STE-U Thermal Balance Test Report
IMPACT Boom Instrument

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SUMMARY

This report contains the STE-U thermal balance (TB) test results and correlation with the analytical model predictions. The test was conducted at the SSL facility in Berkeley, CA per the test plan, Reference 2, on 4/1/04 to 4/4/04. Two test cases were used to simulate the cold and hot flight environments for the STE-U. Subsequently, the test setup was modeled using the TSS program. The corresponding SINDA model was then developed to predict test temperatures and correlate the analytical model. After minor changes to isolator conductance couplings, temperature predictions matched test results within 5ºC except for the STE-U temperature was 7.5ºC warmer than predicted in the hot case. This apparent descrepancy is considered acceptable because of the very small heat balances on the instrument.

An updated flight temperature prediction for the cold case was run based on the correlated STE-U model. The result indicates an increase in the STE-U flight temperature prediction by approximately 7ºC, which should hold true for the hot case as well. The STE-D prediction increases by approximately 9ºC. A complete set of revised flight predictions will be generated following the SWEA thermal balance test in August or September 04.

REFERENCES

1. ICD 7381-9012, INTERFACE CONTROL DOCUMENT (ICD) for the STEREO IMPACT INVESTIGATION, JHU Applied Physics Laboratory, dated 3/7, 2002.
2. Document # XXXX, IMPACT STE-U TB and TV Qualification Test Plan, SSL, UC, Berkeley, dated 26 April 2004.
3. STE ICD, SWEA ICD, and Magnetometer ICD.

TABLES and FIGURES

THERMAL BALANCE TEST DESCRIPTION

Figure 1 shows the STE-U mounted to the STE Pre-Amp as in the flight configuration. Figure 2 is a photograph of the test configuration prior to insertion into the chamber. (These figures were provided by SSL, Berkeley)

The thermal balance test was conducted from May 1 to May 4, 2004 at the SSL, Berkeley facility. Chamber environment goals as specified in the STE-U test plan, Reference 2, were attained. Two equilibrium cases (worst-case cold and worst-case hot) were conducted. Test results provided sufficient data to correlate the analytical model.

TEST VERSUS ANALYSIS RESULTS

Model Changes to Achieve Correlation

Figure 3 depicts the TSS geometry model of the test configuration used for analytical model correlation.

- Conduction coupling through the STE-U isolator was increased by a factor of 1.5. It was originally computed to be 0.0048 Watts/ºK and for test correlation was found to be 0.0072 Watts/ºK. The difference could be due to radiation couplings within the isolator and across contact areas that were not included in the computation. It could also be due to conductive and radiative decoupling of the instrument cover. The model will be upgraded to improve the cover coupling when the STE-D and SWEA are thermal balance tested.
- Conduction coupling through the STE-U Sunshade isolator was increased by a factor of 1.3. It was originally computed to be 0.0077 Watts/ºK and for test correlation was found to be 0.0101 Watts/ºK. The difference again could be due to radiation couplings not included in the computation.
- An additional node was added to represent the Pre-amp/STE mounting interface. This enabled the model to accurately predict the average Pre-amp temperature and the gradient through the Pre-amp from the Adapter to the Pre-amp/STE interface.

Summary of Results

Results show close correlation after implementing the model changes listed above. All sensors match predictions within 5ºC for both test cases except for the STE-U in the hot case; test versus analysis delta in this case is 7.5ºC. This apparent discrepancy is considered to be acceptable considering the small heat balances involved. Test item test temperatures versus thermal analytical model predictions are provided in Table 1. Complete comparisons including chamber shouds and baseplate are delineated in Tables 2 and 3. (Test data was provided by SSL, Berkeley)

TABLE 1: Summary Comparison of Test vs. Analysis Results

Location	Cold Case (ºC)		Hot Case (ºC)	
	Test	**Analysis**	**Test**	**Analysis**
Adapter Center	-19	-19.88	33	31.3
Pre-Amp Center	-23	-20.75	31	29.69
Pre-Amp/STE I/F	-22	-21.97	28	27.62
STE-U Sunshade	-59	-57.7	-27	-33.6
STE-U PRT	-77	-73.97	-50	-57.58

CONCLUSIONS AND RECOMMENDATIONS

- The thermal balance test correlation has successfully verified the STE-U thermal model and the thermal conductance of the STE-U and Sunshade isolators.
- Thermal coatings chosen for the STE-U are adequate for maintaining STE-U temperatures in the acceptable range.
- The increased isolator conductance results in an increase in the expected flight temperature of approximately 7ºC for the STE-U and an increase of about 9ºC for the STE-D. Flight temperature predictions are currently as follows. A final set of analysis runs will be conducted after the SWEA/STE-D thermal balance test:

	Previous Prediction (Cold/ Hot)	Updated Prediction (Cold/ Hot)
STE-U	-85ºC / -70.6ºC	-78ºC / -60ºC
STE-D	-97ºC / -95ºC	-88ºC / -86ºC

- The qualification test for the STE-U has been conducted from –90ºC to –25ºC (operational), which indicates significantly more margin at the hot end than for the cold case. However, the 12ºC margin at the cold end is considered adequate.
- It is recommended the STE-D cold case flight temperature be raised from -88ºC to approximately the same as the STE-U prediction. This can be achieved by covering a portion of the anti-sun side (cover) with a low-E finish such as alodine. The STE-D surface finish scheme will depend on the correlation analysis to be conducted after the SWEA/STE-D thermal balance test.

STE-U THERMAL BALANCE TEST

FIGURES AND TABLES

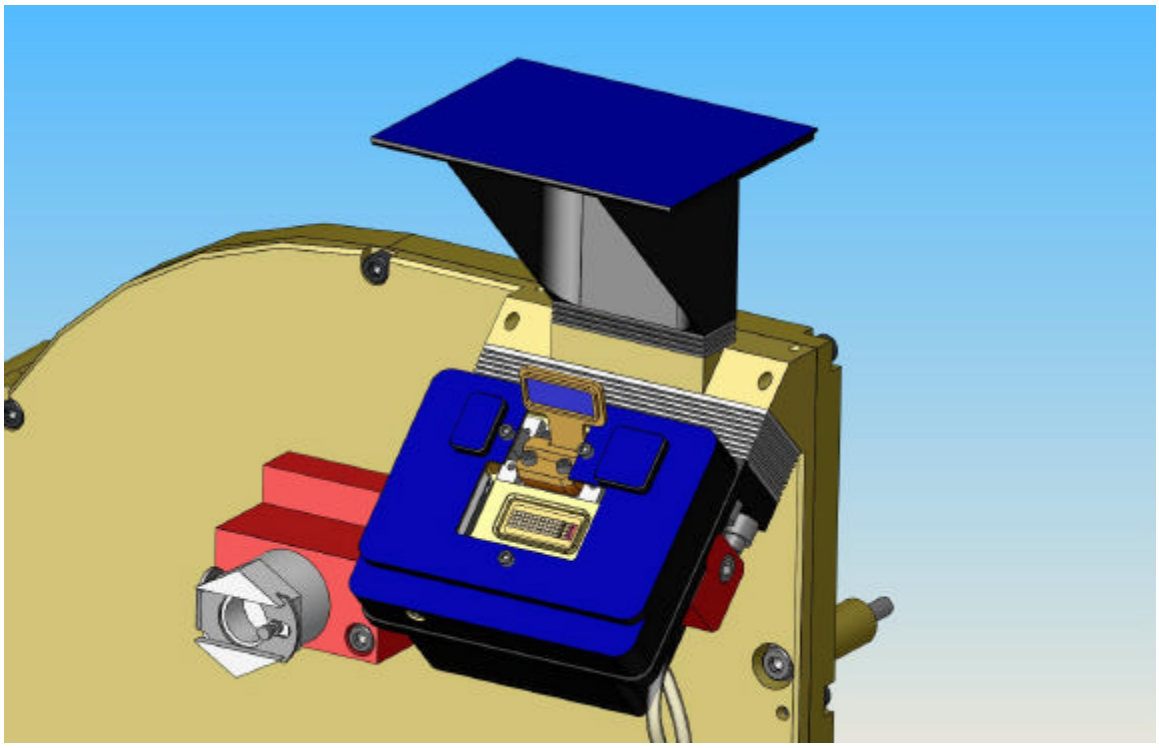

FIGURE 1: STE-U and Pre-Amp Configuration Without MLI
(Colors do not reflect flight coatings)

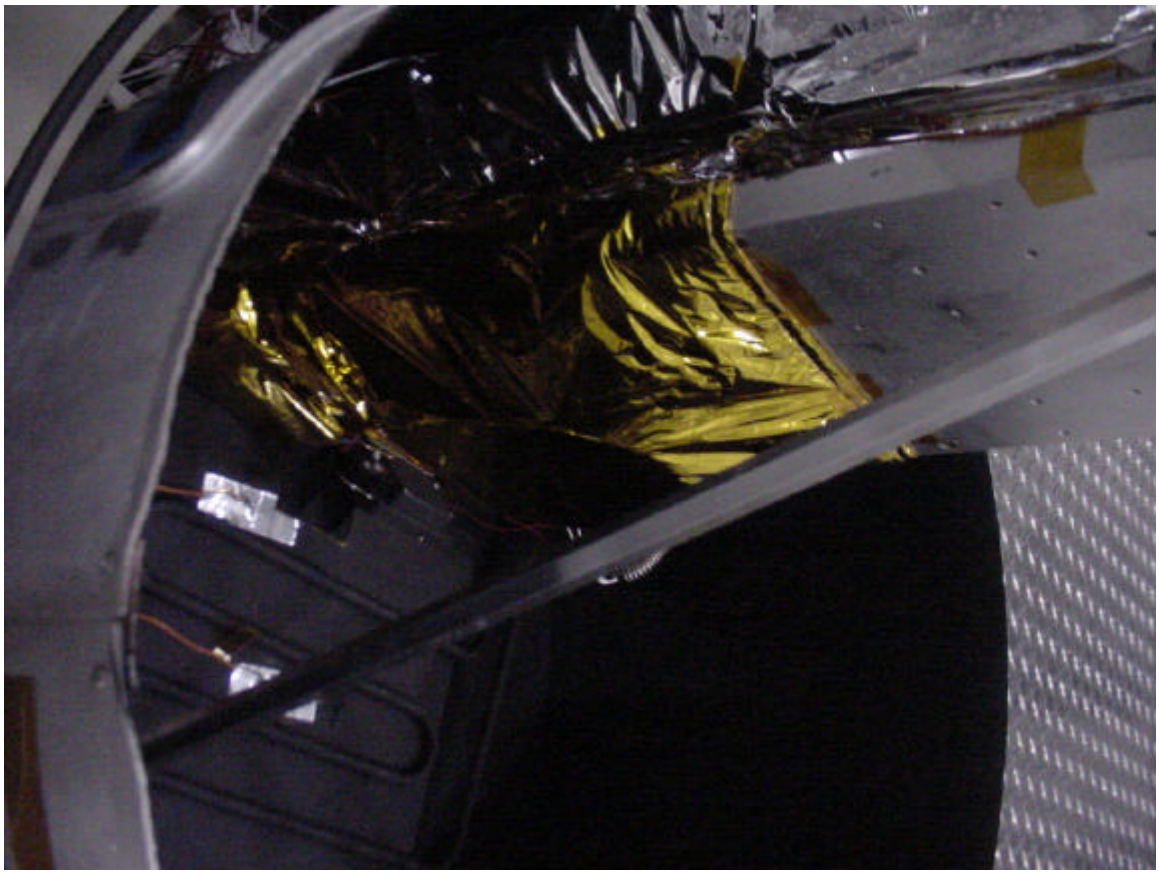

FIGURE 2: Picture showing STE TB Test Configuration

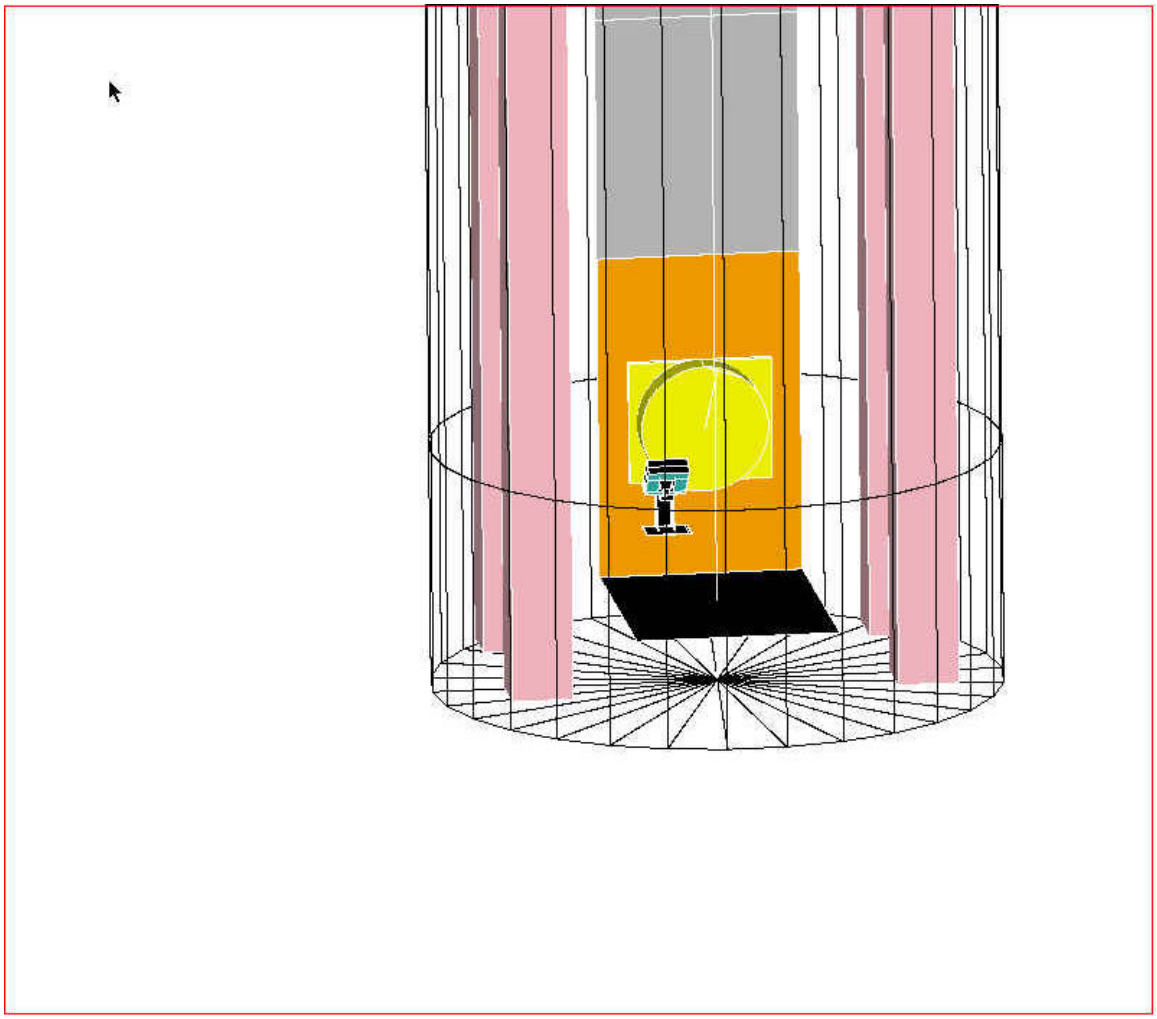

FIGURE 3: View Showing TSS Model Geometry

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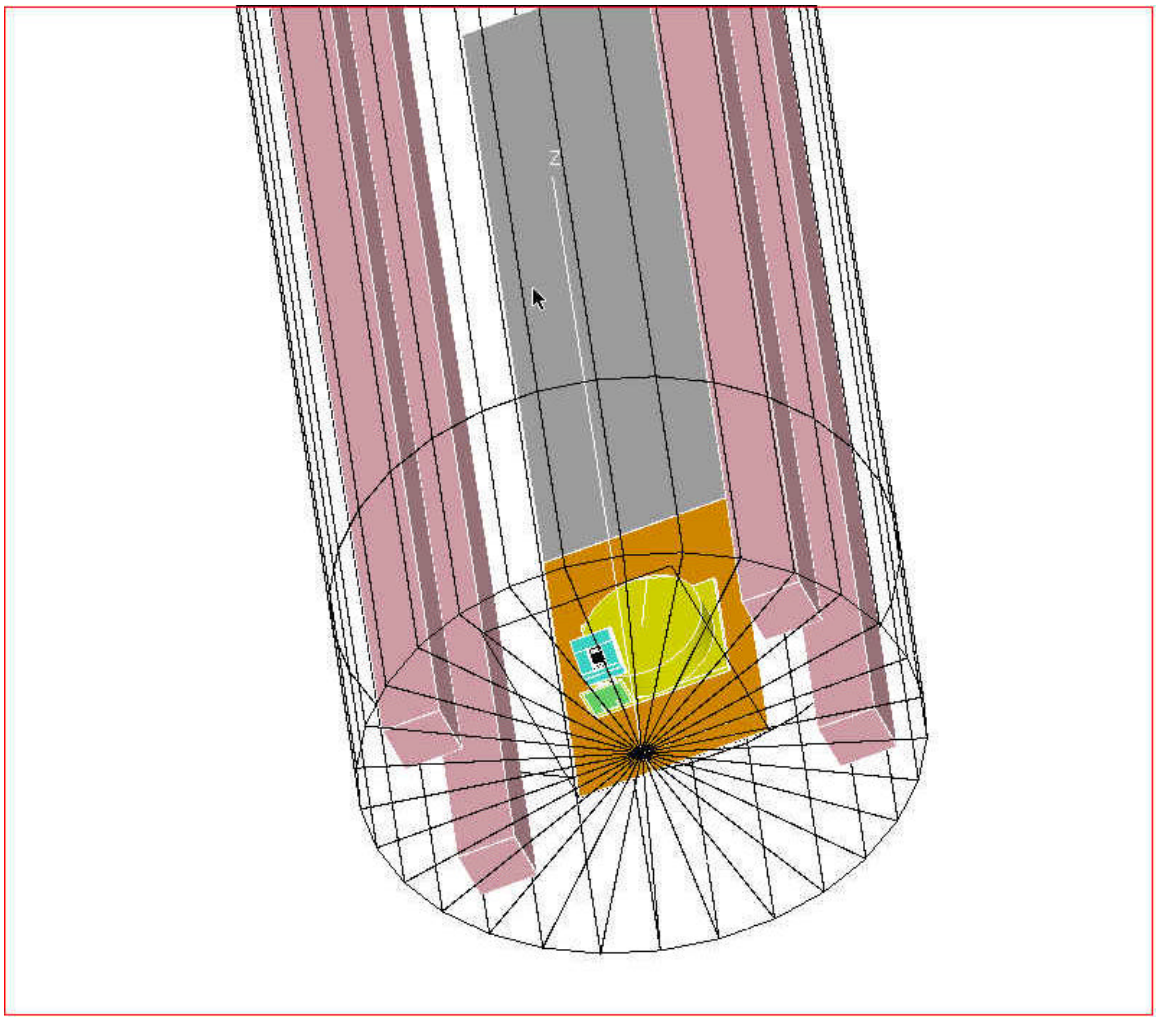

FIGURE 4: Second View Showing TSS Model Geometry

TABLE 2: STE-U Cold CaseThermal Balance Temperatures

Cold Case temperatures taken 03 May 2004, 3:30 PM, after 4-hour stable soak (<0.5°C per hour change in monitor channels).

Sensor #	**Location (Node Number)**	**TB Cold Case Temp (°C)**	**Analysis Predict (°C)**
TC1	Upper Shroud Control (9995)	-110	-110
TC2	Lower Shroud Control (9994)	-138*	-138
TC3	Baseplate Control (888)	-40	-40
TC4	Cold Plate Control (9997)	-105	-105
TC5	Cold Plate @ Heat Strap I/F	-110	
TC6	Baseplate Opposite Adapter (998)	-26 **	-19
TC7	Adapter Center (991)	-19	-19
TC8	Pre-amp Center opposite Adapter (6302)	-21	-20.75
TC9	Pre-amp @ STE-U Interface (63022)	-22	-21.97
TC10	STE-U Sunshade (Center) (6303)	-59	-57.65
TC11	STE-U @ Purge Port	-57	
TC12	Not Used	---	
TC13	Spare / Lower Shroud	-133	
TC14	Upper Shroud Track	-105	
TC15	Upper Shroud Track	-103	
TC16	Room	26	
	STE-U Flight PRT (6301)	-77	-73.97
	Pre-amp Flight PRT (6302)	-23	-20.75

* Shroud was originally shown as the control temperature –75°C. Subsequent testing indicated that the actual shroud temperature was 138°C.
****** TC6 was determined to be reading incorrectly because the baseplate at this location would have to be very nearly the same temperature as the adapter.

TABLE 2: STE-U Hot CaseThermal Balance Temperatures

Hot Case temperatures taken 03 May 2004, 8:30 PM, after two hour stable soak, and 03 May 2004, 10:30 PM, after four hour soak with fluctuations in LN2 supply during last two hours (<0.5°C per hour change in monitor channels during full four hour period).

Sensor #	**Location (Node Number)**	**TB Hot Case Temp (°C)**	**Analysis Predict (°C)**
TC1	Upper Shroud Control (9995)	-111 / -106	-108
TC2	Lower Shroud Control (9994)	-138 *	-138
TC3	Baseplate Control (888)	10 / 9	10
TC4	Cold Plate Control (9997)	-111 / -107	-109
TC5	Cold Plate @ Heat Strap I/F	-118 / -117	
TC6	Baseplate Opposite Adapter (998)	23 / 22 **	33
TC7	Adapter Center (991)	33 / 32	31.3
TC8	Pre-amp Center opposite Adapter (6302)	30 / 30	-29.7
TC9	Pre-amp @ STE-U Interface (63022)	28 / 27	-27.6
TC10	STE-U Sunshade (Center) (6303)	-27 / -27	-33.6
TC11	STE-U @ Purge Port	-30 / -30	
TC12	Not Used	---	
TC13	Spare / Lower Shroud	-132 / -130	
TC14	Upper Shroud Track	-108 / -105	
TC15	Upper Shroud Track	-103 / -101	
TC16	Room	24 / 22	
	STE-U Flight PRT (6301)	-50 / -50	-57.58
	Pre-amp Flight PRT (6302)	31 / 31	29.69

* Shroud was originally shown as the control temperature –73/-72°C. Subsequent testing indicated that the actual shroud temperature was -138°C.
****** TC6 was determined to be reading incorrectly because the baseplate at this location would have to be very nearly the same temperature as the adapter.