comparable to the indicated oven temperature, and that the temperatures are fairly steady.
   Note: Titanium Silicate requires ~45 minutes to come to thermal equilibrium.
6) Turn on SB-10 and P3500 units and allow them to come to equilibrium (appr. 10 minutes) before balancing strain gages. Balance each bridge on the SB10 unit to get zero strain at the reference temperature. Record balance settings and repeat if necessary (i.e. more than 10 channels)
7) Prepare a data sheet to record ambient temperature, nominal temperature (the oven setting), balance settings and the strain reading from each gage. Also, a row should be reserved to record the setting dialed into the P3500 to get zero strain at the reference temperature.

9. Test Procedures

9.1 Pre-Test of 6061 Aluminum Test Specimen and Titanium Silicate Reference Sample (Separate tests)

1) Place prepared aluminum test specimen in the temperature chamber. Position the test specimen(s) to allow convection currents to flow freely around the test article.
2) Connect strain gage and RTD lead wires to measurement instrument(s).
3) Set oven temperature to T_{ref} = +24°C.
4) Once set temperature is reached, soak test piece for at least 20 minutes.

Note: Titanium Silicate requires ~45 minutes to come to thermal equilibrium.

5) Record RTD temperatures by printing the computer screen, and strain gage measurements on the prepared data sheet. At +24°C, balance the bridge and record the balance settings.
6) Increase oven temperature by 10°C, not to exceed 2°C/minute ramp rate.
7) Record strain and RTD measurements on prepared data sheet.
8) Repeat steps 5 and 6 until an oven temperature of +72°C is reached.
9) Decrease oven temperature by 10°C, not to exceed 2°C/minute ramp rate.
10) Record strain and RTD measurements on prepared data sheet.
11) Repeat steps 8 and 9 until an oven temperature of -66°C is reached.
12) Post-process results for measured CTE.

9.2 CTE Test of Silicon

1) Place prepared Silicon and Titanium Silicate sample in the temperature chamber. Position the test specimen(s) to allow convection currents to flow freely around the test article.
2) Connect strain gage and RTD lead wires to measurement instrument(s).
3) Set oven temperature to T_{ref} = +24°C.
4) Once set temperature is reached, soak test piece for at least 30 minutes.
   Note: Titanium Silicate requires ~45 minutes to come to thermal equilibrium.
5) Record RTD temperatures by printing the computer screen, and strain gage measurements on the prepared data sheet. At +24°C, balance the bridge and record the balance settings.
6) Increase the oven temperature to +36°C and repeat steps 4 and 5. Do not exceed 2°C/minute ramp rate.
7) Repeat step 6 for temperatures of +48°C and +60°C.
8) Return oven temperature to T_{ref}, allow test article to soak for 30 minutes and re-balance all strain channels. Record the balance settings.
9) Decrease the oven temperature to 0°C and repeat steps 4 and 5. Do not exceed 2°C/minute ramp rate.
10) Repeat step 9 for temperatures of -25°C and -55°C.
11) Post-process results for measured CTE.

9.3 Tracker Tray Assembly Test

Note: Perform steps 1-4 before proceeding with any of the following tests.

1) Before proceeding, ensure that all equipment is powered up and has reached thermal equilibrium. Also, the testing environment should be maintained at nearly constant temperature during all testing.
2) Set oven temperature to T_{ref} = +24°C.
3) Once set temperature is reached, soak test piece for at least 45 minutes.
4) Balance the strain gage bridge and record the balance settings and RTD temperatures by printing the computer screen.

Test for temperature range of -10° C to +40° C and –55° C to +60° C

a. Cycle between -10°C to +40°C using the following schedule. Do not exceed 2°C/minute ramp rate when changing temperatures.

   T_{set} = +24°C, +30°C, +17°C, +35°C, +10°C, +40°C, +3°C, -4°C, -10°C

b. Once the set temperature is reached, soak the test piece for at least 15 minutes, at each temperature.
c. Record RTD temperatures by printing the computer screen, and strain gage measurements on the prepared data sheet for each temperature setting.
d. Inspect the tray for damage by removing the door at each temperature.
   Note: If damage occurs during test, notify project leader and discontinue the test.
e. Restart testing at +24°C. Set oven temperature to T_{ref} = +24°C.
f. Once set temperature is reached, soak test piece for at least 45 minutes.
g. Balance the strain gage bridge and record the balance settings and RTD temperatures by printing the computer screen.
h. Cycle between -55°C to +60°C using the following schedule. Do not exceed 2°C/minute ramp rate when changing temperatures.

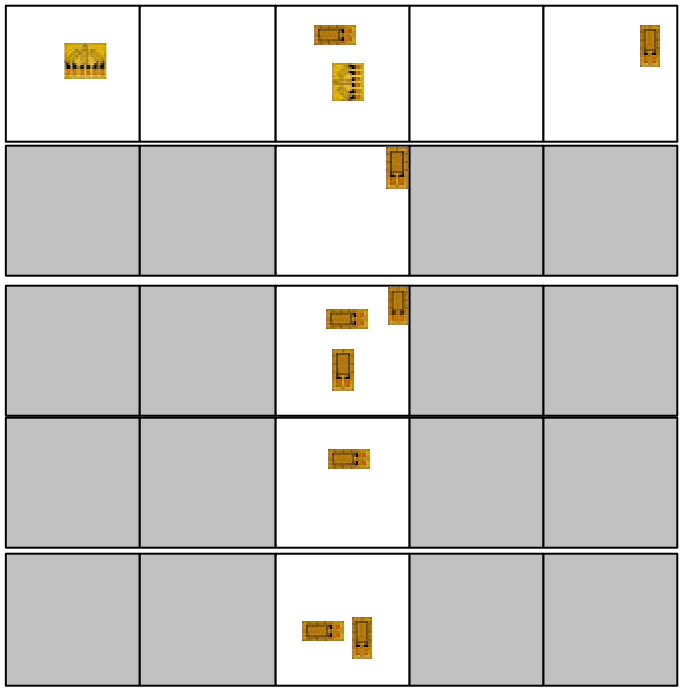
   T_{set} = +24°C, +50°C, +60°C, -20°C, -40°C, -55°C

i. Once the set temperature is reached, soak the test piece for at least 15 minutes, at each temperature.
j. Record RTD temperatures by printing the computer screen, and strain gage measurements on the prepared data sheet for each temperature setting.
k. Return to ambient temperature and inspect the tray assembly for damage by completely removing it from the oven.
   Note: If damage occurs during test, notify project leader and discontinue the test.

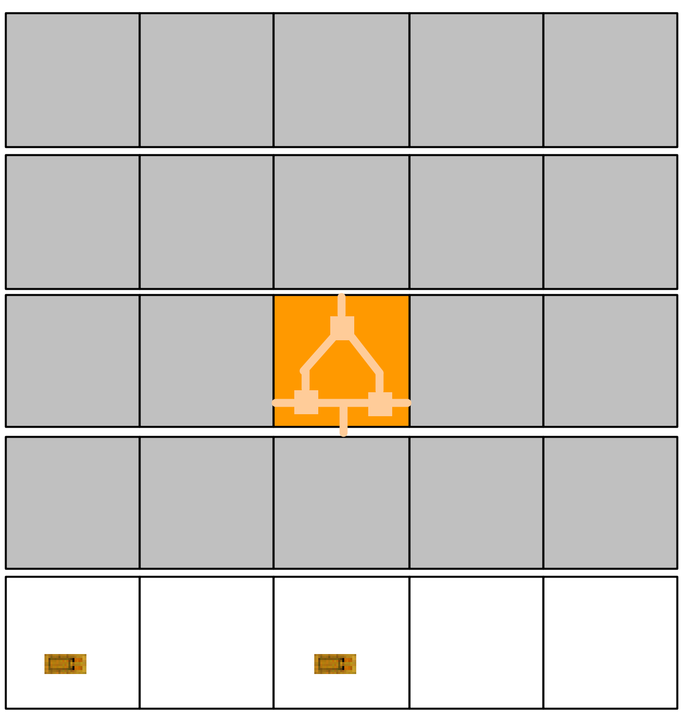
Cyclic test for temperature range of -55° C to +60° C.

a. Perform steps 1-4 from above before proceeding.
b. Increase the oven temperature from T_{ref} to +40°C, and cycle between +40°C and -55°C for three complete cycles. Use the oven's default ramp rate of 15°C/minute throughout this test.
c. At both the maximum and minimum temperatures, soak the test piece for at least 45 minutes. (i.e. +40°C and -55°C, each cycle)
d. Record RTD temperatures by printing the computer screen, and strain gage measurements on the prepared data sheet for each soak temperature.
e. Shut off the oven and return the test tray to ambient. Remove the door and inspect the tray for damage.
   Note: Do not remove door until the test tray/oven have returned to room temperature. (+24°C).

10. Appendix A: Strain Gage Locations

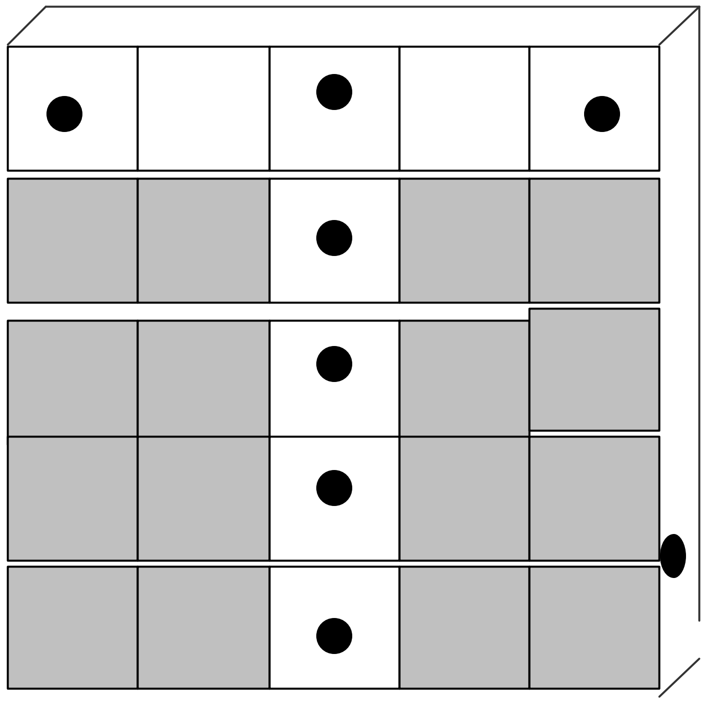


Strain Gage Locations (Tray Assembly Bottom)

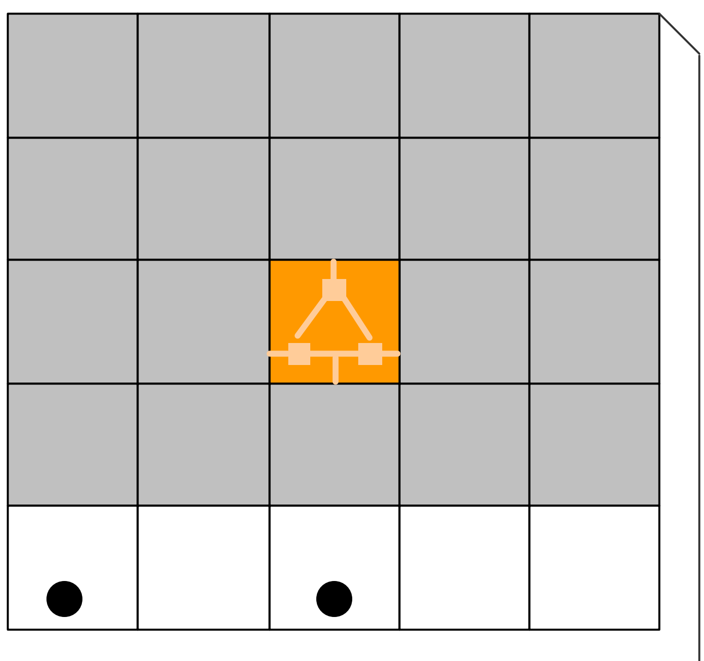


Strain Gage Locations (Tray Assembly Top)

11. Appendix B: RTD Locations

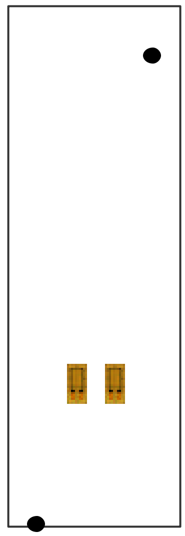


RTD Locations (Tray Assembly Bottom)

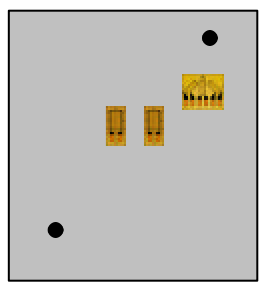


RTD Locations (Tray Assembly Top)

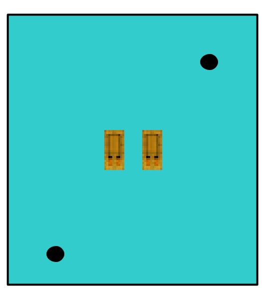
12. Appendix C : Strain Gage and RTD Locations on Test Pieces



Titanium Silicate Reference Strain Gage/RTD Locations



Silicon Sample Strain Gage/RTD Locations



6061 Aluminum Test Specimen Strain Gage/RTD Locations

13. Appendix D: Data Log Sheets

Insert Data Sheets Here
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