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FOR THE MARS OBSERVER MISSION

(TE5)

THERMAL EMISSION SPECTROMETER

FOR THE

CALIBRATION REPORT
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1.1 Introduction

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### Table 1-1 Internal Reference Surface Temperature Deviation

<table>
<thead>
<tr>
<th>Temperature</th>
<th>Deviation</th>
</tr>
</thead>
<tbody>
<tr>
<td>0°C</td>
<td>0.097 ± 0.025°C</td>
</tr>
</tbody>
</table>

The internal reference surface temperature deviation was measured with a high-precision, calibrated instrument.

### 1.2.4 Internal Reference Surface Properties and Instrumentation

**Detector:** A minimum value of 0°C corresponds to -5°C volt.

**Formal:** A maximum value of 0°C corresponds to 11°F. The instrument's output from the internal surface is a linear scale, spanning from 5°F to 5°F.

The internal boiler data are stored as 14-bit integers in 2’s complement.

### 1.2.2 Albedo Boiler Data Structure

- Detector: A minimum value of 0% corresponds to -5%.
- Formal: A maximum value of 100% corresponds to 5°F. The albedo data are stored as 14-bit integers in 2’s complement.
The formulas used in converting the measured accuracy of 0.1°C (±0.5% resistance). The thermistors were calibrated prior to shipment from the manufacturer to an absolute one of each pair was used during calibration; the second was for redundancy. These platinum thermistors placed at the front and back of the cone surface (Fig. 1-3a). Only vacuum chamber (Fig. 1-3c). Each blackbody was instrumented with two pairs of diaphragms, 7° half-angle cones (Fig. 1-3b) that were used within the thermal chambers, 15° half-angle cones (Fig. 1-3b and 1-3p) were identical. The two calibration blackbodies (BCU-1 and BCU-2) were identical, 7.25

### Table 1-2

<table>
<thead>
<tr>
<th>Σ (°C)</th>
<th>Mean (°C)</th>
<th>Reference Thermistor</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.055</td>
<td>25.494</td>
<td>PTH-3</td>
</tr>
<tr>
<td>0.092</td>
<td>25.496</td>
<td>PTH-2</td>
</tr>
<tr>
<td>0.050</td>
<td>25.543</td>
<td>PTH-1</td>
</tr>
</tbody>
</table>

#### Table 1-2: Mean and Sigma of Reference Surface Temperatures

The results are apparent that the three thermistors give identical readings within the specified standard deviations. Results of the three thermistors (Table 2) are given in Table 1-2. From these results, the mean and standard deviations for the mean and standard deviations were determined using the mean and standard deviation. The relative temperature error between the three reference surface temperatures was determined using the following equation:

\[
\text{Temperature} = \frac{1000}{25.4898 	imes 1.0} - 341.0
\]

\[
\text{Resistance} = \frac{25.4898}{1000} \times \text{Temperature} - 341.0
\]

**YSI Thermistors:**
<table>
<thead>
<tr>
<th>Sigma</th>
<th>Mean</th>
<th>Thermister</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.000</td>
<td>34.700</td>
<td>BCU-2 Front</td>
</tr>
<tr>
<td>0.000</td>
<td>190.834</td>
<td>BCU-1 Back</td>
</tr>
<tr>
<td>0.000</td>
<td>190.629</td>
<td>BCU-1 Front</td>
</tr>
</tbody>
</table>

Table 1-4: Mean and Sigma of External Calibration Target Temperatures

\[
\begin{align*}
\text{Table I-4} & = 998.6^\circ C \\
\Delta T_0 & = 998.6^\circ C \\
\text{BCU-2 Back} & \text{ T}_0 = 1000.25 \\
\text{BCU-2 Front} & \text{ T}_0 = 999.25 \\
\text{BCU-1 Back} & \text{ T}_0 = 1000.25 \\
\text{BCU-1 Front} & \text{ T}_0 = 1003.78 \\
\end{align*}
\]

\[
\begin{align*}
\rho & = 1.889 \\
\alpha & = 0.0038 \\
T & = \text{measured resistance (ohms)} \\
\end{align*}
\]

\[
\begin{align*}
d & = \rho - 4.4 \times \alpha \\
c & = 10 - T \\
p & = 1000 \times \alpha \times T_0 + \alpha \\
T_0 & = \frac{1000 \times \alpha \times T}{p} \\
\alpha & = 0.0038 \\
T & = \frac{2\alpha}{T_0} \\
\end{align*}
\]

Platinum Thermisters:

Table 1-3: External Blackbody Target Temperature Derivation

The "plane" blackbody (BCU-2) and the temperatures agree to within 0.2°C for both the hot, "space" blackbody (BCU-I) and the blackbody. The temperature levels are within 1°C in the cold. In addition, the front and back temperatures agree with the 1°C level over 1 minute time periods. As can be seen, the temperature stability is within the points varies from 0 to 1°C at 190°C to 0.2°C at 35°C. The specified values for the mean and resistance to temperature are given in Table 1-3. The deviation of these values is less than 1°C.
### Table 1.6 Internal Instrument Temperature Insulation

<table>
<thead>
<tr>
<th></th>
<th>0.000</th>
<th>34.525</th>
<th>BCU-2 Back</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Location</td>
<td>Sensor</td>
<td></td>
<td></td>
</tr>
<tr>
<td>-------------------</td>
<td>--------</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Secondary Mirror</td>
<td>16</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Primary Mirror</td>
<td>15</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Interferometer Hole</td>
<td>14</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Interferometer Beam Splitter</td>
<td>13</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Interferometer Fixed Mirror</td>
<td>12</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Telescope Field Stop</td>
<td>11</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Power Supply</td>
<td>10</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Electronics</td>
<td>9</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bolometer Blackbody Reference (1a)</td>
<td>8</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Internal Reference Temp 3</td>
<td>7</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Internal Reference Temp 2</td>
<td>6</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Internal Reference Temp 1</td>
<td>5</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bolometer Blackbody Reference</td>
<td>4</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Spectrometer Detector Package</td>
<td>3</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bolometer Detector Package</td>
<td>2</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Albedo Detector Package</td>
<td>1</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Table 1-5: Internal Temperature Measurement Points**
The phase of testing was completed between May and October, 1991.

The thermal vacuum tests were performed to determine and confirm the field-of-view and co-alignment of the thermal-vacuum lens. The tests were conducted before and after vibration and consisted of field of view and out-of-field lens condenser before and after vibration and sub-section. These tests were performed under ambient conditions. The second phase consisted of field of view and system-level testing of the spectral performance of each bench-level testing of the TES instrument was performed in two phases. One

1.3 Bench-Level Test Conditions and Overview

<table>
<thead>
<tr>
<th>Secondary Mirror (16)</th>
<th>Beamline (13)</th>
<th>Field Stop (11)</th>
<th>Electronics (9)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.077</td>
<td>0.696</td>
<td>3.14</td>
<td></td>
</tr>
<tr>
<td>0.051</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>0.055</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>0.082</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sigma ((\sigma))</td>
<td>Mean ((\mu))</td>
<td>Tolerance Point</td>
<td></td>
</tr>
</tbody>
</table>

Table I-7: Mean and Sigma of Selected Internal Telemetry Temperatures

\[
T = \text{measured resistance}
\]

\[
\text{Temperature} = 40.36 - 79.547 \times \log T
\]

- Pennwell Thermistors
- Electronics
- YSI Thermistors: see Table I-2
- Optical Surfaces

Table I-6: Internal Instrument Temperature Deviation
The observational conditions and parameters for the calibration data set are

...where exit 8 occurred.

Overall, however, all of the test and calibration objectives set for this program were

Blackbody was at 720 K.

Albedo calibrations were performed once at each instrument temperature when the planet

The TES was radiometrically calibrated in thermal vacuum at SRRC between

1.4 THERMAL VACUUM TEST CONDITIONS AND OVERVIEW
2.0 BENCH-LEVEL TESTING

A chronologiccal hisoty of the is performed as CEF and Cape Canaveral.

Table 1.15 gives a chronologiccal hisoty of the is performed as CEF.

Table 1.12 gives the instrument and test conction and the number of the data archive tape.

Table 1.13 lists the data, the plan of the instrument, the reference surface, the instrument plan and the reference surface, and the average of the instrument plan.

Table 1.14 gives the plan of the instrument and the plan of the instrument.

Table 1.11 gives the different sequence versions.
Detector array in a clockwise direction proceeds against the limb as viewed in Fig. 2-3.

Scanning the TES pointing mirror in the +6 direction (i.e., toward the bore) reorients the

figure relative to the alignment cube, and "for"-data relative to the alignment cube,

are illustrated in Figures 2-3. Data in Figures 3-2-1, 2-2, and 2-3, the half-power points

half-power and center points are given in Tables 2-1, 2-2, and 2-3, the location of the

16/4/10/1/1 (less HV0S and FVNS) are given in Figures 2-1 and 2-2, the location of the

The results from the final pre-shipment bench alignment measurements performed on

and after thermal vacuum testing and no discernible changes in alignment were observed.

We measured was stable and no further movement was ever detected. Measurements were

this shift was stable and no further movement was ever detected. Measurements were

consistent with the alignment of the abode and thermal polynomials relative to the spectrometer, was found

after extensive testing, we determined that

alignment of the abode and thermal polynomials relative to the spectrometer was found

in instrument assembly and before, and on due course of the efforts, 1994, the

showed excellent alignment of the three instrument subsections. Following initial

Initial bench measurements taken on August 15, 1994 (less HVCI and FVD1)

(4) Location of half-power points were determined using these processed values.

(3) Maximum response was determined and scaled to 1.0. All other values were then

scaled to this value.

(2) Minimum response was determined and set to zero; all other values were offset by

location 0.

(1) Data were corrected for instrument drift using first and last points collected and

for "foz" and "foz".

The field of view positions were determined using the following processing steps:

The ICCS were collected and averaged at each special location. Using these data

view positions are referenced to the TES alignment cube.

These offsets have been included in all of the data presented below, such that the field of
### Relative to TES Alignment Cube

**Table 2-2: Azimuth Half Power Points - From Test P&N**

<table>
<thead>
<tr>
<th>88.8°</th>
<th>90.7°</th>
<th>93.5°</th>
<th>103°</th>
<th>93.5°</th>
<th>6</th>
</tr>
</thead>
<tbody>
<tr>
<td>-0.02</td>
<td>-0.1</td>
<td>-0.39</td>
<td>-0.29</td>
<td>-0.39</td>
<td>5</td>
</tr>
<tr>
<td>-0.17</td>
<td>-0.16</td>
<td>-0.29</td>
<td>-0.35</td>
<td>-0.27</td>
<td>4</td>
</tr>
<tr>
<td>-0.11</td>
<td>0.0</td>
<td>0.35</td>
<td>0.22</td>
<td>0.35</td>
<td>3</td>
</tr>
<tr>
<td>-0.48</td>
<td>0.0</td>
<td>0.47</td>
<td>0.25</td>
<td>0.47</td>
<td>2</td>
</tr>
<tr>
<td>-0.33</td>
<td>0.0</td>
<td>0.33</td>
<td>0.40</td>
<td>0.33</td>
<td>1</td>
</tr>
</tbody>
</table>

*Detector (Right (mrad))  Low (mrad)  High (mrad)  Detector (Left (mrad))  Low (mrad)  High (mrad)*

*Specrometer  Thermal Emitter*

---

### Relative to TES Alignment Cube

**Table 2-1: Elevation Half Power Points - From Test P&N**

<table>
<thead>
<tr>
<th>-0.48</th>
<th>12.0</th>
<th>-5.7</th>
<th>-14.9</th>
<th>-14.9</th>
<th>6</th>
</tr>
</thead>
<tbody>
<tr>
<td>-4.7</td>
<td>3.3</td>
<td>1.1</td>
<td>4.7</td>
<td>3.3</td>
<td>5</td>
</tr>
<tr>
<td>13.9</td>
<td>5.9</td>
<td>14.9</td>
<td>3.3</td>
<td>1.1</td>
<td>4</td>
</tr>
<tr>
<td>-4.5</td>
<td>-5.9</td>
<td>-4.5</td>
<td>14.9</td>
<td>3.3</td>
<td>3</td>
</tr>
<tr>
<td>4.8</td>
<td>-3.6</td>
<td>4.8</td>
<td>-3.6</td>
<td>4.8</td>
<td>2</td>
</tr>
<tr>
<td>14.0</td>
<td>5.9</td>
<td>14.0</td>
<td>5.9</td>
<td>14.0</td>
<td>1</td>
</tr>
</tbody>
</table>

*Detector (Left (mrad))  Low (mrad)  High (mrad)  Detector (Right (mrad))  Low (mrad)  High (mrad)*

*Specrometer  Thermal Emitter*

---

Specrometer detectors 2 and 5.

Results from a detailed 2-dimensional spot scan are illustrated in Figure 2-4 for rotation to the g-direction (i.e., limb) produces a counterclockwise rotation. Finally, the
Table 2-4 TES Alignment Relative to the Spectrocal Axes

As a point source at M01-23 and 18 days hand coordinate system, an attempt to verify this alignment will be made using MARS angles presented in Table 2-1. Represent rotational angles about the spectrally axes in a right-handed coordinate system. The Official Alignment for the MARS Observer Satellite document dated June 6, 1992. The TES alignment cube relative to the spectrally axes taken from Table 1 of the System Alignment Cube Preferred Reference. Table 2-4 gives the measured pre-flight orientation of the TES alignment cube relative to the Spectrometer Axes.

Once the TES was delivered to GE it was aligned on the spectrocal using the

<table>
<thead>
<tr>
<th>Azimuth</th>
<th>Elevation</th>
<th>Azimuth</th>
<th>Elevation</th>
<th>Azimuth</th>
<th>Elevation</th>
</tr>
</thead>
<tbody>
<tr>
<td>(mrad)</td>
<td>(mrad)</td>
<td>(mrad)</td>
<td>(mrad)</td>
<td>(mrad)</td>
<td>(mrad)</td>
</tr>
<tr>
<td>Detector</td>
<td>Specrometer</td>
<td>Detector</td>
<td>Specrometer</td>
<td>Detector</td>
<td>Specrometer</td>
</tr>
<tr>
<td>8.94</td>
<td>1.87</td>
<td>4.7</td>
<td>0.83</td>
<td>9.57</td>
<td>4.47</td>
</tr>
<tr>
<td>10.08</td>
<td>4.45</td>
<td>3.6</td>
<td>0.33</td>
<td>7.0</td>
<td>4.45</td>
</tr>
<tr>
<td>4.44</td>
<td>8.85</td>
<td>4.7</td>
<td>0.33</td>
<td>7.0</td>
<td>4.45</td>
</tr>
<tr>
<td>4.43</td>
<td>9.75</td>
<td>4.7</td>
<td>0.33</td>
<td>7.0</td>
<td>4.45</td>
</tr>
<tr>
<td>5.13</td>
<td>9.06</td>
<td>4.7</td>
<td>0.33</td>
<td>7.0</td>
<td>4.45</td>
</tr>
<tr>
<td>5.30</td>
<td>9.06</td>
<td>4.7</td>
<td>0.33</td>
<td>7.0</td>
<td>4.45</td>
</tr>
<tr>
<td>8.76</td>
<td>4.65</td>
<td>3.6</td>
<td>0.33</td>
<td>7.0</td>
<td>4.45</td>
</tr>
<tr>
<td>10.40</td>
<td>4.65</td>
<td>3.6</td>
<td>0.33</td>
<td>7.0</td>
<td>4.45</td>
</tr>
<tr>
<td>4.44</td>
<td>8.85</td>
<td>4.7</td>
<td>0.33</td>
<td>7.0</td>
<td>4.45</td>
</tr>
</tbody>
</table>

Table 2-3 Field of View Center Points - From TESL FOV8 and FNS
Figure 2.5 shows 3-dimensional examples of the intermediate out-of-field energy blocked to use for background energy subtraction.

Five I/Os were collected at each field position with the aperture open and 5 I/Os with it closed. From 1.47 to 1.47 mrad in azimuth with a spacing of 2.45 mrad (13 points) at each elevation position, the IES position number was scanned across the local plane from 1.92 to 1.92 mrad in elevation with a spacing of 0.5 mrad. Data for these I/Os were collected using a 2 x 2 mrad slit that was manually scanned. The distance was also measured for each field position.

<table>
<thead>
<tr>
<th>86.0</th>
<th>66.0</th>
<th>86.0</th>
<th>24</th>
</tr>
</thead>
<tbody>
<tr>
<td>66.0</td>
<td>66.0</td>
<td>66.0</td>
<td>16</td>
</tr>
<tr>
<td>6.0</td>
<td>96.0</td>
<td>96.0</td>
<td>12</td>
</tr>
<tr>
<td>8.0</td>
<td>6.0</td>
<td>6.0</td>
<td>3</td>
</tr>
<tr>
<td>5.0</td>
<td>0.0</td>
<td>0.0</td>
<td>8</td>
</tr>
</tbody>
</table>

Table 2.5: Design Response to Extended Source

Table 2.5: Normalized Enclosed Energy

Calibration requirements for each instrument sub-section are given in Table 2.5. The energy received by each detector that fell outside of the half-power points of the out-of-field response was done to determine the percentage of the total.

2.2.1 Intermediate Out-of-Field Response

2.2 Out-of-Field Response

Launch predictions have been verified using the Mars approach observations. The coordinate system can be calculated. This final transformation will not be done until the pre-

Using the offsets between the IES alignment cube and the spacecraft axes given in Table 2.4, the position of the center of each IES field of view relative to the spacecraft was determined.
Table 2-6 Measured Normalized Endcapped Entropy

Energy outside this area would result in lower percentages than given in Table 2. Any
system performance, shown in Table 2-6, This analysis explicitly assumes that all
4) The average of the smoothed data from all six detectors was used to determine the
measured area for the albedo and thermal bolometer detectors.

Figure 2-7 shows the results for the albedo and thermal bolometer detectors.
Algorithm for the raw and processed data for the albedo detector 2, Figure 2-7,
between the measured points, Figure 2-6 shows a comparison of this smoothing
3) A linear (or first degree polynomial) was applied to smooth the data

following manner:

The qualitative determination of the percent of endcapped energy was made in the
design specification.

electronically cross-talk between detectors. However, the vertical (energy) axis of these plots

14
The specrometer data collected during tests PVA1 were summarized in the center of the detector, but this approach did not prove successful. Instead, the line-scan data used in section 2.1 had to be used to estimate on-field response.

Table 2.7 gives a comparison of the enclosed energy determined from this method.

<table>
<thead>
<tr>
<th>Strip 2</th>
<th>Strip 1</th>
<th>Total Energy</th>
<th>Total Energy</th>
</tr>
</thead>
<tbody>
<tr>
<td>96'0</td>
<td>96'0</td>
<td>60'09'0</td>
<td>60'09'0</td>
</tr>
<tr>
<td>95'0</td>
<td>96'0</td>
<td>60'09'0</td>
<td>60'09'0</td>
</tr>
</tbody>
</table>

Table 2.6. Line-scan data from test PVO8, as seen from this comparison, the agreement is within 99%. Therefore, the line-scan technique was used to determine the

Thus:

$$\left( \frac{A}{T} \right) \text{ in rad} \times 2 \times \text{Step 2} = \text{Step 1} \times \text{Total Energy}$$

Therefore, this energy over-estimates the sensine-area energy by an amount equal to the enclosed in a sensine area of size L x L. As seen in this figure, what is measured is the

Figure 2.8 illustrates the method that was used. What is desired is the enclosed in a sensine area of size L x L. As seen in this figure, what is measured is the

Thus, the line-scan data used in section 2.1 had to be used to estimate on-field response.
from 795 to 805 cm⁻¹. The TES-processed spectral data was sampled at 800 for each
a 3 cm⁻¹ wide slide. The center wavenumber of this slide was stepped in 1 cm⁻¹ increments
each detector with the output slit of a Perkin Elmer monochromator capable of generating
data were collected to measure the spectral line shape. This test consisted of illuminating

2.3 Spectral Characterization
delected

Instrumental sub-section are given in Figure 2.9. No significant out-of-field energy was
in both the magnitude and the fluctuations in the background energy. Examples from each
made quantity the energy in this area because the contributions were small compared to
problems and search for regions of significant out-of-field contribution: no attempt was
which it blocked to remove the background. This study was performed to look for obvious
3274 mrad source that was scanned across an area 200 mrad by 200 mrad by 200 mrad in azimuth and
was measured during bench testing (test GOOF). Measurements were taken using a 40 x

The energy from an extended area covering 2200 mrad in elevation and azimuth

2.2.2 Per-0f-Field Response

<table>
<thead>
<tr>
<th>0.96</th>
<th>24</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.98</td>
<td>16</td>
</tr>
<tr>
<td>0.50</td>
<td>12</td>
</tr>
<tr>
<td>0.20</td>
<td>3.3</td>
</tr>
<tr>
<td>0.05</td>
<td>6.5 mrad Square</td>
</tr>
<tr>
<td>0.51</td>
<td>Line-Scan</td>
</tr>
<tr>
<td>0.51</td>
<td>Measured Response</td>
</tr>
<tr>
<td>Line-Scan</td>
<td>2-D</td>
</tr>
<tr>
<td>Measured Response to Extended Source</td>
<td></td>
</tr>
</tbody>
</table>

Table 2.7 Comparison of Line-Set and 2-Dimensional Methods
\[ \gamma V(\gamma) \left( \frac{1}{P_{\text{planets}}} - B_{\text{space}} \right) \sum_{100}^{10} \lambda = V \]

of spectral response. \( R(\gamma) \) to be valued.

To test this simulated response function was constructed that allowed the linearity
linear response function?

shield another way, how much deviation from this response is needed to produce a non-
characterization used the bolometric data taken at seven planet blackbody temperatures.
The algorithmic method that was chosen to provide some estimate of the spectral
characterization extended only to 25 \( \mu \text{m} \) and was not done on the high component
seen to the NOSC lab for characterization against a NSTL standard; however, this
be good characterization of the detector response was ever made. A similar detector was
the thermal bolometer detector package, this effort was unsuccessful. In particular, no
response of the individual components. However, the primarily to the large delivery of
response of the thermal bolometer.

The initial effort to characterize the spectral response of the thermal bolometer

2.3.3 Thermal Bolometer Spectral Response

Not completed.

2.3.2 Albedo Bolometer Spectral Response

the Mars Observer failure and was not completed.

predicted effects. Detailed analysis of these data had not been performed at the time of
delivered distance from the optical axis (see TES Functional Requirements Document for
good agreement with both the predicted line shape and the increase in which with increased
intensity narrow in an ideal case. However, preliminary analysis of these data showed
is complicated by the fact that the monochromator input was \( 3 \text{ cm} \) wide, rather than
12.5 \( \text{cm} \). Where the monochromator was located from 1245 to 1255 \( \text{cm} \). The analysis
10 \( \text{cm} \) data and measuring the effective spectral line shape. This test was repeated at
monochromator position. In this manner it is possible to simulate illuminating the TES with
observation and these data were collected and plotted versus the center wavenumber of
The third order equation for the linear curve is:

\[ \frac{df}{d\theta} = -1.5438t^2 + 3.1385t + 7.4809t^2 \]

where \( t \) is the temperature in Kelvin.

The nonlinear curve is:

\[ f(t) = 9.497E-3 t - 3.79E-3 t^2 + 1.97E-3 t^3 \]

where \( t \) is the temperature in Kelvin.

The nonlinear curve is given by the equation:

\[ f(t) = -1.5438t^2 + 3.1385t + 7.4809t^2 \]

where \( t \) is the temperature in Kelvin.

The linear curve is given by the equation:

\[ f(t) = 9.497E-3 t - 3.79E-3 t^2 + 1.97E-3 t^3 \]

where \( t \) is the temperature in Kelvin.

The temperature curve is given by the equation:

\[ t = \frac{f(t)}{9.497E-3} \]

where \( f(t) \) is the function for the linear curve.

The nonlinear curve is given by the equation:

\[ f(t) = -1.5438t^2 + 3.1385t + 7.4809t^2 \]

where \( t \) is the temperature in Kelvin.

The linear curve is given by the equation:

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The linear curve is given by the equation:

\[ f(t) = 9.497E-3 t - 3.79E-3 t^2 + 1.97E-3 t^3 \]

where \( t \) is the temperature in Kelvin.
Independent values of $V_{\text{measured}}$ at each calibration test site:

- Blackbody 1 (Bλ(γ)), and 3 (Bλ(γ)) internal reference surfae. These observations give three blackbody temperatures.
- The fixed cold (space), and the fixed, variable (blackbody 4) pairs (planets 1 and 3, and planet 1 and 4) be made: 1) the temperature-variable (planet) blackbody, 2) the fixed, cold (space) blackbody, and 3) the TES internal reference surface. These observations give three independent spectral measurement.

In the internal vacuum chamber, the independent spectral measurements could and B1) of the environmental and instrument respectively (subsequently referred to simply as B1) measured, and B1) and B1) are energies given by the Planck function, emitted from the target, and where Eλ and Eλ are the emissivities of the target and instrument, respectively, and B1(λ1), measured = E1(λ1) + R1(γ)λ1 E1(γ) + R1(γ)λ1 E1(γ).

Expanding Eq. 1 gives:

$V_{\text{measured}} = (E_{\text{environment}} + E_{\text{Reflected}}) - E_{\text{Planck}}$.

Where $E_{\text{Planck}}$ is the energy emitted by the blackbody, and $E_{\text{Reflected}}$ is the energy emitted by the environment and reflected off of the target. $E_{\text{environment}}$ is the energy emitted by the environment and reflected off of the target.

The measured output voltage ($V_{\text{measured}}$) in units of TES Numbers (TN) is given by:

$V_{\text{measured}} = (E_{\text{environment}} + E_{\text{Reflected}}) - E_{\text{Planck}}$.

3.1 DATA PROCESSING AND ANALYSIS

3.0 SPECTROMETER RADIOMETRIC CALIBRATION

In the responsivity, we do have the detector spectral responsivity and the measured spectral responsivity. We also observe some roll off in spectral responsivity since the one piece of the TES analytical model is linear than this. However, for calibration purposes, it is significant to have the spectral responsivity of the TES channel show this degree of non-linearity that we must assume because of the TES channel show this degree of non-linearity we must assume.

The error caused by the assumption of gross non-linearity of spectral responsivity is 9K.

$T_{\text{out}} = 271.4K$

$T_{\text{out}} = 269.5K$

Solving for the corresponding planet temperature, assuming blackbody functions is...
and reference observations, together with the last three space observations taken as close before the associated planet or reference observations. Use only the first five (5) planet and reference observations, together with the mean of all space observations taken for each approach these analyses approaches are possible: I use the mean of all

number of studies and tests have been performed.

minute intervals. In order to determine the most appropriate set of approximations, a complicated process when the detector devices are operated due to heater cycling over short (1) short time intervals, be non-linear between successive space views, and are further produce changes in instrument temperature (B)). These changes can occur over relatively addition, the very process of observing targets at widely different temperatures can add to the instrument response function, the magnitude of which must be determined. In the instrument response function, the meaning of which must be determined. In

The basic problem stems from the fact that the large differences in signal strength

addition, simplifying assumptions are required.

Clearly some (E1) reference, reference, plane, space, reference, and four equations: Clearly some (E1) plane, space, reference, and four equations. In equation 4 seven variables can be directly measured: Plane, Space, Reference.

\[ V_{\text{Reference}} = (\text{Reference Plane} + \text{Reference Space} - (E1)\text{Plane}) \]

\[ V_{\text{Space}} = (E1)\text{Space} \]

\[ V_{\text{Plane}} = (E1)\text{Plane} \]

With these assumptions given:

plane and space equal to unity and plane and space equal to zero. Simplifying Eq. 3.

Plane and space backdrops are considered sufficiently blackbody in nature to set

those three lengths. For the purpose of the TES calibration, the external calibration lengths

where the subscripts plane, space, and reference refer to observations and properties of

\[ V_{\text{Reference}} = (\text{Reference Plane} + \text{Reference Space} - (E1)\text{Space} \]

\[ V_{\text{Space}} = (E1)\text{Space} \]

\[ V_{\text{Plane}} = (E1)\text{Plane} \]
response with the heater off as both the detector temperature and instrument temperature was set at 270 K. Variation in instrument temperature produces a large change in set-point temperatures were varied from 20 to 30°C; the plane block body temperature unils of instrument response used throughout are I/V cm² s⁻¹ cm⁻¹ (Lam 2011). Instruments shown for detector 2 for both the heater on and heater off cases (Fig. 3-1). Note: the

Examples of the instrument response functions derived from this analysis are

Equation 1: \( E_{\text{reference}} = E_{\text{detector}} + \frac{E_{\text{sample}}}{E_{\text{detector}}} \)

Equation 2: \( E_{\text{detector}} = E_{\text{sample}} + \frac{E_{\text{detector}}}{E_{\text{sample}}} \)

Equation 3: \( E_{\text{sample}} = \frac{E_{\text{detector}}}{E_{\text{reference}}} \)

Independent of signal strength, i.e., Eq. 4, this assumption results in:

The simplifying assumption was made that the instrument response function was

the precise calibration studies done at fixed instrument temperature. For this study,

results were then used to correct for the slight variations in instrument temperature during

specimen performance as a function of instrument and detector temperature. These

An initial analysis was performed to determine the approximate variation in

HEATER STABILITY

3.2 Instrument Response Function Versus Instrument Temperature

The reference view, i.e., the mean of Sl and S2, and S3 to the mean of S2 and S3.

the space view between plane and reference views, spaced and S3 to the space look after

the space view before the plane view, spaced and S3 to the space look after

the associated plane or reference observations. These three methods are repeated to as: (1)

Before “null;” (2) before “null;” (3) both “null.” In the numerical development, spaced and S3 refer to

the associated plane or reference observations; together with the mean of all space observations taken both before and after

attempts to minimize temperature drifts; and (3) use the mean of all plane and reference

in time as possible to the associated plane or reference observations. This approach
The detector heater on.

(See Section 3-8) there appears to be no significant advantage in operating the TES with
insert problems encountered with temperature stability and noise when the heater is on.
there is little difference in performance between the two conditions. Thus, given the
advantage of instrument temperatures. For instrument temperatures of 0 to 10 C.

An important result from this study is the comparison of heater-off to heater-on.

Of instrument response data from the time period of interest.

be done by fitting a function (most likely a second-order polynomial) to the complete set
expected variations in due to variations in instrument temperature. This separation will
period of -1 to 14 days. However, the substantial variations in instrument temperature
over a time surface observation will be reduced by combining multiple determinations over a time

In Figure 3-2 shows the same instrument response data versus detector temperature.

Figure 3-2 shows the same instrument response data versus detector temperature.

Performance is nearly optimal.

is best near room temperature; whereas the spectrometer was alligned and the detector
interferometer alignment degraded with decreasing temperature. Overall, the performance
interferometer alignment degraded with decreasing temperature. Both detector performance and

Performance drops with instrument temperature, as both detector performance and
both the alignment and detector performance vary, producing a greater variation in
alignment, and temperature. Both the heater off, both the detector and instrument vary in temperature so
explained as follows: with the heater on the detector performance is nearly constant but
very over -35 C. The heater-on case shows less variation. These variations can be
that the correction for detector temperature was appropriate and necessary. Corrections for detector temperature were performed for detector temperature variations of 0 to 0.7°, with the maximum occurring at 0°C (Figure 3-5). Once the data were corrected for detector temperature variations, all of the data were normalized to a temperature of 0°C. The corrected y-axes offsets vary from 0 to 0.7°, with the maximum occurring at 0°C (Figure 3-5). The corrected y-axes offsets did not vary significantly over the entire set of data. Where the detector temperature did not vary significantly over the entire set of data, Figure 3-5 shows the uncorrected heater fit for each of the five instrument/temperature sets. Figure 3-5 shows the uncorrected heater fit for each of the five instrument/temperature sets.

Figure 3-5 shows the y-axes offsets as a function of wafer number for the uncorrected case, with an example of the raw (Vplane - Vspace) data for a single detector (Deq 2), a single wafer number (983 cm-1), and a single instrument set-point temperature (0°C). Figure 3-5 shows the importance of correcting the response for instrument/temperature. For the heater offset test, an initial study was performed to determine the relative linearity. A heater fit was forced through the origin.

Investigated: 1) used 1 heater fit (the forced fit forced 0 pass through the origin); 2) used a heater fit (the forced fit was not forced to pass through the origin); 2) wa the values of the Vplane and Vspace. The values of the 0 for the instrument/temperature. A linear fit was performed (weighted by the blackbody temperatures). The least squares fit was performed, weighted by the blackbody temperatures, along with the corresponding (Vplane - Vspace) values using the measured blackbody temperatures, was processed together. The set of "corresponding instrument/temperature" consists of either six or seven blackbody temperatures, was processed together. The primary objective of the TES radiometric testing was to determine the
schematically in the measurement of the blackbody.

The collection of a set of planet and space observations, in which case the \( E \) and \( E' \) terms (Fig. 5) would not cancel; 2) systematic errors in the measurement of the blackbody.

However, they are systematic and therefore were investigated further. Possible causes for these errors include any combination of; 1) variations in instrument temperature during calibration or 2) errors in absolute calibration that would result. These errors are calculated to a \( 0.3\% \) or less in absolute calibration that would result. These errors are calculated to a \( 0.3\% \) or less in absolute calibration that would result.

As seen in Figures 5-6 and 5-7, the \( \Delta \)-axis residual errors are remarkably small.

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producing the observed deviations from a linear response, they are not the sole

highest planet temperatures. Thus, while blackbody temperature offsets may play a role in

temperature errors for intermediate planet temperatures and falls considerably for the

blackbody temperatures (Fig. 3-12). However, this model includes requires much larger

relative temperature between the two blackbodies for the lowermost (130 K) planet

The x-axes residuals can be nearly reproduced by a small error of ~2.5 K in the

between the x- and x-axes residuals.

Figure 3-11 shows the relationship

absolute temperature between the two blackbodies. Figure 3-11 shows the relationship

temperature of 0 °C (15K4-lvK28), these residuals are assumed to represent the error in

the x-axes was then determined, shown in Figure 3-10 for an instrument set-point

was then used with the y-axes term set to zero to calculate model points. The residual in

assumption that the response function should pass exactly through the origin. This slope

best-fit was used to determine the slope of the response function at each wavelength.

cause of the apparent y-axes offset that was investigated extensively. An uncorrected, linear

The presence of errors in the blackbody temperature measurements are possible

temperature variations as a possible cause.

Comparison of Figures 3-9a and b with Figure 3-5p, effectively eliminating instrument

residuals for these cases are essentially identical to the both-full case, as seen by

residuals of ~0 °C (15K4-lvK28), are shown in Figure 3-9. The y-axes offsets and

the both-full data processed above. The results for these two cases, for an instrument

were studied by processing the both-full and before-with data in an identical manner to

possible variations in instrumental temperature during a suite of measurements

these is discussed below.

from Yplane, or (~) non-linearities in instrumental response with signal level. Each of

(temperatures; 3) an energy term that was not correctly removed by differentiation Yspace
these small residual errors. The instrument response function will be assumed to be
that no corrections will be made to the instrument data in light to arrive to remove
non-linearity in response has been transformed through the spectrometer. It is concluded
the overall magnitude of the errors in very small and because the most likely cause due to
observed symmetric residual errors from a simple linear response. However, because
In conclusion, no correcting, single mechanism has been found to account for the
complex manner through the entire spectrum and cannot be easily corrected.
process assumes a linear response, so that any non-linearities have been transformed in a
below the best-fit line. It is important to note, however, that the Fourier transform
residual error with signal strength with large signal levels producing responses slightly
In summary: Comparison of Figures 3.12 and 3.13 shows some consistency in the
residual response. Figure 3.13 shows the magnitude of raw data measured from the
Finally, it is possible (likely?) that non-linearities exist in the instrument.
observed residuals. No other possible energy terms have been investigated.
and the blackbodies is invoked, differences in larger emissivities cannot explain the
implausible mechanisms such as temperature-dependent variation of the emissivity of
have the same Y residuals. This prediction was confirmed by analysis. Thus, unless
the Y-axis values. The residual best fit line would have a different Y-offset, but would
consistent over the set of blackbody temperatures. The result would be a consensus shift in
however, the magnitude of this recovered component should remain approximately
recovered back onto the detection. For a given, near zero component instrument temperature,
responsible for one of the blackbodies so that different amounts of instrumental energy were
observed through the TES aperture. A possibility would be subtle differences in the
close to the TES aperture to minimize the amount of external energy that could be
were placed at small (30°) symmetric angles of the nadir position, and were placed
was limited by design in the experimental setup. Both larger blackbodies were identical,
the possible energy terms that might remain after calculating Y-space - Yspace
\[
\eta_{\text{Ref}} = \frac{J_{\text{Ref}}}{J_{\text{Ref}} + \eta'_{\text{Ref}}}
\]

The cavity with the cover closed is itself close to a blackbody cavity, leads to the high expected emissivity of the reference surface and the fact that the TES internal volume. Ignoring the effect of reflected environment emitted, which is reasonable given the high \(T_H\). Absorption is very sensitive to noise in \(\eta'_{\text{Ref}}\) and of limited utility in practice. Precision is very close to being so that the denominator

For the before-full case:

\[
\frac{J_{\text{Ref}} - \eta'_{\text{Ref}}}{J_{\text{Ref}} + \eta'_{\text{Ref}}}
\]

\[
\frac{J_{\text{Ref}}}{\frac{J_{\text{Plane}}}{\lambda} - \frac{\eta'_{\text{Plane}}}{\lambda}} = \frac{J_{\text{Ref}} - \eta'_{\text{Plane}}}{\frac{J_{\text{Plane}}}{\lambda}} = J
\]

\(\eta'_{\text{Ref}}\) and \(\eta'_{\text{Plane}}\) were

made into the instrument response function was linear within signal strength. Solving for \(J\)

Based on the results from the Inertial study, the simplifying assumption was

external blackbodies have an emissivity of unity.

blackbodies to the internal reference surface, under the fundamental assumption that the

surface, the integral of this activity was to transfer the calibration from the external target.

The next study was done to determine the emissivity of the internal reference.

### 3.4 Determination of Reference Surface Emissivity (Ref - EMiss)

\[\eta_{\text{Space}}(0) = (0.3)\text{, linear with signal strength and have zero offset (c. B_{\text{Plane}} - B_{\text{Space}}) = 0 when (}\text{Plane} - \text{Space})
\]
Because the reference surface was not used for any
manner as seen in this figure, the same spectral features are present near 425 and 1000

Figure 3-25 shows the emissivity of the space blackbody determined in this

\[
\frac{E_{\text{space}} - B_I}{E_{\text{space}} - B_I} = \frac{1}{(\frac{B_{\text{plan}}}{B_{\text{space}}})^{\frac{1}{\lambda}}}
\]

Solving for space gives:

\[
\int \frac{B_{\text{plan}}}{B_{\text{space}}} \frac{1}{(1 - E_{\text{space}})(B_{\text{plan}} - B_I) \Lambda} \text{space} = \frac{1}{E_{\text{space}}}
\]

For double scans, mix off and mix on respectively.

For single scan, mix on. For completeness, figures 3-14c and 3-14d show the cases
better representation of the reference surface emissivity. Figure 3-14b shows the similar
is the average of the five detectors, which, given the calibration method, should provide a
is the average of the five reference surface temperature measurements. Also shown
determination for single scan, mix off data for each of the five good detectors calculated

When these two blackbodies were close in temperature,

assumption that the best transfer from the external to internal blackbodies could be done

\[T_{\text{INS}} = 0 \text{ C, } T_{\text{BP}} = 70 K, \text{ Heaters off (test set 1K22). This test was selected under the} \]
For the "both F (full)" case, these emissivities derived for this case deviated by up to 0.5% spectrometric detector heathers on. $T_{\text{max}} = 0 \degree C$. $T_{BP} = 270 \degree K$. Heaters on (test set 1R22).

The reference surface emissivity was also derived using data collected with the heater. Rather than choose in the temperature of the reference surface, the small deviations from a perfectly linear response as discussed in the previous section, the small deviations seen in Figure 3-17 are most likely due to no other combination of temperature 5.231 \degree C, and sensor 3 (-5.277 \degree C) respectively. In this set the average temperature does not provide a good result for the emissivity, but no other combination of temperature sensor 1 (-5.317 \degree C, sensor 2 (-5.067 \degree C). Figure 3-17 shows the reference surface emissivity using the average temperature, while Figures 3-16b, c, and d show the emissivity calculated using only temperature sensor 1 (0.952 \degree C, sensor 2 (1.019 \degree C, and sensor 3 (0.734 \degree C) respectively. As can be seen, the average temperature provides the closest values to unity emissivity and will be used for all in-flight calibrations. Figures 3-16b, c, and d show the emissivity calculated using only temperature sensor 1 (red). Figure 3-14a and the spectral response near 425 and 1000 cm$^{-1}$ can be used to surface blackbody temperatures, $T_{\text{avg}}(\text{averaged}) = 0.938 \degree C$ (test set 1R22 - note: this is same as Figure 3-14a and the spectral response near 425 and 1000 cm$^{-1}$ can be used to surface blackbody temperatures, $T_{\text{avg}}(\text{averaged}) = 0.938 \degree C$, and the average of the three reference blackbody temperatures, $T_{\text{avg}}(\text{averaged}) = 0.90 \degree C$. This figure gives the reference surface emissivity determined using the measured surface temperatures.

The next study investigated the best choice of reference surface temperature.

Emmissivity will be used for all in-flight calibrations. The conclusion, therefore, is that the emissivity of the reference surface is indistinguishable from unity, to within the noise levels of the instrument, and until calibration check has been made on the reference surface.

The conclusion is apparent that these features must be present on one (or both) of the
an estimate of the effective absolute temperature error in the calibration. This brings

(4) The brightness temperature of the planet blackbody was determined to provide

provides an estimate of the absolute radiance error that results from the calibration
determination, along with the difference between these two determinations. The difference

function using the average of the two planet blackbody instrument temperatures was

(3) The ratio of Planetary radiance (measured) to Planetary (predicted) from the Planck

(accurately stitched).

(2) Measurements of the external „planetary„ blackbody were converted to radiance

used, together with the average of the three reference surface temperatures,

goes through the origin. The reference surface emissivity determined in Section 3.4 was

with the assumption that the instrument was perfectly linear and the transfer function

the results of Section 3.3, the assumption that Planck’s constant is used, along

observations of the cold external blackbody and the internal reference surface. Based on

involved the following steps:

The next step was to perform a complete end-to-end calibration test. This test

3.5 ABSOLUTE CALIBRATION (CALLIR-SIMPLE)

reference surface emissivity will be taken to be unity for both single and double scans.

the results obtained here should be valid for other conditions. For all future studies, the

approximately isothermal. This condition will, however, be true in operation at Mars and

the cover closed viewing the reference surface. In this state the entire cavity is

emissivity is likely due in part to the fact the instrument sees a blackbody cavity with

surface emissivity of unity to within the noise levels of the instrument. This high

Planetary blackbody were nearly the same temperature give a reference

In summary, data taken under conditions where the internal reference surface and

Section 3-8) and the heaters will not be operated at Mars.

from unity. These problems, however, are typical for „heaters-on“ observations (see
and there is more noise and structure in the derived temperature data.

Comparing Figs. 3-21 to Figs. 3-20, the absolute calibration is worse in the heated case, as can be seen from the relative small errors in the derived temperature. The NEAT is only ~3°C for the TEMPO case. Also shown as a straight line is the measured planet blockbody temperature using the average of the two hemispheres. As can be seen from these figures, the radiation from a blackbody at the appropriate temperature for each planet blockbody is very close to the measured value. Points are included to illustrate the magnitude of the radiation error for each planet blockbody temperature. The radiation from a blackbody at the appropriate temperature is shown in Figs. 3-18 and compared to the TES-calculated temperature for each planet blockbody. The results of this analysis are shown in Figs. 3-18 through 3-21. Figure 3-18 shows the difference between the TES-calculated and Planck emission for all detectors for T$_{\text{inst}}$ = 0°C. Figure 3-19 shows the difference between the TES-calculated and Planck emission for all detectors for T$_{\text{inst}}$ = 0°C. Figure 3-20 shows the difference between the TES-calculated and Planck emission for all detectors for T$_{\text{inst}}$ = 0°C. Figure 3-21 shows the difference between the TES-calculated and Planck emission for all detectors for T$_{\text{inst}}$ = 0°C. Figure 3-22 shows the difference between the TES-calculated and Planck emission for all detectors for T$_{\text{inst}}$ = 0°C. Figure 3-23 shows the difference between the TES-calculated and Planck emission for all detectors for T$_{\text{inst}}$ = 0°C.

For determining the apparent emissivity of the target, again in the worst case (127.3°K case),
Typical values are 0.1-0.15. Planet temperature increases from 130 K to 325 K. The temperatures decrease by a factor ~2 and ~5 respectively at the +10 and +20 °C, the signages decrease by a factor ~2 and ~5 respectively. Conversely, for instrument temperatures of -20 °C, -10 °C, and 0 °C, there is little variation, although the highest instrument temperatures do not appear systematic. For instrument temperatures -20 °C, -10 °C, and 0 °C, the signages vary somewhat with planet temperature. The signages vary somewhat with planet temperature, with average values of approximately 0.12.

3. The signages for the space views are roughly constant for a given instrument temperature. The signages are lower for the reference views, with average values around 0.07.

2. Sinusoidal deconvolution is roughly linear, and in some instances it is roughly constant. In some cases there is a pronounced jump in noise levels near 1000 cm⁻¹, with low wavenumbers (~400 to 800 cm⁻¹) and high wavenumbers (~1000 to 1400 cm⁻¹). For the heater off case, there is an increase in noise levels of typically 20 to 40% from low wavenumbers to high wavenumbers (~1400 cm⁻¹).

1. For the heater on case, the same is true in noise levels.

Figure 3.2. The same cases for the spectrometer on and off are shown in Figure 3.2a. The planter heater with the spectrometer on and off (Figure 3.2a); the planet heater with the spectrometer on and off (Figure 3.2b); the planet heater with the reference target (Figure 3.2c); the planet target (Figure 3.2d); the reference target.

Figure 3.2 shows the sign of the values computed for the T = 0°C case with observed due to cyclic variations in the instrument.

The most likely of these is due to variations in the sensitivity of the various targets.

The signal-to-noise (SNR) of the TES was investigated using the standard deviation, detected in the standard way, as a measure of the noise in instrument.

3.6 SIGNAL-TO-NOISE PERFORMANCE
headers were off, and the planet blackbody temperature was 310 X (res 1227). In
blackbody at the four gain settings. The instrument footprint temperature was +30°C.

Figure 3-24 shows the results comparing the signals from the external planet

all of the gain settings that would not saturate.
and 2) for those cases where the signal levels permitted, the planet target was viewed at
cycled through all four settings for the reference view for each instrument/planet case;
the actual instrument gain scaling were evaluated in two ways: 1) the gains were
adjustable on a ground command.
the measured signal prior to transmission to Earth. The parameters in this table are
on-board the instrument. The values in this table are used in the flight software to divide
the actual values of the gain is stored in the Instrument Parameter Tune Table

and 8. A concerted attempt was made to achieve these values using 1% precision.
The TES spectrometer has four integral gain settings that nominally are: 1.2, 5, 4,

3.7 SPECTROMETER GAIN ANALYSIS
appears that there is a scene-energy-dependent noise source. It
temperature because it was not observed for the heater off case. Instead, it

130 X 10 to 0.12 for a planet temperature of 325 K. This effect should not be due
decrease in the signal from average values near 0.4 for a planet temperature of
(planet). These trends are easily seen in Figure 3-23, where there is a systematic
wave numbers (Fig. 3-23). Observations of cold targets (both space and cold

0.15 to 0.7 with heater on, which have the lowest noise (~0.65) for heater on, the typical values range from
which have the lowest noise (~0.6) for heater off, the typical values range from
(6) The spectrometer heater does introduce additional noise. For the reference views,
the base noise level and in greater variability in the noise spectrum.

(5) Inc produces some additional noise, both as an approximately 25% increase in
Systematic fluctuations are correlated between different detectors as well.

Two wave numbers are sampled by two different detectors (Fig 3.1), and demonstrate that these wave numbers for a single detector; Figure 3-2G shows the comparison for a single noise (Fig 3-2G) is apparent that there are systematic fluctuations in signal strength when wave numbers are compared for these two wave numbers to remove some of the random noise. However, when 10 IOK Figures 3-27 shows the noise variation in the raw data for two wave numbers.

Condition is varying of time-scales of this duration or less.

Rounding observations taken less than 10 IOK, apart, including that some instrument parameters that involved display one set of observations by another, such as output of data from a radiance calibration studies done with the heater on. The initial indication of noise related to the spectrometer detector heater was

3.8 SPECTROMETER HEADER PERFORMANCE ANALYSIS

Process errors unless in Fig 3-4 indicated a variation in radiative gain values.

Errors to within 0.1%. Given this result, the nominal gains will be used for standard gain. As seen in Figure 3-2D, the actual gains agree with the nominal set point of 22.8°C. The data in this figure do not appear to suffer from the types of problems seen of gain. The gain of 1, 0, and 1 for the signal from the reference surface as a temperature of 3-25 gives the ratio. Figure 3-24 shows significant deviation from unity that is most likely due to

Ratios shown in Figure 3-24 should equal one. Therefore, if the actual gains have these values, then the ratios shown in calculating the signal transmitted from the instrument, the nominal gains of 1, 2.5, 4, and
Figure 3-27 shows a comparison of the 10 IKC averages for waveunits 1503 for changes in the temperature of the detectors themselves is possible, though unlikely. Physical does the fact that the problem is correlated with spectrometer heater, since the changes would appear to rule out physical changes in the temperature of the targets, as shown much higher with the detector heater off (Fig. 3-21) when with heater on (Fig. 3-29).

152 Relative to IKC 42, Comparison with Figure 3-29 shows that the spectral shape is much weaker correlation between different waveunits than seen with the heater on. Figure 3-21 shows the ratio of the raw spectral data for IKC 52, 122, and 124, and in Figure 3-28, both with the spectrometer detector heater off. As seen in this figure, there is a much weaker correlation between different waveunits than seen with the heater on. Figure 3-21 shows the 10 IKC averages for the identical sequence of data shown.

Producing a correlated change in response with the spectral character shown in Figure 3-29 and Figure 3-28) when the spectral ratios reflect variations at all waveunits, as is observed in some instrument property, over time scales of ~0-20 IKC. It is responsible for the weaker correlation between different waveunits than seen with the heater on. Most importantly, the spectral shape of these correlated fluctuations is not apparent from Figure 3-29, that the spectral fluctuations are highly correlated in the dotted curve in Figure 3-29.

Figure 3-29 and 1988 Different (Fig. 3-22) IKC 82 versus IKC 42 in time periods where waveunits 1503 and 1503 differ (Fig. 3-22). For the ratio of IKC 42 to IKC 52, values at the two times and the ratio of the spectra should be approximately unity. Such as at IKC 42 and 52 in Figure 3-28, when all waveunits should have similar values for two time periods in which two spectral channels have nearly identical values, acquired a different time intervals. If the variations are correlated between waveunits, time variations in all waveunits simultaneously. This was done by ratioing spectra.

The non-random nature of these fluctuations can be further illustrated using the
(1)  \[
\frac{\lambda}{(\lambda)^{\text{plane}}} - \frac{\lambda}{(\lambda)^{\text{plane}}} = B(L) \sum_{u} (\lambda_{e}^{(d)} \sum_{u} (\lambda_{e}^{(d)} \sum_{u} (\lambda_{e}^{(d)}))
\]

Solving for the calibrated radiance gives:

\[ I = \frac{1}{T_{I}} \text{Instrument response function} \]
\[ T_{I} = \text{Instrument temperature} \]
\[ T = \text{Planck function radiance} \]
\[ L_{p} = \text{Temperature of surface component p} \]
\[ \epsilon_{p} = \text{Planar emissivity of surface component p} \]

Where:

\[ u = \text{number of surface components} \]

(6)

\[
\left( \lambda/\lambda_{e} \right) \sum_{u} \left( \lambda_{e}^{(d)} \sum_{u} \lambda_{e}^{(d)} \sum_{u} \lambda_{e}^{(d)} \right) = \left( \lambda/\lambda_{e} \right)
\]

Given by:

The measured signal (\( \lambda/\lambda_{e} \)) viewing Mars, as a function of frequency (\( \lambda \)), is

3.9.1 Definition of In-Flight Calibrated Radiance

3.9.2 Determination of In-Flight Calibrated Radiance

Either:

- Because of this problem the bolometer heater will not be used in flight.
- This problem appears to be related to electronic oscillations in the heater. An additional electronic noise in the spectrometer data is observed whenever the bolometer is operated. Based on this study the spectrometer heater will not be operated in flight.

Possibilities include power supply noise that is enhanced when the heater circuits are active, or possibly noise produced by oscillations in the heater circuit itself. Both of these possibilities must be considered and the mechanism for producing the observed variability must be common in all detectors. Thus, the noise source must be different for detectors 1 and 3, whereas detectors 2 and 5 do not. This is seen in these figures, the correlation is as good between all three detectors as it is for detectors 2 and 3 (Fig. 3-32a) and detectors 2 and 5 (Fig. 3-32b).
the functional form of I, again using the spectrometer detector temperature for each measurement. The value of \( I \) used in Eq. 2 for each plane measurement is then determined from temperature.

Interest in the spectrometer detector temperature waveform will be used for instrumental polynomial (due to complete set of instrumental response data) from the time period of this separation will be done by fitting a function (most likely a second-order polynomial) to the expected variations in due to variational in instrumental temperature.

A time period of 15-7 (17) days. However, the smallest variations in \( I \) must be separated from the expected variations in due to variational in instrumental temperature.

The noise in the instrumental response function (9) is from a single pair of measurements and \( I \) is used to calculate the best known parameter of the entire ITS-90.

All responses (see Section 3-4), \( I_{\text{ref}} \) is from the average of the three reference surfaces where \( \text{ref} \) was derived from SIRC internal vacuum testing and found to be unity at 273K.

where \( \lambda = (\alpha \text{ref})^{-1} \).\( \lambda \) can be used directly to calculate \( I \) given by equation. Reference view are obtained close together in plane (within several ICs) then these two for the small variations due to changes in instrumental temperature. As long as space and for the instrumental response function (9) should be a slowly varying function except

\[ \frac{\lambda \text{ref} \lambda_0}{\lambda - \lambda_0} = (\lambda) \]

3.92 Instrument Response Function

means for interpreting the background energy \( \phi (I, I) \) between calibration observations.

Taking advantage of their repetitive and predictable forms, and to develop an effective previous. The objectives in Figure are: (1) to minimize the noise on these functions by

To compute calibrated radiances, both \( f \) and \( P(T, \lambda) \) must be determined as outlined.
The advantage is that it provides a physically plausible function for the Planck function as well. Except in this case, the smoothing function is the Planck function and not the Planck function to which a more sophisticated weighting scheme could be used. In any case, the effective instrument temperature would be used in the Planck function to determine the effective instrument temperature. If the model-estimated effective instrument temperature is nearly identical to the effective instrument temperature determined from the data, then a uniform weighting (average) of the data instrument temperatures over a range of frequencies would be sufficient to get a reasonable estimate of the Planck function to calculate $I(T)$ over an appropriate range of frequencies. In the simplest case, this best fit could be done by simply smoothing (filtering) the $I(T)$ data over frequency. These data should have the dependence on $\Lambda$:

\[ I(T) = \frac{\int f \, d\lambda}{\int f \, d\lambda \, \Lambda} \]

Experiments have shown that this is obtained by averaging space, which provides an excellent target of known (low) temperature and emissivity. For each space view the instrument effective $B(T)$ is obtained by viewing space, which provides an instrument energy.
However, initial analyses were done to verify that the instrument met its functional
performance but not been completed. This detailed study has not been performed.
At the time of the loss of Mars Observer, a detailed analysis of the albedo channel
SNR

4.2 SIGNAL-TO-NOISE PERFORMANCE

Not completed.

4.1 RADIOMETRIC PERFORMANCE

4.0 ALBEDO BOLOMETER RADIOMETRIC CALIBRATION

that is actually changing.

has the advantage of more accurately representing the variable (instrument temperature)
interpolation would be between the derived instrument temperature(s). This latter method
would be between the smoothed, derived instrument energy. For Method 2, the
repetitive, periodic variations in instrument temperature. For Method 1, the interpolation
used; when time in which a more complex function will be determined to account for
views, initially a simple linear interpolation between bounding space values will be
functional fit to the instrument energies determined for the nearest bounding space
either case the instrument energy for each planet view will be determined using a
and used to determine the calibration radiance for each planet observation. In
method, this energy must be interpolated for all of the intervening planet observations.
Once the background energy is determined at each planet observation by either

functions.

and the associated computational complexities and potential radiance errors

smoothly. The disadvantage would come if the instrument were not isothermal.
### Table 5-1: Bolometer Channel Slopes and Offsets (Least-Squares Fits)

<table>
<thead>
<tr>
<th>Channel</th>
<th>Slope 1</th>
<th>Slope 2</th>
<th>Slope 3</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>4</td>
<td>3</td>
<td>2</td>
</tr>
</tbody>
</table>

Units (planck-space signal).

Slopes are in units of watt.cm⁻².ster⁻¹ (planck-space radiances) and offsets are in signal.

1. To determine the channel slopes and offsets for each instrument, we fit a linear regression model to the data.

2. The IRS temperature corresponding to each cell is determined using the calculated slope and offset values.

3. The final temperature is calculated using the IRS reference temperature as a constant.

#### Introduction

5.1. Radometric Performance (Fron's Chase Report 8/3/93 Report)

6.0. Thermal Bolometer Radometric Calibration
In this method, the radiances corresponding to the IRS temperatures used and curves were calculated by a method that more nearly represents the actual data. If the slope (IRS radance-space)/(IRS thermal-space) and the OTC were checked, the assumption that the slopes of the four IRS curves are all equal and that the temperature will be underestimated if the radiances were used.

When these least-squares fit transfer functions were used to check agreement of the reference surface data, errors of up to 10% in radiances were encountered where the reference data were available. In the absence of a reference data set, the use of the least-squares fit transfer functions is recommended.
Table 5-3. Channel Slopes at Each Planet Blackbody Temperature (+30°C Run)

A more likely explanation is simply the manner in which the data were plotted. This will

be illustrated in Section 5-1-3.

In suggesting that the instrumental temperature and therefore the gain, was quite stable,
the change in slope is less than 1% over the
this case for +30°C instrument temperature. Moreover, Table 5-2, below shows IRG slopes at each planet blackbody temperature (in
Moreover, Table 5-2, below shows IRG slopes at each planet blackbody temperature (in
Comparing these slopes to those in Table 5-1, show differences of less than 1%.

<table>
<thead>
<tr>
<th>Channel</th>
<th>Slope 170.2°C</th>
<th>Slope 173.1°C</th>
<th>Slope 175.9°C</th>
<th>Slope 178°C</th>
<th>Slope 182.3°C</th>
<th>Slope 185.3°C</th>
<th>Slope 188°C</th>
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</thead>
<tbody>
<tr>
<td>1</td>
<td>171.9905</td>
<td>173.608</td>
<td>175.357</td>
<td>177.18</td>
<td>179.34</td>
<td>182.51</td>
<td>185.73</td>
</tr>
<tr>
<td>2</td>
<td>170.800</td>
<td>172.36</td>
<td>174.06</td>
<td>175.83</td>
<td>177.54</td>
<td>180.28</td>
<td>182.96</td>
</tr>
<tr>
<td>3</td>
<td>169.920</td>
<td>171.58</td>
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<td>176.79</td>
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<td>169.040</td>
<td>170.70</td>
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<td>175.92</td>
<td>178.66</td>
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<td>168.160</td>
<td>169.82</td>
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<tr>
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<td>Slope 170°C</td>
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<td>Slope 182°C</td>
<td>Slope 185°C</td>
<td>Slope 188°C</td>
</tr>
</tbody>
</table>

Table 5-2. Bolometer IRG slopes calculated at a planet temperature of 270K

Shown in Table 5-2.

data fit to a curve shown in the above. The slopes computed in this manner are
data fit to a curve shown in the table above. The slopes computed in this manner are
the curve is assumed to go through zero. This is a fairly good assumption based on the
temperatures sensors). The abscissa is IRS temperature (the average of the three temperature at 238K). The dependence for all six channels for a relatively constant planet blackbody this dependence have a responsibility dependence on temperature. Figure 5.1 shows:

<table>
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<tr>
<th>1.79, 605</th>
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5.1 - Temperature Dependence:

<table>
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<th>1.72, 528</th>
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<th>1.73, 829</th>
<th>1.73, 784</th>
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<td>1.82, 84</td>
<td>1.82, 77</td>
<td>1.82, 75</td>
<td>1.82, 69</td>
</tr>
<tr>
<td>1.82, 738</td>
<td>1.81, 738</td>
<td>1.82, 738</td>
<td>1.82, 738</td>
<td>1.82, 738</td>
<td>1.82, 738</td>
</tr>
</tbody>
</table>
5.2. For an instrument temperature of +30°C, the IRS slope. The ratio of the calculated value to the measured value is shown in Figure 5-1. The calculated plane-space radiances were determined by dividing the plane-space signal by the IRS radiances at a corresponding temperature to the IRS was calculated. The agreement of the plane radiances to that of 5-1.3. Internal Reference Surface (IRS) (IRS) based on the discussion in Section 5-1.1, the agreement of the plane radiances to that of

The slope of these curves is about 0.00617 signal units per K.

Figure 5-1. Temperature Dependence of Bolometer Channel Responses
The resulting error is much smaller. This can be seen in Figure 5.3. However, when the ratio of the radiance difference to a fixed radiance at 270K is plotted, we see scaling in the previous analysis. This is the type of error I believe we are seeing in proportion to a fixed radiance error. Thus, the radiance ratios should be seen to grow at low planet temperatures because the planet radiance is decreasing in proportion to the fixed radiance.

Figure 5.2. Ratio of Radiance Error at Each Planet Temperature.
Figures 5.3.1-5.3.3. These plots for all instrument temperatures are shown in the following figure. The plots at different instrument temperatures are different shapes, but the errors are comparable. The plots are for radiant difference at 270K, for $+30^\circ C$ instrument temperature.
Figure 5-4. Ratio of Radiance Difference to the Radiance at 270K, for +2OC Instrument
Temperature

Figure 5-5. Ratio of Radiance Difference to the Radiance at 270K for +10C Instrument
Figure 5-7. Ratio of Radiance Difference to the Radiance at 270K for 10C Instrument.
Functional requirements with a SNR of ~2000.

However, initial analysis was done to verify that the instrument met its performance. However, initial analysis was done to verify that the instrument met its performance. This detailed study has not been completed. This detailed study has not been completed. At the time of the loss of Mars Observer, a detailed analysis of the thermal behavior of the instrument was not available.

5.2 SIGNAL-TO-NOISE PERFORMANCE

Figure 5.8: Ratio of Radiance Difference to the Radiance at 270K, for -20°C Instrument

Temperature
<table>
<thead>
<tr>
<th></th>
<th>Test Condition</th>
<th>Test</th>
<th>Target Temp (°C)</th>
<th>Range Temp</th>
<th>Vector (°C)</th>
<th>Temp</th>
<th>Optic</th>
<th>Name</th>
</tr>
</thead>
<tbody>
<tr>
<td>7</td>
<td></td>
<td>i/b</td>
<td>45</td>
<td>25.5-25.6</td>
<td>45</td>
<td>i/b</td>
<td></td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>SBRC Post. VIB Bench</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>SBRC T.V N2</td>
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<td></td>
<td></td>
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<td></td>
</tr>
<tr>
<td>4</td>
<td>SBRC Vacuum - mid</td>
<td>3/4</td>
<td>1.4/0.8</td>
<td>3/7-4/6</td>
<td>1.4/0.8</td>
<td>3/4</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>SBRC Vacuum - early</td>
<td>1/2</td>
<td>1/2</td>
<td>1/3.8</td>
<td>1/2</td>
<td>1/2</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>SBRC Vacuum - late</td>
<td>2</td>
<td>2</td>
<td>2.5/4.6</td>
<td>2</td>
<td>2</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>SBRC Vacuum - mid</td>
<td>2</td>
<td>2</td>
<td>2.5/4.6</td>
<td>2</td>
<td>2</td>
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<td></td>
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<tr>
<td></td>
<td>SBRC Vacuum - mid</td>
<td>2</td>
<td>2</td>
<td>2.5/4.6</td>
<td>2</td>
<td>2</td>
<td></td>
<td></td>
</tr>
<tr>
<td>12</td>
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<td>15.7</td>
<td>10</td>
<td>0</td>
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<td></td>
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<td>C.P. Ambient</td>
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<td>10</td>
<td>0</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>10</td>
<td>GE pre-shiip Ambient</td>
<td>1</td>
<td>18-25</td>
<td>1</td>
<td>1</td>
<td></td>
<td></td>
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<tr>
<td>9</td>
<td>GE deflag</td>
<td>3</td>
<td>14/17-1/476</td>
<td>6</td>
<td>14/17-1/476</td>
<td>6</td>
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<tr>
<td>8</td>
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<td>1</td>
<td>18-25</td>
<td>1</td>
<td>1</td>
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<tr>
<td>7</td>
<td>Pre-shiip Ambient</td>
<td>1</td>
<td>22.3</td>
<td>1</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>SBRC Vacuum - late</td>
<td>2</td>
<td>37/46</td>
<td>2</td>
<td>37/46</td>
<td>2</td>
<td></td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>SBRC Vacuum - mid</td>
<td>2</td>
<td>71/26</td>
<td>2</td>
<td>71/26</td>
<td>2</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>SBRC Vacuum - mid</td>
<td>2</td>
<td>17/26</td>
<td>2</td>
<td>17/26</td>
<td>2</td>
<td></td>
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</tr>
<tr>
<td>3</td>
<td>SBRC Vacuum - early</td>
<td>2</td>
<td>17/26</td>
<td>2</td>
<td>17/26</td>
<td>2</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>SBRC Vacuum - early</td>
<td>2</td>
<td>17/26</td>
<td>2</td>
<td>17/26</td>
<td>2</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>SBRC Vacuum - mid</td>
<td>2</td>
<td>17/26</td>
<td>2</td>
<td>17/26</td>
<td>2</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Table 4.1**

History summary:

The Table 4.1 summarizes the test conditions for the tests used in this time assuming that the instrument temperature was equal to the spectrometer detector temperature. However, in many cases (e.g., bench ambient) only a hot target was available. In some cases (e.g., thermal vacuum) both cold and hot targets were available. The integration, test, and flight phases. These results included ambient, thermal vacuum, and post-thermal vacuum, and flight conditions. In some cases (e.g., ambient) only a hot target was available.
Transport to the Cape or after launch, served to improve response. Importantly, no further changes were observed during the course of this change is unknown, but longer (~30 days) than the GE test (~10 days). The cause of this change is unknown, but
were observed before and after thermal vacuum at SPBC, which lasted significantly
instrument response did not return to its earlier value after thermal vacuum. No changes
change occurred in the instrument response during vacuum conditions and that the
during and after (4-36) data at an expanded scale. It is apparent from these figures that a
all tests in GE thermal vacuum and later. Figure 4-3 gives the same before (4-34) and
acquired to GE thermal vacuum chamber under vacuum. Figure 4-2b gives the results of
subtle differences near 1000 and 600 cm⁻¹. Figure 4-2a shows the results of all tests

differences in detector temperature, as discussed in Section 3.2. Close inspection reveals
listed in Table 4-1. The large differences in response are due to the significant
Figure 4-1 gives the instrument response (in TN) in single-scan mode for all of the cases

<table>
<thead>
<tr>
<th>79</th>
<th>0</th>
<th>15-9</th>
<th>0</th>
<th>12</th>
<th>12</th>
</tr>
</thead>
<tbody>
<tr>
<td>4</td>
<td>1.1</td>
<td>-270</td>
<td>79</td>
<td>1.1</td>
<td>-270</td>
</tr>
</tbody>
</table>

Data stored in the $\text{CALIB/ARCHIVE/instresp/resp-sng}$.
Examples of far out-of-field results.

Schematic of method used to estimate out-of-field energy using line scan data.

(b) Thermal bolometer detectors.

2.7 Percent of energy contained versus distance from center of (a) Abbe detector.

Illustration of smoothing algorithm described in text to estimate percent of energy

2.6 Intermediate out-of-field energy - Detector 1.

2.5 Detailed detector response mapping for detectors 2 and 5.

2.4 Channels in elevation and azimuth

2.3 Special location of half power points for spectrometer, bolometer, and Abbe

2.2 Detector 3-4 (c) Detectors 5-6.

2.1 Detector 4-6.

2.0 Pre-cockpit azimuth field of view definition and alignment (a) Detectors 1-2.

1.9 TES thermal vacuum chamber.

1.8 Prior to closing the chamber door for thermal vacuum calibration.

1.7 Instrument in the SIRIG thermal vacuum chamber. Image was taken immediately

1.6 Photograph of the two external calibration blockdodes, along with the TES TES.

1.5 Photograph of the finished external calibration blockdode.

1.4 Location of the temperature sensors.

1.3-4 Cross-section of the external calibration blockdode showing dimensions and the

40037, Sheet 3, Section C-C.

1.2 Location of the three hemispheres in the reference surface. From SIRIG drawing

1.1 Cross-section of the TES internal reference surface

FIGURE CAPTIONS
3.7 Y residus converted to Inducance (W cm-2 si-1 cm-1), Uncorrected case: (a) Instrument section temp = -10 °C, B-space. Data have been corrected for instrument temperature. (b) Instrument section temp = +10 °C, B-space. Data were not corrected for instrument temperature.

3.6 Y-axis offset for an uncorrected, heater fit to (Yplane - Yspace) versus (Bplane - Bspace) N-TN.

3.5 X-axis offset for an uncorrected, heater fit to (Yplane - Yspace) versus (Bplane - Bspace) N-TN.

2.11 Normalized slope response simulation detail.

2.10 Averaged versus unaltered thermal bolometer response function. See text for details.

2.7 Instrument response in units of TLS Numbers (TN)/(W cm-2 sr-1 cm-1).

The first six selected wave numbers. (a) Instrument response versus detector temperature for detector heaters on. (b) Instrument response versus heater function. (c) Detector heaters off. (d) Detector heaters on. (e) Detector heater calibration.

1.1 Instrument response in units of TLS Numbers (TN)/(W cm-2 sr-1 cm-1).

(d) Instrument section temp = +10 °C, B-space. Data were not corrected for instrument temperature. (e) Instrument section temp = 0 °C, B-space. Data were not corrected for instrument temperature. (f) Instrument section temp = -10 °C, B-space. Data have been corrected for instrument temperature. (g) Instrument section temp = -20 °C, B-space. Data have been corrected for instrument temperature.

Forced case: (c) Instrument section temp = -10 °C, B-space. (d) Instrument section temp = +10 °C, B-space. (e) Instrument section temp = 0 °C, B-space.

Y residus converted to Inducance (W cm-2 si-1 cm-1), Uncorrected case: (a) Instrument section temp = -10 °C, B-space. Data have been corrected for instrument temperature. (b) Instrument section temp = +10 °C, B-space. Data were not corrected for instrument temperature.
temperatures for instrument section temperature - 10°C. (a) Average of all three
reference surface emissivity calculated using different reference surface
3-17) Reference surface emissivity calculated using instrument
1. (c) Reference surface emissivity using thermistor 2. (d) Reference surface
reference surface emissivity. (q) Reference surface emissivity using thermistor
reference surface emissivity calculated using different reference surface
3-16) Reference surface emissivity calculated using instrument section temperature
3-15) Derived emissivity of the space backbody. Derivation method described in text.

good detectors with average - IKS 873-903 (time on set).
with average for LVK22 - IKS 43-45 (time off set). (d) Double scan, all five
with average - IKS 703-718 (time on set). (e) Double scan, all five good detectors
for LVK22 - IKS 199-214 (time off set). (q) Single scan, all five good detectors
3-14) Reference surface emissivity. (q) Single scan, all five good detectors with average

(TN)

Instrument section temperature of 0°C. Special data in units of TES Numbers
3-13) Raw special data for detector 2 for all seven blackbody temperatures for
blackbody with the difference between blackbodies at 1.46 and 1.43.5°C
3-12) Comparison of X-axes (radiance with \text{cm}^{-2} \text{sr}^{-1} \text{cm}^{-1})
residual for the 130 K planet
3-11) Schematic showing the comparison of X- and Y-axes residuals discussed in text.
blackbody temperatures for instrument section temperature of 0°C.

3-10) X-axes residuals (radiance with \text{cm}^{-2} \text{sr}^{-1} \text{cm}^{-1}). Data for detector 2, all seven

before mini-case. Y in units of TES Numbers (TN).
3-9) Y-axes offset (radiance with \text{cm}^{-2} \text{sr}^{-1} \text{cm}^{-1}). (q) Space - before only case. (q) Space

before - Yspace). (Yplane - Yspace).
3-8) Schematic of the best-fit lines and residuals calculated for (Yplane - Yspace) vs

0°C. (q) Instrument section temp = +10°C. (q) Instrument section temp = +20°C.
Temperature of 22.3°C.

3.25) Ratio of Gain 2/Gain 1, 3/1, and 4/1 for the signals from the reference surface at a signal in TN transmitted from the instrument.

ln(TN). Nominal gains of 1.25, 4, and 8 were used in filter software to scale the levers. Heaters were off, and the planet blackbody temperature was 3.10 K (rest +3.2°C). Heaters were off, and the planet blackbody temperature was blackbody at the four gain settings. The instrument sensor temperature was 3.24) Spectrometer Gain values. Comparison of the signals from the external planet's target with the instrument.

Target with Inc. Off; (d) planet target with Inc. on heater on. (a) space target (spectral < 2), (b) reference target (ret2); (c) planet. 3.23) Signal values (TN) computed for the Tinst = 0°C case with spectrometer detector.

Target with Inc. Off; (d) planet target with Inc. on heater off. (a) space target (spectral > 2), (b) reference target (ret1); (c) planet. 3.22) Signal values (TN) computed for the Tinst = 0°C case with spectrometer detector.

Detector heaters on.

3.21) Brightness Temperature (K) derived for each planet blackbody case for Tinst = 0°C.

Detector heaters off.

3.20) Brightness Temperature (K) derived for each planet blackbody case for Tinst = 0°C.

Blackbody at the appropriate temperature.

3-19) Difference between calculated and Planck radiance (W cm⁻² sr⁻¹ cm⁻¹) for detector.

3-18) Difference between calculated and Planck radiance (W cm⁻² sr⁻¹ cm⁻¹) for all detectors. Tinst = 0°C. TBP = 270K, heaters off (test set t=22°C).

Reference surface temperatures. (p) Reference surface temperature using thermometer 2. (d) Reference surface temperature using thermometer 3.
3-26) Illustration of characteristic spectral shape observed in derived reference surface emissivity.

3-27) Time variation in the raw data for wavenumbers 1503.5 and 1608.6 for test tvl22, spectrometer detector heaters on.

3-28) 10-ICK time averages of spectral data for wavenumbers 1503.5 and 1608.6 for test tvl22, spectrometer heaters on.

3-29) Ratio of spectra from ICK 42 and 52 for test tvl22, spectrometer heaters on.

3-30) 10-ICK averages of the time variation in the spectral data for wavenumbers 1503.5 and 1608.6 for test tkv22, spectrometer detector heaters off.

3-31) Ratio of the raw spectral data for ICKs 62, 102, 122, and 152 relative to ICK 42 for test tkv22, spectrometer detector heaters off.

3-32) Comparison of the 10 ICK averages for wavenumber 1503 for test tvl22, heaters on. (a) detectors 2 and 3; (b) detectors 2 and 5.

4-1) Time history of instrument response. Calculated assuming instrument temperature equal to detector temperature. Tests are listed in Table 4-1.

4-2 Instrument response (TN/W cm⁻² str⁻¹ cm⁻¹). (a) All tests prior to GE thermal vacuum. (b) All tests during and after GE thermal vacuum.

4-3 Instrument response (TN/W cm⁻² str⁻¹ cm⁻¹). (a) All tests prior to GE thermal vacuum. (b) All tests during and after GE thermal vacuum.

5-1) Temperature Dependence of Bolometer Channel Responsiveties

5-2) Ratio of Radiance Error at Each Planet Temperature

5-3) Ratio of Radiance Difference to the Radiance at 270K, for +30C Instrument Temperature

5-4) Ratio of Radiance Difference to the Radiance at 270K, for +20C Instrument Temperature

5-5) Ratio of Radiance Difference to the Radiance at 270K, for +10C Instrument Temperature
Temperature

Ratio of Radiation Difference to the Radiation at 270K, for -20°C Instrument

5.8

Temperature

Ratio of Radiation Difference to the Radiation at 270K, for +10°C Instrument

5.7

Temperature

Ratio of Radiation Difference to the Radiation at 270K, for +20°C Instrument

5.6
Figure 9-4

TES T/V Test Profile (Actual)

- Ambient
- Heaters OFF
- Heater Debug
- Thermal Balance Test
- Heaters OFF
- Heaters ON
- Heaters OFF
- Heaters ON
- Heaters OFF
- Heaters ON
- Heaters OFF
- Heaters ON
- Heaters OFF
- Heaters ON
- Heaters OFF
- Heaters ON
- Heaters OFF
- Heaters ON

Elapsed Time From 9/13/91 (Days)

Instrument Temperature (°C)
fva: detector 1, alb channel, difference
zs = 0.05 (plotted 6/3/91)
fva: detector 1, bol channel, difference
zscale = 0.2      (plotted 6/3/91)
fva: detector 1, pp channel, difference
zscale = .5   (plotted 6/3/91)
detector 1, alb channel, difference
detector 1, bol channel, difference
detector 1, spc channel, difference
\[ R(\tau) = -8.277 \times 10^{-3} \tau + 1.0377 \]

**Slope Response Simulation**

- Est. PI outp
- Est. PI outp-A

**Graph Details:**
- Y-axis: Psig-Spsig
- X-axis: Pirad-Sprad

Page 1
Slope Response Simulation (Normalized)
Fig 3-7c
Ave of 5 good detectors - all tests (snrd6-c12)
Ave of 5 good detectors - pre GE TV (snrd6 snre1 tvf6 tvn5 tvk33 tvn38 data mod) Jan 11 12:08 05 1995