3.2 SPHERE

3.2.1 Purpose and Construction of the Integrating Sphere System

Updated and condensed version of Reference 3.2.1-1

Reference 3.2.1-1 - " 40" Integrating Sphere Operation", David I. Brown

The purpose of the 40 inch integrating sphere is to present an absolutely calibratable source of uniform radiance to the ISS cameras over the 350 to 1100 nm spectral region. The sphere is made of fiberglass and painted inside with Kodak 6080 coating, a diffusely reflecting coating that has a virtually constant, high reflectivity (>95%) from the UV through NIR . It has two 14" ports: the input port with it's adjustable diaphragm that meters light into the sphere from the source, and the output port which nicely mates to the vacuum vessel port for presentation to the camera (see Figure 3.2.1-1). It is illuminated by a 600 W tungsten lamp in a 1000 W Oriel lamphouse which is powered by a highly stabilized Hewlett Packard 6030A DC power supply (set for constant current operation in order to keep lamp output stable). The lamphouse has a fan and ozone filter system to cool the bulb and rid the atmosphere of copious amounts of ozone produced. The red radiometer is held outside the sphere by an exterior bracket and peers through a 2" port to provide absolute spectral radiance measurements at any time during the test. It is used in conjunction with the adjustable diaphragm on the light source to accurately set flux levels as well. A Schott glass filter holder has been made and placed inconspicuously behind the adjustable diaphragm holder. It takes 6"x6" plates of Schott glass. This allows some control over the light entering the sphere. Two IR pass filters have been made for this holder for RBI testing, if needed. In order to ensure that the vacuum vessel's optical window is not contaminated by outgassing from the new sphere, a thin float glass window has been placed on the sphere's exit. It has virtually flat 90+% transmittance from 350 to 1100 nm.

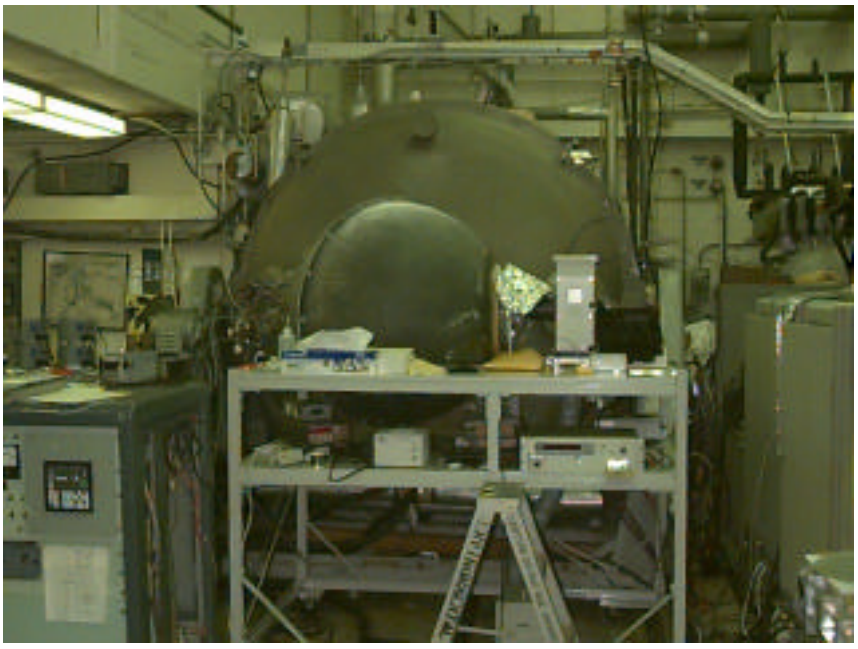

Figure 3.2.1-1 - Integrating Sphere (Thermal Vac Set-up)

3.2.2 Red Radiometer

3.2.2.1 Operation

Condensed Version of Reference 3.2.1-1

The purpose of the radiometer is to calibrate, absolutely, the sphere's radiant output. The radiometer consists of several parts listed below:

1) a well-baffled tube that defines the field of view and f/no (solid angle) of the radiometer
2) a series of precision apertures: 20,15, and 10 mm for the front end of the tube , and 8,4, and 2 mm for the detector end. These apertures are spaced 200 mm apart. For most purposes, the 20 mm and 8 mm apertures are used.
3) a filter holder
4) a calibrated set of narrow band filters: Melles Griot VIS-10, and IR-10 sets, in filter holders.
5) a NIST-traceable, calibrated silicon photodiode detector head containing a Hammamatsu 1337-1010BQ diode
6) a thermoelectric cooler driven by an external Alpha-Omega Instruments TEC controller (to control the photodiode temperature)
7) Keithley 617 electrometer for readout.

The radiometer in its standard configuration has an f/# of 10.0, as defined by the front 20 mm aperture and 200 mm front-to-rear aperture distance. The filter head has three openings for :

1) Melles Griot filters, in holders
2) window simulation filter in holder
3) dark insert (protective cover) / open insert

The dark current insert is positioned nearest the aperture, then the Melles Griot filter, then the window filter. The dark insert is installed when a background current is to be determined, and it also serves as a protective cover when the radiometer is not in use. When the dark cover is not installed, an open insert is installed to prevent light leakage.

When calibrating a camera, the 700 nm Melles Griot filter was used, independent of the camera filters installed, in order to obtain the sphere's radiant output readings prior to a performing a calibration test. Also, the lamp's radiant output was measured daily using the Melles Griot filters.

3.2.2.2 Current to Radiance Conversion Factors

Reference 3.2.2-1

Reference 3.2.2-1 - IOM 387-ER-97-628, "Cassini ISS Data Conversion/Transmission Factors", E. Romo, March 12, 1997

The red radiometer system, used for measuring the sphere's radiant output for thermal vac calibration testing, measured the sphere's radiant output via a calibrated silicon photodiode detector head containing a Hammamatsu 1337-1010BQ diode. Current levels from the photodiode were read with a Keithly 617 electrometer. This red radiometer system was calibrated 3 separate times by David Brown using a calibrated lamp. This data was compared to data taken previously with the calibrated lamp, as well as with data taken from a typical lamp used for flight calibration testing.

The conversion factors presented in the attachment were based on the latest red radiometer system calibration taken with the calibrated lamp on 7/15/96 (towards the end of flight calibration testing) and can be found on herschel @ CASSINI:[CALIB_ARCHIVE.RADIOMETRY]. The listed conversion factor (in units of $W/m^2/sr/nm/A$) is given to convert from current readings taken at the time of calibration testing (recorded in the VICAR label in units of picoamps) to radiance (in units of $W/m^2/sr/nm$). Note that the

current readings recorded in the image VICAR label were made with the 700 nm Melles Griot filter installed in the red radiometer system.

Wavelength	Current to Radiance Conversion Factors Data from 7/15/96 ($W/m^2/sr/nm/A$)
350	2.5735E+06
400	2.6788E+06
450	2.0063E+06
500	1.1694E+06
550	1.2717E+06
600	1.0943E+06
650	9.4540E+05
700	1.0879E+06
750	9.6294E+05
800	8.7264E+05
850	1.1544E+06
900	1.3885E+06
950	2.5225E+06
1000	6.1780E+06
1050	1.4085E+07
1100	5.1665E+07

Table 3.2.2-1 - Sphere Current to Radiance Conversion Factors

3.2.3 Sphere Uniformity

Reference 3.2.3-1 - Sphere Uniformity Test Data, M. Cerezo, January 12, 1996

The uniformity of the sphere's radiant output was measured (Reference 3.2.3-1) with the red radiometer in 1 inch increments across the sphere's 14inch diameter port which mates to the vacuum vessel port for presentation to the camera (see Figure 3.2.3-1). The data shown below (see Table 3.2.3-1) was taken January 12, 1996. It can be seen from the data (see Table 3.2.3-2) that the uniformity of the sphere's radiant output is within 2% for the majority of the view through the port, and most definitely for the view of the cameras.

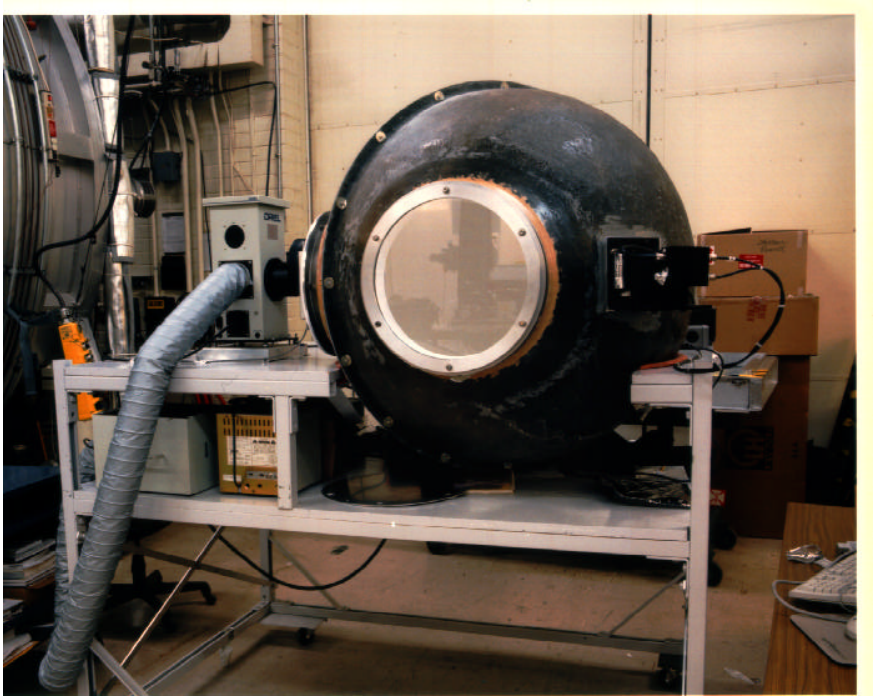

Figure 3.2.3-1 - Integrating Sphere (14” Port View)

SPHERE RADIANT OUTPUT MEASUREMENTS

						1.54						
				1.577		1.548			1.56			
		1.561	1.563	1.564	1.564	1.555	1.567	1.567	1.565	1.56	1.553	
		1.561		1.569		1.563			1.572		1.562	
	1.555	1.557	1.559	1.564	1.564	1.571	1.573	1.577	1.577	1.573	1.567	1.556
		1.555		1.56		1.576			1.586		1.572	
1.373	1.555	1.554	1.554	1.559	1.568	1.579	1.588	1.594	1.588	1.574	1.56	1.551
		1.552		1.557		1.582			1.594		1.578	
	1.554	1.553	1.552	1.552	1.555	1.582	1.575	1.587	1.594	1.587	1.58	1.564
		1.552		1.55		1.581			1.594		1.58	
		1.545	1.548	1.548	1.551	1.579	1.57	1.583	1.59	1.586	1.577	
				1.542		1.574			1.595			
						1.567						

Table 3.2.3-1 - Sphere Uniformity Raw Test Data

SPHERE UNIFORMITY IN %
(DETERMINED AGAINST READING TAKEN AT CENTER OF THE SPHERE)

						-2.47						
				-0.13		-1.96			-1.20			
		-1.14	-1.01	-0.95	-0.95	-1.52	-0.76	-0.76	-0.89	-1.20	-1.65	
		-1.14		-0.63		-1.01			-0.44		-1.08	
	-1.52	-1.39	-1.27	-0.95	-0.95	-0.51	-0.38	-0.13	-0.13	-0.38	-0.76	-1.46
		-1.52		-1.20		-0.19			0.44		-0.44	
-13.05	-1.52	-1.58	-1.58	-1.27	-0.70	0.00	0.57	0.95	0.57	-0.32	-1.20	-1.77
		-1.71		-1.39		0.19			0.95		-0.06	
	-1.58	-1.65	-1.71	-1.71	-1.52	0.19	-0.25	0.51	0.95	0.51	0.06	-0.95
		-1.71		-1.84		0.13			0.95		0.06	
		-2.15	-1.96	-1.96	-1.77	0.00	-0.57	0.25	0.70	0.44	-0.13	
				-2.34		-0.32			1.01			
						-0.76						

Table 3.2.3-2 - SPHERE UNIFORMITY (%)