Payload* Verification Requirement Compliance Matrix (VRCM)
S0493 Rev. B

Part Number: 65113-1C34292-101 Rev B
Serial Number: SM-01

December 6, 2002

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*For the Payload Acceptance Review, payload is defined as the integrated Probe, Dewar, Vatterfly Valves and Science Instrument Assembly. Electronics, GMA, Sunshade, Magnetometer, and Proton Monitor are covered in separate acceptance data packages. Vatterfly Valves, Dewar, Probe, and SIA component level verifications are also covered by separate acceptance packages.

ITAR Assessment Performed ____________ **ITAR Control Req'd?** ☐ Yes ☒ No
Tom Langenstein 12/8/02

Document Revision Record

Document Title: Payload Verification Requirement Compliance Matrix (VRCM)

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Rev.	Section	Requirement	Change Description
—	2.1	T003 #12.3.2 & 12.7	Moved from “To Go” List Sec. 2.2 to “Verified”
—	3.1	PLSE-12 #3.2.1.4.1, 3.2.1.5.2.2, 3.2.1.5.3.2, 3.2.1.5.3.2.1, 3.2.5.6.4, 3.3.1.1.5, 3.7.2.2.3.6.2, 3.7.5.5.1	Moved from “To Go” List Sec. 3.2 to “Verified” at Payload Level
—	3.2	PLSE-12 # 3.7.1.6.2.1.4, 3.7.5.9.1.7, 3.7.8.13.5.2.1, 3.7.8.13.5.2.2, 3.7.8.13.5.2.3, 3.7.8.13.5.2.4	Moved from “Verified at a Higher Level” Sec. 6 to “To Go” List
—	4	PLSE-12 #3.7.1.4.2.1	Moved from “Verified” at Payload Level Sec 3.1 to “Verified” Lower Level
—	6	PLSE-12 #3.2.1.14.1	Moved from “To Go” List Sec 3.2 to “Verified at a Higher Level”
A	1.1	T002 #7.0	Moved from “To Go” List Sec. 1.2 to T002 “Verified”
A	2.1	T003 #6, 7.2.3, 7.4.1	Moved from “To Go” List Sec. 2.2 to T003 “Verified”
A	3.1	1) PLSE-12 #3.2.1.5.1, 3.2.1.5.3.3, 3.7.1.6.2.1.4, 3.7.5.9.1.7, 3.7.5.11.1, 3.7.5.11.2, 3.7.8.13.5.2.2, 3.7.8.13.5.2.3, 3.7.8.13.5.2.4 2) PLSE-12 #3.2.5.6.5, 3.7.2.2.3.7.2, 3.7.3.8.3, 3.7.5.9.1.4, 3.7.6.1.7	1) Moved from “To Go” List Sec 3.2 to “Verified” at Payload Level 2) Moved from “Verified at a Higher Level” Sec. 6 to “Verified” at Payload Level

VRCM Contents:

This Verification Requirements Compliance document contains several tables, representing the full extent of Payload–level verification. The Payload Specification, PLSE-12, maintained within the Gravity Probe B Hardware and Configuration Database, is the principal requirement document governing the design, construction, and performance of the Gravity Probe B Payload. Additional requirements come from T002 and T003.

As described on page 1 of this document, the payload (as defined for the purposes of this verification milestone) contains the Probe, Dewar, SIA, and Vatterfly Valves. Other hardware, not physically attached to the payload as delivered to Lockheed-Martin Building 205 is controlled by other documentation, or other sections of the Payload Specification. Vatterfly valve acceptance is documented in the Vatterfly Valve Acceptance Data Package and not repeated here. Dewar and Probe C acceptance is covered in their respective data packages; SIA acceptance is covered in the Probe-SIA Acceptance Data Package and Delta Acceptance Package (covers thermal repair and replacement of gyro #4). The following figure is a graphical representation of the "As-Built" configuration of the payload, part number 65113-1C34292-101 Rev B, serial number: SM-01.

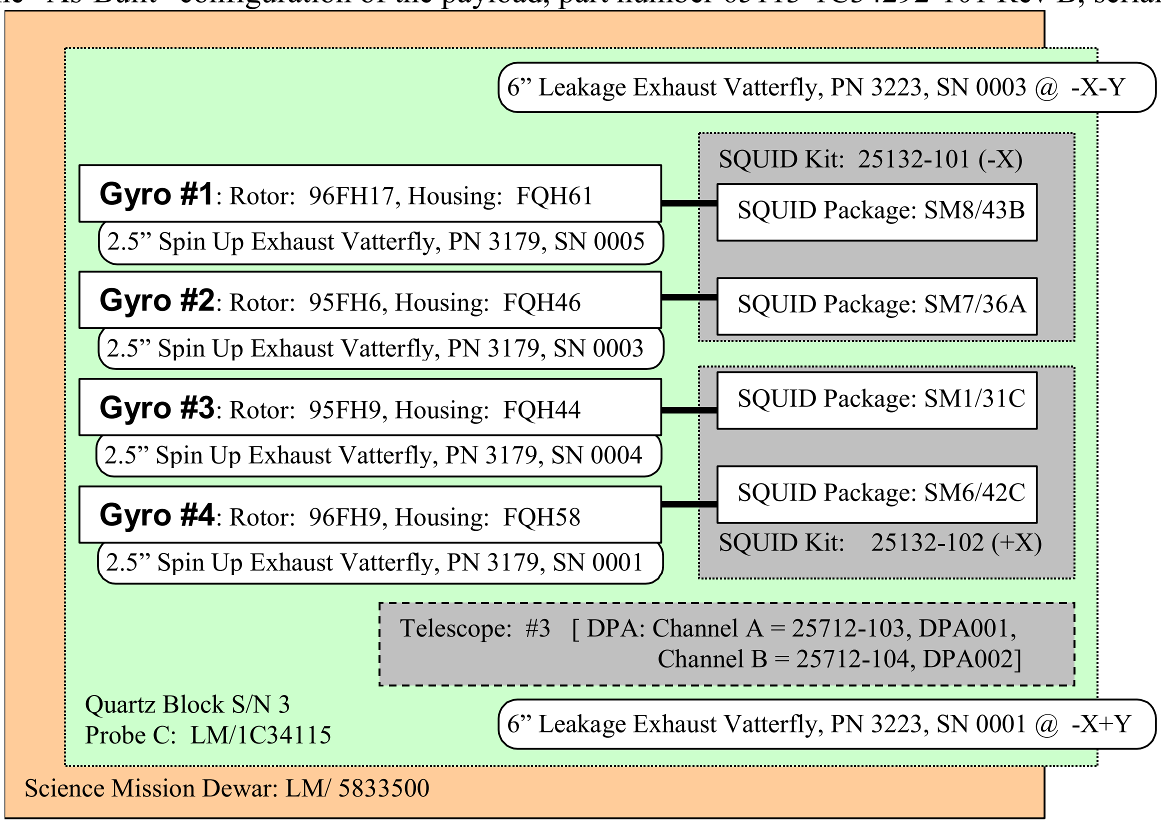
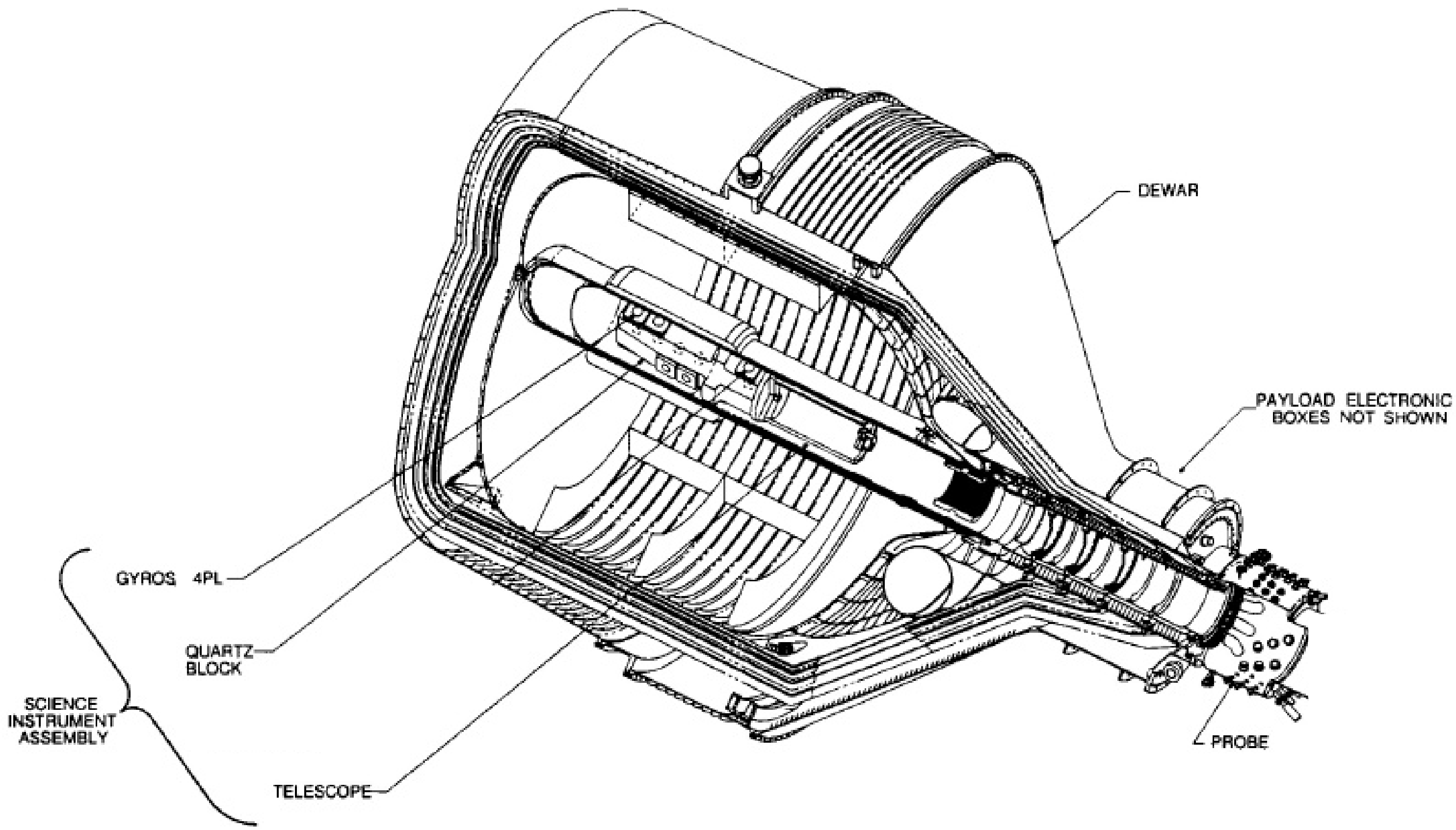


Diagram of Installed Payload Hardware

(Vatterfly Valve requirements covered in separate ADPs)

Contents



Dewar + Probe + Science Instrument Assembly

Lower level acceptance data packages:

1. SQUID Package VRCM; May 14, 1998 **2.** SQUID kit VRCM; Sept. 10, 1998 **3.** Science Telescope VRCM 10/14/98 **4.** DPA VRCM Feb 99 **5.** Gyro VRCM; FQH61, 46, 58, 44 **6.** QBA VRCM 4/8/99	**7.** SIA/ Probe Integration VRCM 7/6/99 **8.** Dewar VRCM, PLIT-03, GPB 100155A, 26Feb 97. **9.** Probe C AR, GPB-100269 v3, 15 May 98; final Probe C ADP, June 2001 **10.** Caging VRCM 4/19/99 **11.** DPA VRCM Feb 99

Table 1 T002 Requirements

1.1 Requirements Verified

para#	Title	T002 Requirements	Method	Compliance Data	Verified
7	Science Telescope (ST)	Within the central range of +/- 100 marcsecs, the ST readout system, after appropriate filtering and calibration, shall have a linearity consistent with an error of less than 0.1 mas/yr. The noise properties and biases are consistent with the requirements stated in requirement 8A below.	A	S0686 "Verification of Telescope Readout Linearity Requirements" details 7 telescope/window system parameters affecting error in the geodetic and frame-dragging coefficients due to telescope/window system nonlinearity. In addition there are 3 ATC system parameters affecting the error in the geodetic and frame-dragging coefficients due to nonlinearity, which are derived from other requirements imposed on the ATC system by higher level requirements. The evaluation of the 10 parameters in the analysis S0686 yields a high confidence error value due to nonlinearity of the telescope/window system of 0.081 marcsec/yr. using the set of 7 parameters having a >= 99% confidence of being achieved and using the required values for the set of 3 parameters related to the performance of the ATC system. The high confidence value of 0.081 marcs/yr. in the error in the coefficients of the geodetic and frame-dragging coefficients due to nonlinearity meets the required value of <= 0.100 marcsec/yr. The expected value of the error is 0.011 marcsec/yr. T002 requirement 7 contains the phrase, "within the central range of +/- 100 marcsec." Analysis shows that this statement has no affect on the error due to nonlinearity given above. For information purposes, it is noted that for the worst-case parameters the pointing is within +/- 100 marcsec 90% of the time and for the likely-case parameters is within +/- 100 marcsec 96% of the time. The analysis in S0686 verifies that T002 requirement 7 is met.	VLOA written and approved

1.2 Requirements To Go (due at Payload level)

para#	Title	T002 Requirements	Method
6	Science Gyroscope Spinup and Alignment	The Science Gyroscope rotors shall be spun up to a speed in the range 80 to 180 Hz. After spin up, the spin axes of the gyroscopes shall be aligned in a specified direction with respect to the line of sight to the guide star with accuracy better than 10 arcsec maximum.	A, T

Table 2 T003 Requirements
2.1 Requirements Verified

T003#	Title	T003 Requirements	Method	Compliance Data	Verified
1.5	Trapped Flux	The trapped magnetic flux in the gyro rotor shall correspond to an average magnetic field of less than 9e-6 Gauss. This will be verified with an analysis of the readout magnitude during ground gyroscope operation.	T	P0575 Final Flux Measurement, was run in Payload Test Phases A, C & D. Due to other operational difficulties encountered during phases C and D, the results of the phase A test are sited here: Gyro1: 8.3 microgauss, 1.75, 2.5, and 0.9 microgauss for Gyros 2, 3, and 4. See S0564 for further verification information.	VLOA written and approved
3.2.1.1	High Frequency	In the frequency range 100-1000 Hz the harmonic distortion of each of harmonics 2-5 of sinusoids with amplitude corresponding to the trapped flux levels of section 1.5 shall be less than 1e-4.	T	P0833 run #5 (SQUIDs 2,4) and run #9 (SQUIDs 1, 3) collected data verifying that the harmonic distortion of each SQUID for the fundamental and first 4 harmonics is less than 1e-4. The values determined are as follows: SQUID 1,Table 12.6.3 (-87.6, -85.3, -92.3, -87.2 dB) SQUID 2,Table 13.6.3 (-85.9, -84.9, -89.1, -86.5 dB) SQUID 3,Table 14.6.3 (-95.1, -83.5, -91.8, -86.8 dB) SQUID 4,Table 15.6.3 (-85.8, -84.8, -88.1, -87 dB) (note < -80 dB corresponds to < 1e-4) See S0575 for additional information regarding SQUID verification.	VLOA written and approved
3.2.2	Noise	The gyroscope readout system single-sided noise spectral density at the roll frequency shall be less than 190 marcsec/sqrt-Hz (corresponding to a 10 hour integration time to resolve a 1 marcsec angle) for roll period of 3 minutes or less and gyroscope spin speed >=130Hz.	T	A single-sided noise spectral density of 190 marcsec/sqrt-Hz is equivalent to 47.50 micro-Phi0/sqrt-Hz. Runs 6 and 16 of P0833 in Payload Test measured the single-sided noise spectral density to be 40, 34, 29, and 25 micro-Phi0/sqrt-Hz for SQUIDs 1-4, respectively. See S0575 for additional information regarding SQUID verification.	VLOA written and approved
3.4	Temperature Control	The readout SQUIDs shall be maintained at their nominal operating temperatures between 2.5K and 3.1K with (a) a stability of 5 micro-Kelvin rms over a 3 mHz frequency band centered on roll frequency, (b) a long-term drift averaged over 1 year of <=30 mK/year, and (c) a long-term stability of 30mK rms within a 1 Hz bandwidth, while Science Data is collected.	I, A, T	**Inspection**: Per vendor datasheet, the long term GRT stability is < 1 mK / year at T= 4 K. Required stability is <=30 mK / year. Datasheet is contained in SQUID Bracket GRT parts folder (P/N 23531-101). **Analysis**: S0575 shows that the temperature stability is 0.70 micro-K which is significantly better than the 5 micro-K requirement. **Test**: P0833 run #19 operated SQUID bracket #2 in fine temperature control mode. The nominal temperature of the SQUID during the test was 2.646 Kelvin. Data from test was used in S0575 analysis.	VLOA written and approved

T003#	Title	T003 Requirements	Method	Compliance Data	Verified
3.7	Flux Quantum Calibration	The Readout System shall have the capability of measuring changes in the scale factor to an accuracy of better than 1e-5 using the flux quantum in the SQUID.	T	P0833 section 17 (Run #13) measured the FLL output repeatedly using both the SRE analog port and the SRE Data Acquisition System(DAS) at both ends of an excursion offset current equivalent to ~100 Phi-0 (~60 Phi-0 for SQUID 4). A 3-sigma estimate of the standard error of the mean FLL stability in units of delta Phi-0 per Phi-0 was calculated to be: SQUID 1: 1.4 e-6 SQUID 2: 1.5 e-6 SQUID 3: 0.8 e-6 SQUID 4: 6.6 e-6 See S0575 for additional information regarding SQUID verification.	VLOA written and approved
6	Science Gyroscopes – Evacuation. (U)	Ultrahigh vacuum bakeout of the SGs shall be performed after spinup to achieve an effective pressure between the SG rotors and the housings of not more than 2.6 x 10^8 Pa (2 x 10^-10 Torr).	A, T	P0547 Low Temp Ultra-high Vacuum Bakeout S0594 SIA Vacuum Pressure after Low Temperature Bakeout Achieved 2 x 10^-10 torr.	VLOA written and approved
7.2.3	Linear Range	The fused quartz ST shall meet the linear range and error requirements of T002, requirement 7.	A	S0686 "Verification of Telescope Readout Linearity Requirements" details 7 telescope/window system parameters and 3 ATC parameters affecting error in the geodetic and frame-dragging coefficients due to telescope/window system nonlinearity. The evaluation of the 10 parameters in the analysis S0686 yields a high confidence error value due to nonlinearity of the telescope/window system of 0.081 marcsec/yr.	VLOA written and approved
7.4.1	Pointing Angle Scale Factor Calibration, ATC	Based on ground test data and analysis, the derivative of the telescope normalized pointing signal with respect to angle on orbit shall be >= 0.4 /arcsec and <= 1.4 /arcsec	A, T	P0503B Artificial Star 3 Focus, Scale Factor and Strehl Ratio Tests of Telescope was run in PL Phase: B S0619 Flight Telescope Window Verification of Wavelength Dep. Requirements Scale Factor >= 0.44 and <=1.27.	VLOA written and approved
8.2	Steady State Field	The total steady state field at the SGs shall be less than 9 e-10 T (9 e-6 Gauss).	T	P0575 Final Flux Measurement, was run in Payload Test Phases A, C & D. Due to other operational difficulties encountered during phases C and D, the results of the phase A test are sited here: Gyro1: 8.3 microgauss, 1.75, 2.5, and 0.9 microgauss for Gyros 2, 3, and 4. See S0564 for further verification information.	VLOA written and approved
8.3	Attenuation	The magnetic shielding factor against variations in the external field at roll frequency shall be 2 e-12 or less.	A, T	P0860 AC Shielding Test was run in PL Phase: D2 From S0543, Payload Magnetics Requirements Verification: A magnetic field of 0.25 Gauss amplitude at 15 mHz was applied to the SIA. An attenuation of 2e-12 would result in a 3.29e-7 flux quantum SQUID reading. SQUID readings were below 3.29e-7 flux quantum, which shows the attenuation is greater than 2e-12.	VLOA written and approved
12.3.2	Magnetic Field	The probe shall satisfy the magnetic field requirements delineated in section 8.	T	The applicable magnetic field requirements in section 8 were discussed and verified in S0543 P0575 Final Flux Measurement was run in PL Phase C and D.	VLOA written and approved

T003#	Title	T003 Requirements	Method	Compliance Data	Verified
12.7	Heaters	The probe shall support heaters for magnetic flux flushing of the SGs (to meet the magnetic requirements), for low temperature bakeout of the QBA (to meet the gyroscope vacuum requirements), and for evaporation of gas condensation on the windows.	T	P0542 ECU Flux Flush P0547 ECU Low Temp Bakeout P0540 ECU Check out Procedure EM 245 Prediction of Temperature Probe Windows During On-orbit Window Bake-out Window Bake-out is compliant with the current Oct 30, 2002 launch date. Windows #3 & 4 seasonal constraints are +/- 30 days from September 1st, 2002 and +/- 30 days from March 1st.	VLOA written and approved
12.8	Thermal Requirements	The probe has a thermal design consistent with the Dewar lifetime requirement (Section 13). During on-orbit operation when the heat power in the QBS meets the requirements in 3.7.2.5.7 (Heat Power into QBS) of PLSE-12, the probe thermal design shall (a) provide a temperature of the QBS fingers of <= 3.0K with the capability of being maintained with a stability of 1.0 mK rms in a 100 mHz bandwidth and with a stability of 0.2 mK in a 3 mHz bandwidth centered on roll frequency, and it shall (b) provide a temperature at the SQUID bracket attachment point of <= 3.0 K.		"Analysis: Dewar Lifetime data from Test-correlated thermal model as given in LM EM TCS 342A is 17.1 months vs. 16.5 months required. Heat power into QBS equals sum of individual contributors: Item Req'd Total Power (mW) Actual SQUID Bracket Assy (3.7.2.5.7.1) 0.500 0.010 (max) -ref S0575, P0833 QB GRTs (lot) (3.7.2.5.7.2) 0.001 0.0002 - ref S0516 SDs (lot) not used (3.7.2.5.7.3) 0.000 0.0 - ref S0516 Thermal radiation on QB (3.7.2.5.7.4) 0.250 0.01 (max) - ref LM EM 342A (S0600) Gyroscope Assemblies (3.7.2.5.7.5) 0.004 0.0000 - ref S0520 Telescope DPA (2 ea. DMAs) (3.7.2.5.7.6) 6.000 5.200 - ref S0558, P0822 QBS heater (3.7.2.5.7.7) 2.000 0.200 - ref S0583, P0544 TOTAL 8.755 5.420 (a) S0583: QBS finger temperature < 2.614K; stability 0.47mK in 100 mHz bandwidth; stability = 0.082 mK in a 3 mHz bandwidth. (b) S0575: SQUID bracket attachment point temperature achieved is 2.646 K Test: (a)P0862 collected data on the ECU controlled QBS temperature. (b)P0833, Run #19 operated the SQUID bracket controller in fine mode (data was sampled at 1 Hz).	VLOA written and approved

T003#	Title	T003 Requirements	Method	Compliance Data	Verified
12.9	Spinup	The probe supports a spinup system supplying each SG with low-temperature helium gas. Spinup gas leakage out of the channel shall be vented by a common line through the neck tube at a rate ensuring that the pressure between the SGs and the housing does not exceed 7.1 e-2 Pa (5.3 e-4 Torr). A gate valve on the front of the probe is opened during spinup to vent to space the residual gas leaking into the probe. During launch and measurement of Science Data the gate valve is closed.	T	P0519 Gyro Flow and Thermal Testing was run in PL Phases C and D. The phase D test verified the pressure between the gyro and the housing for gyros 1 & 2 as: Gyro 1: 1.03 x 10^-4 torr <5.7x10^-4 torr Gyro 2: 1.85 x 10^-4 torr <5.7x10^-4 torr The phase C test verified the pressure between the gyro and the housing for gyros 3 & 4 as: Gyro 3: 2.7 x 10^-4 torr <5.7x10^-4 torr Gyro 4: 2.17 x 10^-4 torr <5.7x10^-4 torr All 4 gyroscopes meet this requirement using a common line through the neck tube to vent spin up leakage gas.	VLOA written and approved

2.2 T003 Requirements To Go (due at Payload level)

para#	Title	T003 Requirements	Method	Note / Comment
8.4	External Field	The variable (in body coordinates) instantaneous magnetic field generated by the spacecraft at the nominal position of the opening of the lead bag (in the absence of the lead bag and cryoperm shield) shall not exceed 1 e-5 T (0.1 Gauss) in addition to the Earth's field in any direction and under any operating condition.	A	Deferred to SV level, requires spacecraft mated to the payload.

Table 3 PLSE-12 Requirements

3.1 Requirements Verified

Requirements from Sections 3.2 and 3.3 address Payload level requirements.
[Note that this section of the Payload Specification must be re-verified when GMA, electronics and Sunshade are integrated]

Table 3.1 – Verified Requirements

PLSE-12 #	Title	Requirement	Method	Compliance Data	Verification Status
3.2.1.2.1	Vacuum During Spin-up	The Science Payload shall be capable of maintaining a pressure of <= 7.1 x 10-2 Pa (5.3 x 10-4 torr) at the SIA during spin-up with a helium leakage mass flow rate <=110 micrograms/second through the probe.	T	P0519 Gyro Flow and Thermal Testing was run in PL Phase C. section B, page 4, dated 4/12/01 This requirement only needs to be verified once, but was verified for each P0519 gyro test: Gyro 3: 4.17x10^-4 torr Gyro 4: 4.31x10^-4 torr P0519 Gyro Flow and Thermal Testing was run in PL Phase D. section B, page 4, dated 4/12/01 This requirement only needs to be verified once, but was verified for each P0519 gyro test: Gyro 1: 3.13x10^-4 torr Gyro 2: 3.2x10^-4 torr	Verified at PL level
3.2.1.2.2	Vacuum After Spin-up	The Science Payload shall be capable of maintaining a pressure <= 2.6 x 10-8 Pa (2 x 10-10 torr) at the SIA over the lifetime specified in section 3.2.1.10 after spin-up of the science gyroscopes, low temperature bake-out and subsequent evacuation.	A,T	Logan, S0594 SIA Vacuum Pressure After Low Temperature Bakeout, works with PCB 496 P0872, Low Temp Bakeout Pressure Verification, run in PL Phase D3.	Verified at PL level
3.2.1.2.3	Trapped Volumes	Designs shall not create trapped volumes that are difficult to pump out or other construction (such as large surfaces that are tightly compressed together) that may become virtual leaks.	A	Whelan, S0599	Verified at PL level

Table 3.1 – Verified Requirements

PLSE-12 #	Title	Requirement	Method	Compliance Data	Verification Status
3.2.1.3	Magnetic Shielding Requirements	The Science Payload shall provide the following magnetic shielding at the science gyroscope locations from the time the SIA and its associated cryogenic electronics have been cooled below their superconducting transition temperature through all ground handling and testing, through the launch environment specified in section 3.2.5, and over the operational lifetime specified in section 3.2.1.10. The assumed disturbance field is equal to the Earth's magnetic field such that the maximum orbital external flux density is equal to 5.0 x 10-5 tesla (0.5 gauss) and the magnetic flux density produced by the entire space vehicle at the mouth of the cryoperm shield shall be <= 1.5 x 10-5 tesla (0.15 gauss).	A,T	Mester, S0543 P0575 Header for 3.2.1.3.1 and 3.2.1.3.2 3.2.1.3.1 are met in S0564 Trap Flux 3.2.1.3.2 are met in S0543 Magnetic Requirements	Verified at PL level
3.2.1.3.1	Steady State Field	The Science Payload shall provide a steady state flux density of <= 9 x 10^-10 Tesla (9 x 10^-6 Gauss) at the science gyroscope. The steady state field below the mouth of the lead bag (Station 191) shall be <= 1 x 10-5 tesla (0.1 gauss).	T	S0543 further supports this verification P0575 Final Flux Measurement was run in PL Phases A, C & D2. Due to other operational difficulties encountered during phases C and D, the results of the phase A test are sited here: Gyro1: 8.3 microgauss, 1.75, 2.5, and 0.9 microgauss for Gyros 2, 3, and 4. See S0564 for further verification information. Steady state field below mouth of lead bag verified in Engineering Memorandum (EM) from E. Lufer on cryoperm performance: LM/5834101 and 5835036 (from SMD ADP). RT measured field was 0.0574 G at the wall, 0.1367 G at the centerline; cryoperm reduces fields by factor of 1.5 at 4K, therefore field is 0.038 G at wall, 0.091 G at centerline.	Verified at PL level

Table 3.1 – Verified Requirements

PLSE-12 #	Title	Requirement	Method	Compliance Data	Verification Status
3.2.1.3.2	Attenuation Factor	The Science Payload shall provide attenuation of external magnetic fields at the science gyroscopes (flux density at gyros external flux density) of <= 2 x 10-12 over the frequency band from 0.00167 Hz (10 minute period) to 0.0167 Hz (1 minute period). This attenuation factor refers to an equivalent field referred to the area of each gyro pickup loop regardless of actual coupling mechanism. Compliance with this requirement may be verified by an attenuation measurement at any frequency in the specified range.	A,T	Mester, S0543 P0860 AC Shielding Test was run in PL Phase: D2 Data to be provided by Barry	Verified at PL level
3.2.1.4	Thermal Requirements	The Science Payload shall be capable of meeting the SIA thermal requirements specified in 3.4, 11.1, and 12.8 of T003.	I,A,T	Muhlfelder, S0583, QBS Thermal Stability This requirement is closed when T003 3.4 and 12.8 are complete. Requirements of T003 11.1 have been verified (11.1.1 and 11.1.2) previously. T003 3.4 and part b of 12.8 (ref. PLSE-12 3.7.2.5.1.3 verification) are discussed in S0575 P0862 Dewar Lifetime and Thermal Data Acquisition run in PL Phase D3.	Verified at PL level
3.2.1.4.1	Helium Bath Temperature	The helium bath operating temperature during the science data taking phase shall be no greater than 1.85 K, maintained with an accuracy of +/- 30 mK about the chosen operating temperature.	A	A. Logan, S0608, Verification of Helium Bath Temperature Requirements This is controlled by the Attitude Control System (ACS). Temperature stability is covered in monthly SC TPM Figure #15. The accuracy at 99% ullage given worst case atmospheric density is +/- 1 mK. Helium bath temperature of less than 1.8 K has been achieved, and is a preset command in the control algorithm. EM 245 supports that the Helium supply is sufficient to support the ACT temperature control during science data phase.	Verified at PL level
3.2.1.5.1	Optical System Linearity	The linear range and linearity shall meet the requirements of 7.2.3 Linear Range in T003.	A	S0686 "Verification of Telescope Readout Linearity Requirements" The requirement from T003 #7.2.3 (from T002 #7.0) is 0.100 marcsec/yr. and the error in GR drift coefficients due to the nonlinearity of the Telescope System is 0.081 marcsec/yr. based on a greater than 99% confidence parameter.	Verified at PL level

Table 3.1 – Verified Requirements

PLSE-12 #	Title	Requirement	Method	Compliance Data	Verification Status
3.2.1.5.2.2	Field of View	The optical system shall have a field of view meeting the requirements of 7.2.1.3 Minimum Field of View with Usable Signal and 7.2.2 Saturation Range of T003.	T	Bernier P0502B Artificial Star 3 Transmissibility and Acquisition Range Tests of Telescope was run in PL Phase: B. The data from P0502B & P0503 was summarized in S0570. From S0570 the FOV >= 65.4 arcsec & Saturation Range >= +4.65 arcsec / <= -1.95 arcsec	Verified at PL level
3.2.1.5.2.3	Primary Mirror Aperture	The optical system shall provide an aperture at the primary mirror of the telescope of at least 0.1422 meters (5.6 inches)	I	Telescope drawing 25060 shows that the aperture defined by the forward plate is 5.66".	Verified at PL level
3.2.1.5.3.2	Efficiency of Light Input to Current Output	The efficiency of light input (at Window #4 over the clear aperture of the telescope) to photodetector current output shall be measured with an accuracy of 10% within a wavelength of 100 nm of mid-band (700 nm) for each of the eight (8) detectors. This measurement is made at telescope null and at <= 200 marcsec intervals over a 10 arcsec range centered on null in the two readout axes. The unit is A/W.	T	Bernier P0503B Artificial Star 3 Focus, Scale Factor and Strehl Ratio Tests of Telescope was run in PL Phase: B The results of P0503B are summarized in S0570 Flight Telescope/Window System Verification. The measured value accuracy known to <=4.3% @ 668 nm.	Verified at PL level
3.2.1.5.3.2.1	Minimum Efficiency	The minimum efficiency of light input to photodetector current output of the sum of the current of all eight detectors shall be >= 0.038 A/W within a wavelength of 100 nm of mid-band (700 nm).	A, T	Bernier, S0570 & P0503B Artificial Star 3 Focus, Scale Factor and Strehl Ratio Tests of Telescope was run in PL Phase: B The results of P0503B are summarized in S0570 Flight Telescope/Window System Verification. The minimum efficiency >=0.0509 A/W @ 668 nm.	Verified at PL level
3.2.1.5.3.3	Strehl Ratio, System	With the telescope/window system in the Payload configuration, the derivative of the normalized Pointing signal with respect to angle at a nominal wavelength of 668 nm +/- 10 nm shall be >= 0.45 /arcsec within 100 marcsec of null. The normalized pointing signal is the current difference between a photo-detector pair divided by the sum of their currents.	A, T	Turneaure, S0570, Flight Telescope Window System Verification. The derivative of normalized pointing signal >= 0.455 /arcsec @ 668 nm for x and y-axes. Related AS3 analysis: S0574, The Design, Optics, Controls and Calibration of Artificial Star #3 for Gravity Probe B. P0503B Artificial Star 3 Focus, Scale Factor and Strehl Ratio Tests of Telescope was run in PL Phase: B.	Verified at PL level
3.2.1.5.5	Guide Star	The guide star shall be chosen from the list of candidate stars given in section 25.1 of T003.	I	D. Ross PCB 330 changed the list of two guide stars to a list of one guide star. This guide star IMPeg (HR8703) is the chosen star and is listed in the T003 paragraph 25.1	Verified at PL level

Table 3.1 – Verified Requirements

PLSE-12 #	Title	Requirement	Method	Compliance Data	Verification Status
3.2.1.7.1	Final Gyroscope Angular Velocity	The science gyroscopes shall be capable of being spun up to 80-180 Hz using pressurized helium gas at a mass flow rate <= 2.8 mg/s of He4 or <= 2.1 mg/s of He3 (both equivalent to 950 scc/m) supplied to the input of each gyroscope spin-up channel. Further, the above required spin speed shall be achieved with a total helium mass per gyro of < 26.5 g for He4 or < 19.9 g for He3. (equivalent to 950 scc/m for 158 min)	A,T,S	Clarke, S0579 predicted on-orbit spin speeds are (G1-G4): 129, 154, 131, and 149 Hz P0522 Gyro Fast spin Speed Testing Procedure	Verified at PL level
3.2.1.7.2	Gyroscope Alignment	The science gyroscopes shall be capable of being aligned towards the target star to within 10 arcseconds. The spin alignment system shall be capable of functioning simultaneously for any number of gyroscopes. The total time required for spin alignment of all gyroscopes shall be less than 10 days.	A	Brumley, S0256 (Bencze), Gyroscope Spin Axis Alignment T003 5.2, Course Alignment Accuracy has been verified with S0256. It is a suspension system function. Time to alignment predicted at ~12 hours per gyroscope: comply.	Verified at PL level
3.2.1.7.3	Spin-up Configuration	The Science Payload shall provide the capability to individually spin-up each of the gyroscopes.	I	Capability to spin-up each gyroscope has been demonstrated before the Payload Acoustic Test (Nov-Dec/ 2000) and after Acoustic Test (Apr & Jul/ 2001) in procedure P0516, Slow Spin Test	Verified at PL level
3.2.1.7.6	Post Spin-up Helium Venting	The Science Payload shall be capable of venting the remaining pressurized helium after the spin-up is complete to prevent leakage into the probe.	I	Capability to vent helium after spin-up is provided by Vatterfly Valves, installed on Payload per P0509 (June 2000).	Verified at PL level
3.2.1.8.2	Storage After Space Vehicle Integration	After integration into the space vehicle, the Science Payload shall be capable of being stored and transported while filled with cryogen for a period of five years when stored in a controlled environment per sections 3.2.5.1-3.2.5.4.	A	Whelan, S0599	Verified at PL level
3.2.1.9.1	Guard Tank	The guard tank shall have adequate liquid helium capability so that it does not have to be refilled for a period of >= 5 days.	A,T	K. Burns, LM / EM TCS 336 verifies this to 7 days, but operational constraints have reduced the refill period to 5 days. P0840 Unvented Rate of Rise of Main Tank w/ Gas in Well was run in PL Phase B. Section G7 in P0840 verified that the Guard Tank hold time is 5 days.	Verified at PL level

Table 3.1 – Verified Requirements

PLSE-12 #	Title	Requirement	Method	Compliance Data	Verification Status
3.2.1.9.2	Main Helium Tank	After the main tank is filled with SFHe, with the guard tank maintained with NBPHe, a period of >= 90 days shall elapse before the temperature of the SFHe rises above 1.85 K. This period may include up to 2 launch aborts at intervals >= 24 hours and a subsequent successful launch.	A,T	K. Burns, LM/EM TCS 336 + PCB 437. PCB addressed a known discrepancy with Dewar hardware that is accommodated by a change to the launch pad GSE and servicing scheme. P0515 Unvented Rate of Temperature Rise Using Guard Tank Procedure was run in PL Phase B.	Verified at PL level
3.2.1.10	Orbital Life	The Science Payload shall have an orbital operating lifetime of >= 16.5 months after initiation of launch. The lifetime includes operations such as spinup, flux flushing and low temperature bakeout. The 16.5 mo. requirement is reduced on a pro-rata basis for any increased helium flow rate required by the spacecraft helium thrusters for attitude control, translation control, or orbit trim.	A,T	K. Burns, LM / EM TCS 342A P0862 Dewar Lifetime and Thermal Data Acquisition run in PL Phase D3. Data collected in Payload Test will be used to update/ confirm thermal model. Current analytical prediction is that we meet the 16.5 month requirement.	Verified at PL level
3.2.1.10.1	Orbital Design Life	The on-orbit design life of the Payload, excluding helium, shall be >= 3 yrs.	A	Whelan, S0599	Verified at PL level
3.2.1.11	Proton Shielding	The Science Payload shall provide an average of 20 g/cm2 aluminum equivalent shielding for gyroscopes 1 through 3. Gyroscope 4 may have lower shielding.	I,A	Whelan, S0549, Proton Shielding Analysis: comply	Verified at PL level
3.2.1.12	Electromagnetic Shielding	The Science Payload shall provide EMI shielding within the probe vacuum shell with the following attenuation of electromagnetic fields from external sources: 80 dB from 10 kHz to 250 MHz; 80 dB at 250 MHz decreasing to 65 dB at 1 GHz; 40 dB from 1 GHz to 100 GHz	A,T	Verified with requirements 3.7.3.7.4.1.1 and 3.7.3.7.4.2 per final Probe C VRCD. (Window 4 covers the high frequency attenuation).	Verified at PL level
3.2.1.14.2	Long Term Drift	The roll position sensor boresight, relative to the QB position, shall drift in a "random walk" fashion less than ten arcseconds per year. The relative drift shall not correlate with any periodic behavior of the satellite.	A	This requirement is flowed down from T003 21.4 which is fully verified by SCSE-04, part 5, "Control System Error Budgets and Capability"	Verified at PL level

Table 3.1 – Verified Requirements

PLSE-12 #	Title	Requirement	Method	Compliance Data	Verification Status
3.2.1.14.3	Roll Period Stability	The roll position sensor mounting plane, relative to the QB position, shall not shift more than 0.5 arcsecond during a roll period. (Assuming 10 deg C dewar vacuum shell variation).	A	This requirement is flowed down from T003 21.4.2 which is fully verified by SCSE-04, part 5, "Control System Error Budgets and Capability"	Verified at PL level
3.2.2.1	Physical Interface	The Science Payload shall meet the physical interface requirements of the Spacecraft to Science Payload ICD, F277233.	I	D. Ross (PCB 473 will change this to inspection only)	Verified at PL level
3.2.2.5	Proton Monitor	The Science Payload shall provide a proton detector capable of monitoring the flux of protons in a minimum range from 30 35 MeV to 500 MeV. The proton detection shall be along two directions, 90 and 180 deg from the guide star direction, with a nominal cone angle of 45 deg.	I,A	Range of 35MeV to 500 MeV verified at lower level: Proton Monitor Acceptance Data Package D. Ross	Verified at PL level
3.2.2.5.1	Proton Monitor Power Consumption	All power for the Proton Monitor shall be drawn from the Spacecraft primary power bus (28 Vdc nominal)	I	Compliant by design	Verified at PL level
3.2.2.5.1.2	Load Shed Science Mission Operation	During periods of low power availability, the Proton Monitor may be turned off to save power. The Proton Monitor shall survive being turned off for up to one year.	I	Compliant by design (per Proton Monitor VRCM)	Verified at PL level
3.2.3	Reliability	The probability of the Science Payload operating as specified shall be optimized within the cost, schedule, weight, power and performance requirements and limitations of the Relativity Mission program. The reliability evaluation shall include the entire life cycle of the Science Payload and its components and spares in the analyses performed, as well as system safety, maintenance, human interaction, inspection, storage, transportation and test.	I	Allen, S0573: comply	Verified at PL level

Table 3.1 – Verified Requirements

PLSE-12 #	Title	Requirement	Method	Compliance Data	Verification Status
3.2.3.1	Mechanism Reliability	No single mechanism failure shall cause major system damage, resulting in loss of mission.	A	Allen, S0573: comply	Verified at PL level
3.2.3.2	Electrical Reliability	No single electrical failure shall cause major system damage, resulting in loss of mission.	A	Allen, S0573: comply	Verified at PL level
3.2.4.1	Repair, Replacement, and Calibration	The design shall allow for repair, replacement, or calibration of any item that is subject to wear-out or drift, has limited-life that may be exceeded prior to launch, or may reasonably be expected to fail during pre-integration operation, test, storage, or transportation (such as a fuse).	I	D. Ross - Compliant by design 11/08/01	Verified at PL level
3.2.4.2	Damage-Free Maintenance	Repair, replacement, or calibration of any serviceable item shall be performed without damage to neighboring or interacting hardware and with the introduction of a minimum amount of contaminants to the hardware.	I	D. Ross - Compliant by design 11/08/01 and supported by P0059 and P0157 Contamination Control	Verified at PL level
3.2.4.3	Testability	Subassemblies shall incorporate sufficient self-test or in-place testability through test connectors to isolate system malfunctions to a specific item.	I	D. Ross	Verified at PL level
3.2.5.6.5	Micrometeorite Environment	The Science Payload shall perform as specified while exposed to on-orbit radiation environment in accordance with Stanford document P0149, "Natural Orbital Environment Specification" section 1 titled “Meteoroid and debris strike resistance”.	A	EM SYS 316A shows that the SV will meet the expected on-orbit micrometeorite and orbital debris environment. The SV has adequate shielding and redundant systems.	Verified at PL level

Table 3.1 – Verified Requirements

PLSE-12 #	Title	Requirement	Method	Compliance Data	Verification Status
3.2.5.5.1	Launch Loads	The load factors for the primary structure are given below: All Except Sunshade (Lateral) ± 2.5g Sunshade (Lateral) ± 20.0g All (Axial) 6.2 ± 0.6 Secondary structures design load factors are given by the SSD secondary structure loads curve below, taken from EM 310A/P030739A. Secondary structures include all hardware not in the primary load path, such as plumbing, valves, electronics boxes, connectors, burst discs, etc.	A	Skinner, EM 304 & EM 349 verification complete,	Verified at PL level
3.2.5.6.3	Magnetic Environment	The Science Payload shall perform as specified while exposed to the earth's magnetic field peak magnitude of 5.0 x 10-5 tesla (0.5 gauss).	A, T	Gyro and SQUID procedures run during PL Ver II included P0522, P0516, P0159, and P0833. Analyses for performance include S0575 and S0579. Thermal performance verified by P0862, and correlated in S0600. Trapped Flux levels at the gyro documented by P0575 and S0564. Payload complies	Verified at PL level
3.2.5.6.4	Radiation Environment	The Science Payload shall perform as specified while exposed to on-orbit radiation environment in accordance with Stanford document P0149, "Natural Orbital Environment Specification" section 2.0 titled "Ionizing radiation".	A	R. Brumley, S0610 Rob B - HW (gyros + telescope, also J. Goebel)+SQUIDs	Verified at PL level
3.3.1.1	Material Requirements	The material selected for design shall be selected per GPB-100275 and the requirements in the following subsections.	I	Comply by design. SIA: this subassembly of the Payload has been designed and built in accordance with Stanford's Contamination Control (P0059) and Magnetics Control (P0057) plans which have more stringent controls than GPB-100275. Lower Level verification per Dewar AR, GPB-100155A, 26 Feb 97; Probe C AR, GPB-100269 v3, 15 May 98	Verified at PL level
3.3.1.1.1	Thermal Vacuum Stability	Materials in the payload hardware that are exposed to a thermal-vacuum environment shall be selected to minimize contamination of optical or functionally critical surfaces by deposition of volatilized materials.	I	Comply by design. SIA: this subassembly of the Payload has been designed and built in accordance with Stanford's Contamination Control (P0059) and Magnetics Control (P0057) plans. Lower Level verification per Dewar AR, GPB-100155A, 26 Feb 97; Probe C AR, GPB-100269 v3, 15 May 98	Verified at PL level

Table 3.1 – Verified Requirements

PLSE-12 #	Title	Requirement	Method	Compliance Data	Verification Status
3.3.1.1.1.1	Total Mass Loss	Materials shall have a total mass loss (TML) <=1.0 percent.	I	Comply by design. SIA: this subassembly of the Payload has been designed and built in accordance with Stanford's Contamination Control (P0059) and Magnetics Control (P0057) plans. Lower Level verification per Dewar AR, GPB-100155A, 26 Feb 97; Probe C AR, GPB-100269 v3, 15 May 98	Verified at PL level
3.3.1.1.1.2	Volatile Condensable Material	Materials shall have a volatile condensable material (VCM) content <= 0.1 percent.	I	Comply by design. SIA: this subassembly of the Payload has been designed and built in accordance with Stanford's Contamination Control (P0059) and Magnetics Control (P0057) plans. Lower Level verification per Dewar AR, GPB-100155A, 26 Feb 97; Probe C AR, GPB-100269 v3, 15 May 98	Verified at PL level
3.3.1.1.2	Materials Flammability	The use of combustible materials shall be minimized.	I	Comply by design. SIA: this subassembly of the Payload has been designed and built in accordance with Stanford's Contamination Control (P0059) and Magnetics Control (P0057) plans. Lower Level verification per Dewar AR, GPB-100155A, 26 Feb 97; Probe C AR, GPB-100269 v3, 15 May 98	Verified at PL level
3.3.1.1.3	Corrosion Control	The Science Payload shall use materials that are corrosion-resistant.	I	Comply by design. SIA: this subassembly of the Payload has been designed and built in accordance with Stanford's Contamination Control (P0059) and Magnetics Control (P0057) plans. Lower Level verification per Dewar AR, GPB-100155A, 26 Feb 97; Probe C AR, GPB-100269 v3, 15 May 98	Verified at PL level
3.3.1.1.5	Dissimilar Metals	Dissimilar metal combinations shall not be used unless protected against electrolytic corrosion. Metals are considered compatible if they are in the same grouping as specified in MIL-STD-889.	I	R. Brumely, S0609 to verify compliance in the Gyro caging system, even though it does not meet the MIL spec. D. Ross - Compliant by P0036 Approved and Restricted Materials (5/23/97) and P0057 GP-B Magentics Control Plan. SIA material selected for cleanliness and magnetics considerations for operation at ~2 K. Environment precludes susceptibility to electrolytic corrosion; therefore this requirement does not apply to the SIA. Lower level compliance per: Dewar AR, GPB-100155A, 26 Feb 97; Probe C AR, GPB-100269 v3, 15 May 98	Verified at PL level

Table 3.1 – Verified Requirements

PLSE-12 #	Title	Requirement	Method	Compliance Data	Verification Status
3.3.1.1.6	Electrical Bonding	Materials and finishing systems shall be consistent with requirements for electrical grounding in accordance with MIL-B-5087.	I	Comply by design. SIA: this subassembly of the Payload has been designed and built in accordance with Stanford's Contamination Control (P0059) and Magnetics Control (P0057) plans. Lower Level verification per Dewar AR, GPB-100155A, 26 Feb 97; Probe C AR, GPB-100269 v3, 15 May 98	Verified at PL level
3.3.1.1.7	Fungus Resistance	Materials that absorb or retain moisture to the extent performance characteristics are degraded or are nutrients for fungus shall be avoided in the design.	I	Comply by design. SIA: this subassembly of the Payload has been designed and built in accordance with Stanford's Contamination Control (P0059) and Magnetics Control (P0057) plans. Lower Level verification per Dewar AR, GPB-100155A, 26 Feb 97; Probe C AR, GPB-100269 v3, 15 May 98	Verified at PL level
3.3.1.1.8	Sensitive Materials	Materials with unlimited shelf and assembly life shall be used. Where limited shelf or assembly life materials are required, appropriate storage controls shall be specified in the applicable specification.	I	Comply by design. SIA: this subassembly of the Payload has been designed and built in accordance with Stanford's Contamination Control (P0059) and Magnetics Control (P0057) plans. Lower Level verification per Dewar AR, GPB-100155A, 26 Feb 97; Probe C AR, GPB-100269 v3, 15 May 98	Verified at PL level
3.3.1.1.9	Prohibited Materials	The following materials are prohibited: 1) Cadmium, zinc, or selenium except internal to hermetically sealed devices. 2) Pure, unalloyed tin (greater than 99.1% Sn). 3) Corrosive solder fluxes, except where approved by Quality Assurance. 4) Mercury and compounds of mercury, except internal to hermetically sealed devices. 5) Silicones which evolve a corrosive acetic acid.	I	Comply by design. SIA: this subassembly of the Payload has been designed and built in accordance with Stanford's Contamination Control (P0059) and Magnetics Control (P0057) plans. Lower Level verification per Dewar AR, GPB-100155A, 26 Feb 97; Probe C AR, GPB-100269 v3, 15 May 98	Verified at PL level
3.3.1.1.10	Material Strength Properties	The material properties used in the design and analysis of all structural and pressure system components are to be the values such that the vendor guarantees that 99% of material will have a 95% confidence level. Materials selection shall consider the effects of fabrication processing, cleaning materials and procedures, and the effect of dye penetrant & proof test fluids.	I	Comply by design. SIA: Not a pressure vessel or structure: This subassembly of the Payload has been designed and built in accordance with Stanford's Contamination Control (P0059) and Magnetics Control (P0057) plans. Lower Level verification per Dewar AR, GPB-100155A, 26 Feb 97; Probe C AR, GPB-100269 v3, 15 May 98	Verified at PL level

Table 3.1 – Verified Requirements

PLSE-12 #	Title	Requirement	Method	Compliance Data	Verification Status
3.3.1.1.11	Material Fracture Toughness	Fracture properties shall be considered in selection of all pressure vessel components, with the materials' fracture toughness to be as high as practical. Materials with a threshold stress intensity factor KTH of <= 60% of the critical stress intensity factor KIc for the expected service environment shall require a "worst case" fracture mechanics analysis.	I	Comply by design. SIA: Not a pressure vessel or structure: This subassembly of the Payload has been designed and built in accordance with Stanford's Contamination Control (P0059) and Magnetics Control (P0057) plans. Lower Level verification per Dewar AR, GPB-100155A, 26 Feb 97; Probe C AR, GPB-100269 v3, 15 May 98	Verified at PL level
3.3.1.1.12	Temperature Effect on Material Properties	Thermal effects which result in changes in the physical and mechanical properties of the materials of construction shall be considered in the design of all pressure vessels, and all other structures. These effects shall be based on temperature extremes which simulate those predicted for the operating environment plus a design margin. Materials shall be selected on the basis of proven environmental compatibility, material strengths, fracture properties, and service life consistent with the specific program thermal requirements.	I	Comply by design. SIA: Not a pressure vessel or structure: This subassembly of the Payload has been designed and built in accordance with Stanford's Contamination Control (P0059) and Magnetics Control (P0057) plans. Lower Level verification per Dewar AR, GPB-100155A, 26 Feb 97; Probe C AR, GPB-100269 v3, 15 May 98	Verified at PL level
3.3.1.1.13	Material Characterization	Mechanical properties, strength and fracture properties of all materials selected for pressure vessels shall be characterized in sufficient detail to permit reliable and high confidence predictions of their structural performance in the expected operating environments unless these properties are available from reliable sources such as MIL-HDBK-5, MIL-HDBK-17, ASTM Standards, Military Specifications, Aerospace Structural Metals Handbook, or other sources approved by the procuring agency.	I	Comply by design. SIA: Not a pressure vessel or structure: This subassembly of the Payload has been designed and built in accordance with Stanford's Contamination Control (P0059) and Magnetics Control (P0057) plans. Lower Level verification per Dewar AR, GPB-100155A, 26 Feb 97; Probe C AR, GPB-100269 v3, 15 May 98	Verified at PL level

Table 3.1 – Verified Requirements

PLSE-12 #	Title	Requirement	Method	Compliance Data	Verification Status
3.3.1.1.14	Magnetic Properties of Materials	Selection of materials for use in the Science Payload shall meet the requirements of P0057-A. An approved materials and process list is contained in GPB-100275. The standards for magnetic acceptability for materials to be used in the various zones are given in Table 2 of P0057-A.	I	Comply by design. SIA: this subassembly of the Payload has been designed and built in accordance with Stanford's Contamination Control (P0059) and Magnetics Control (P0057) plans. These plans that cover the SIA are more stringent than GPB-100275 since the entire SIA is in more tightly controlled magnetics and contamination zones. Lower Level verification per Dewar AR, GPB-100155A, 26 Feb 97; Probe C AR, GPB-100269 v3, 15 May 98	Verified at PL level
3.3.1.1.14.2	Remanent Magnetization	The remanent magnetization for finished parts according to zone shall meet the requirements of Table 4 of P0057-A.	I,A,T	Mester, S0543 P0575, Trapped Flux Measurement. Part screening defined by policy (Magnetics Control Procedure, P0057). Lower level compliance per: Dewar AR, GPB-100155A, 26 Feb 97; Probe C AR, GPB-100269 v3, 15 May 98	Verified at PL level
3.3.1.1.14.3	Payload Produced Magnetic Field	The instantaneous magnetic field produced by the payload shall not exceed 0.1 gauss at the location of the lead bag mouth at any time or under any operating conditions, excluding the shielding effects of the lead bag and the cryoperm shield.	A,T	Mester, S0543, Magnetics Requirements Verification P0575, Trapped Flux Measurement Lower level compliance per: Dewar AR, GPB-100155A, 26 Feb 97; Probe C AR, GPB-100269 v3, 15 May 98	Verified at PL level
3.3.1.1.15	External Surface Protective Coatings	External surfaces visible by the science telescope (i.e., window 4), shall be protected as required, such that they do not cause signal degradation at the detectors due to the impingement of atomic oxygen, as defined in Stanford document P0149.	A	Shestople, S0544, PLSE-12 Section 3.3.6 Verifications	Verified at PL level
3.3.1.2.1	Process Quality	Processes shall conform to recognized industry practices of sufficient proven quality to allow the part, assembly, or equipment on which it is applied to meet spacecraft system performance life cycle and all ground plus space environmental requirements.	I	Comply by design. SIA: this subassembly of the Payload has been designed and built in accordance with Stanford's Contamination Control (P0059) and Magnetics Control (P0057) plans and is a highly specialized instrument. Lower Level verification per Dewar AR, GPB-100155A, 26 Feb 97; Probe C AR, GPB-100269 v3, 15 May 98	Verified at PL level

Table 3.1 – Verified Requirements

PLSE-12 #	Title	Requirement	Method	Compliance Data	Verification Status
3.3.1.2.2	Process History	Processes shall have a satisfactory history in the production of parts, assemblies, or equipment of sufficient proven quality to meet the performance life cycle and environmental requirements.	I	Comply by design. SIA: this subassembly of the Payload has been designed and built in accordance with Stanford's Contamination Control (P0059) and Magnetics Control (P0057) plans. Lower Level verification per Dewar AR, GPB-100155A, 26 Feb 97; Probe C AR, GPB-100269 v3, 15 May 98	Verified at PL level
3.3.1.2.3	Space Qualification	Processes shall be developed to satisfy a specific set of performance and environmental criteria established for spacecraft application.	I	Comply by design. SIA: this subassembly of the Payload has been designed and built in accordance with Stanford's Contamination Control (P0059) and Magnetics Control (P0057) plans. Lower Level verification per Dewar AR, GPB-100155A, 26 Feb 97; Probe C AR, GPB-100269 v3, 15 May 98	Verified at PL level
3.3.1.2.4	Process Consistency	Processes shall have adequate controls and verification requirements to assure consistent results.	I	Comply by design. SIA: this subassembly of the Payload has been designed and built in accordance with Stanford's Contamination Control (P0059) and Magnetics Control (P0057) plans. Lower Level verification per Dewar AR, GPB-100155A, 26 Feb 97; Probe C AR, GPB-100269 v3, 15 May 98	Verified at PL level
3.3.1.2.5	Prohibited Processes	The following processes shall be prohibited for use: 1) Electrodeposited tin plating unless subsequently fused or reflowed. 2) Structural adhesive bonding unless materials evaluation and design verification testing has been conducted for hardware using adhesive bonded joints.	I	Comply by design. SIA: this subassembly of the Payload has been designed and built in accordance with Stanford's Contamination Control (P0059) and Magnetics Control (P0057) plans. All SIA, Probe, and Dewar adhesive bonds have been fully qualified and tested. Lower Level verification per Dewar AR, GPB-100155A, 26 Feb 97; Probe C AR, GPB-100269 v3, 15 May 98	Verified at PL level
3.3.1.2.6	Contamination Control	Contamination control of the Science Payload shall satisfy the requirements and approach delineated in the Science Payload Contamination Control Plans, LMMS 5835083 for Lockheed supplied probe and dewar hardware, and P0059 for Stanford supplied hardware.	I,T	Comply by design. SIA: this subassembly of the Payload has been designed and built in accordance with Stanford's Contamination Control (P0059) and Magnetics Control (P0057) plans. Lower Level verification per Dewar AR, GPB-100155A, 26 Feb 97; Probe C AR, GPB-100269 v3, 15 May 98	Verified at PL level

Table 3.1 – Verified Requirements

PLSE-12 #	Title	Requirement	Method	Compliance Data	Verification Status
3.3.1.2.6.2	Cleanliness Requirements	Components in each zone shall meet the cleanliness requirements stated in Lockheed document 583503 and Stanford document P0059.	I,T	Comply by design. SIA: this subassembly of the Payload has been designed and built in accordance with Stanford's Contamination Control (P0059) and Magnetics Control (P0057) plans. Lower Level verification per Dewar AR, GPB-100155A, 26 Feb 97; Probe C AR, GPB-100269 v3, 15 May 98	Verified at PL level
3.3.1.2.7	Electrostatic Discharge (ESD)	The payload shall comply with the Electrostatic Discharge Control procedures described in Section 1.17 of the LMMS Safety, Reliability, Maintainability and Product Assurance Plan (SRMPA), F428533E.	I	Comply by design. SIA: this subassembly of the Payload has been designed and built in accordance with Stanford's Contamination Control (P0059) and Magnetics Control (P0057) plans. ESD sources within the payload would produced magnetic fields; these were eliminated to meet higher level requirements which have been verified (low trapped flux, gyro levitation, etc). Lower Level verification per Dewar AR, GPB-100155A, 26 Feb 97; Probe C AR, GPB-100269 v3, 15 May 98	Verified at PL level
3.3.4	Workmanship	All hardware shall be built and maintained to workmanship standards suitable for a precision spacecraft component.	I,T	Comply by design. SIA: this subassembly of the Payload has been designed and built in accordance with Stanford's Contamination Control (P0059) and Magnetics Control (P0057) plans. Lower Level verification per Dewar AR, GPB-100155A, 26 Feb 97; Probe C AR, GPB-100269 v3, 15 May 98	Verified at PL level
3.3.5	Interchangeability	Within the Science Payload, items with identical part numbers (including rev nos) shall be interchangeable without modification. Such items shall have similar interface definition, within tolerance and state-of-the-art limitations, including form, fit, and function. Such interchange shall be possible without damage to neighboring or interfacing hardware and with a minimum of contamination introduced into the hardware.	I	Comply by design. SIA: this subassembly of the Payload has been designed and built in accordance with Stanford's Contamination Control (P0059) and Magnetics Control (P0057) plans. As a highly specialized instrument, the SIA requires very special handing during modification (i.e. during Gyro 4 replacement). Lower Level verification per Dewar AR, GPB-100155A, 26 Feb 97; Probe C AR, GPB-100269 v3, 15 May 98 This requirement does not apply to bonded items, which are permanently mated.	Verified at PL level
3.3.6.1.2	Failure Tolerance Design Criteria	The system must be designed to tolerate a number of credible failures and/or operator errors, determined by the degree of hazard involved in the operation. The required failure tolerance is given in table 3.3.6-1 (see OLE tab).	I	Harv Moskowitz, S0544, ref GPB-100269 v3, Probe-C VRCD, p. 7	Verified at PL level

Table 3.1 – Verified Requirements

PLSE-12 #	Title	Requirement	Method	Compliance Data	Verification Status
3.3.6.1.4	Hazard Control	Hazards that present unacceptable levels of risk will be eliminated or controlled using an order of precedence as follows: 1) Design for Minimum Risk Design to eliminate hazards. If an identified hazard can't be eliminated, attempt to control the unacceptable risks that it presents through design tradeoffs. 2) Safety Devices Hazards that cannot be eliminated or controlled through design selection should be controlled to an acceptable level through the use of fixed, automatic, or other safety design features or devices. Where possible, make provisions for periodic functional checks of safety devices. 3) Warning Devices When design selection or safety devices can't eliminate or effectively control identified hazards, warning devices should be incorporated in the design to detect hazardous conditions and generate warning signals to alert personnel to danger. 4) Procedures, and Training Where it is impractical to eliminate hazards through design selection or adequately reduce the associated risk with safety and warning devices, procedures and training shall be used. However, without a specific waiver, no warning, caution, or other form of written advisory shall be used as the only risk reduction method for Category I or II hazards (defined in section 1B.1.1.5.d of EWRR 127-1). Procedures may include the use of personal protective equipment. Tasks and activities judged critical require certification of personnel proficiency.	I	Shestople, S0544, PLSE-12 Section 3.3.6 Verifications	Verified at PL level
3.3.6.1.6.1	Design Yield Load Capability	All systems shall be capable of withstanding the design yield loads and pressures without experiencing detrimental deformation.	A	Shestople, S0544, PLSE-12 Section 3.3.6 Verifications and the following analyses: EM No. SMS 304 Evaluation of Coupled Loads Analysis Results, EM No. SMS 349 Evaluation of PreMECO &MECO Loads Analysis Results, EM No. SMS 355 Probe C Caging Lines Stress Analysis, EM No. SMS 288 Parametric of Probe C Thermal Gradients and Forces, EM No. SMS 339B Modification to the Axial Lock Restraint System (Belleville Preload System, BPS), EM No. SMS 396 GP-B Sunshade Stress Analysis Update and EM No. SMS 261 Probe C CNT Static Load Test Results; Probe C Redesign Stress Analysis, SMS 358A	Verified at PL level

Table 3.1 – Verified Requirements

PLSE-12 #	Title	Requirement	Method	Compliance Data	Verification Status
3.3.6.1.6.2	Design Ultimate Load Capability	All systems shall be capable of withstanding design ultimate loads and pressures without rupture or collapse. Pressurized structures subject to destabilizing external loads shall be designed for buckling using ultimate loads and pressures, except that any load or internal pressure that tends to alleviate buckling shall not be increased by any safety factor for this buckling calculation.	A	Shestople, S0544, PLSE-12 Section 3.3.6 Verifications	Verified at PL level
3.3.6.1.6.3.1	Pressure System Safety Factors	Pressure or vacuum systems shall be designed using the safety factors in Table 3.3.6-2a and 3.3.6-2b. (See OLE tab.)	A	Shestople, S0544, PLSE-12 Section 3.3.6 Verifications	Verified at PL level
3.3.6.1.6.3.2	Structural Safety Factors	The Science Payload will be protoflight hardware. As such, it must be designed with higher margins of safety than an item which has had a qualification unit tested to its ultimate strength limit. All structural components of the science payload shall be designed using the safety factors listed in table 3.3.6-3. (See OLE tab.)	A	Shestople, S0544, PLSE-12 Section 3.3.6 Verifications	Verified at PL level
3.3.6.1.6.4	Margin of Safety	All margins of safety shall be positive and shall be determined by analysis or test at design yield and design ultimate levels, when appropriate, at the temperatures expected for all critical conditions.	A	Shestople, S0544, PLSE-12 Section 3.3.6 Verifications	Verified at PL level

Table 3.1 – Verified Requirements

PLSE-12 #	Title	Requirement	Method	Compliance Data	Verification Status
3.3.6.2.1.1	Stresses in Pressure Vessels	The entire anticipated service life stress history shall be determined in accordance with specified mission requirements. As a minimum, the following factors and their statistical variations shall be considered: 1) Design loads and pressures. 2) Environmental stresses, which act simultaneously with design loads and pressures, such as thermal effects, including heating rates, temperatures, and thermal stresses. 3) The frequency of application of stresses mentioned in 1 and 2 and their levels and duration. These data shall be used to define the design spectra, which shall be used for design analysis, and testing. The design spectra shall be revised as the structural design develops and the stress analysis matures.	A	Shestople, S0544, PLSE-12 Section 3.3.6 Verifications	Verified at PL level
3.3.6.2.1.2.1	Internal Loads	Pressure vessels shall possess sufficient strength and stiffness to withstand limit loads and internal pressures in the expected operating environments throughout their respective service lives without experiencing detrimental deformation. Pressure vessels shall be capable of withstanding ultimate internal loads and internal pressures in the expected operating environments without collapse or rupture.	A	Shestople, S0544, PLSE-12 Section 3.3.6 Verifications	Verified at PL level
3.3.6.2.1.2.2	External Loads	Pressure vessels shall be capable of withstanding ultimate external loads and ultimate external pressures (destabilizing) without collapse or rupture when internally pressurized to the minimum anticipated operating pressure.	A	Shestople, S0544, PLSE-12 Section 3.3.6 Verifications	Verified at PL level

Table 3.1 – Verified Requirements

PLSE-12 #	Title	Requirement	Method	Compliance Data	Verification Status
3.3.6.2.1.2.3	Proof Pressure	Pressure vessels and plumbing shall sustain proof pressure without incurring gross yielding or detrimental deformation. When proof tests are conducted at temperatures other than design temperatures, the change in material properties at the proof temperature shall be accounted for in determining proof pressure.	T	Shestople, S0544, PLSE-12 Section 3.3.6 Verifications CNT and caging lines tested. Test results in Probe-C Acceptance Test Procedure, 1C34932 Vol. 1 of 3. SMD Acceptance Test Procedure, Critical Components Test, 5835036 Vol. 3.	Verified at PL level
3.3.6.2.1.3	Stiffness of Pressure Vessels	Pressure vessels shall possess adequate stiffness to prevent all detrimental instabilities of coupled vibration modes, minimize detrimental effects of the loads and dynamics response which are associated with structural flexibility, and minimize adverse interaction with other vehicle systems.	A	Shestople, S0544, PLSE-12 Section 3.3.6 Verifications	Verified at PL level
3.3.6.2.1.4	Manufacture and Refurbishment	The structural design for all pressure vessels shall employ proven processes and procedures for fabrication and repair to preclude damage or material degradation. The design shall emphasize the need for access, inspection, service, replacement, repair and refurbishment. For all reusable pressure vessels, the structural design shall permit these structures to be maintained in and refurbished to a flight worthy condition. Repaired and refurbished structures shall meet all stipulated conditions of flight worthiness.	I	Harv Moskowitz, S0544, ref S0378 Fracture Control Summary	Verified at PL level
3.3.6.2.1.4.1	Fracture Toughness	The fracture toughness, mechanical and physical properties of the parent materials, weldments and heat-affected zones shall be within established design limits after exposure to the intended fabrication processes.	A	Shestople, S0544, PLSE-12 Section 3.3.6 Verifications	Verified at PL level

Table 3.1 – Verified Requirements

PLSE-12 #	Title	Requirement	Method	Compliance Data	Verification Status
3.3.6.2.1.4.2	Fracture Control	Fracture control requirements and precautions shall be defined in applicable drawings and process specifications. Detailed fabrication instructions and controls shall be provided to insure proper implementation of the fracture control requirements. Special precautions shall be exercised throughout the manufacturing operations to guard against processing damage or other structural degradation. In addition, procurement requirements and controls shall be implemented to insure that suppliers and subcontractors employ fracture control procedures and precautions consistent with the fabrication and inspection processes intended for use during actual hardware fabrication.	A	Shestople, S0544, PLSE-12 Section 3.3.6 Verifications	Verified at PL level
3.3.6.2.2.1	Pressure Relief Capability	There shall be no tanks, components or sections of plumbing in any GSE or flight cryogenic system that can be isolated without pressure relief capability in any configuration of the system or valves. Sufficient pressure relief devices shall be incorporated to meet the failure tolerance requirements of section 3.3.6.1.2.	I	Harv Moskowitz, S0544 10/21/01	Verified at PL level
3.3.6.2.2.2	Relief Devices	The pressure relief systems shall be designed to handle a sudden loss of the vacuum in the dewar or probe with full main and guard tanks.	I	Harv Moskowitz, S0544 10/21/01	Verified at PL level

Table 3.1 – Verified Requirements

PLSE-12 #	Title	Requirement	Method	Compliance Data	Verification Status
3.3.6.2.2.2.1	Location	Rupture disks shall be located so that the debris fragments from the disks, if used, do not impinge upon or obstruct plumbing, lines, tanks, cables, or primary structure. Relief devices shall be located such that they do not ice up prior to or during activation sufficient to become ineffective. The external locations of the exhaust ports for the pressure relief system shall be as shown in drawing 5833115.	I	Harv Moskowitz, S0544 10/21/01	Verified at PL level
3.3.6.2.2.2.2	Relief Pressure Setting	Rupture disks shall burst, at the nominal working temperatures, at a pressure <= the maximum expected operating pressure (design limit load) of the applicable assembly. The lower limit shall be high enough so that normal operations of the associated pressure vessel are not impaired.	I	Harv Moskowitz, S0544 10/21/01	Verified at PL level
3.3.6.2.2.2.3	Plumbing Line Size	Pressure relief discharge lines shall be of sufficient size that they do not restrict the relieving capability of the safety device.	A	Shestople, S0544, PLSE-12 Section 3.3.6 Verifications	Verified at PL level
3.3.6.2.2.2.4	Redundancy	Redundant pressure relief devices shall have independent pressure escape routes.	I	Shestople, S0544, PLSE-12 Section 3.3.6 Verifications inspected by Harv Moskowitz, S0544 10/21/01	Verified at PL level
3.3.6.2.2.2.5	Cleanliness	Relief discharge lines shall be provided with protective devices to prevent the entrance of contaminants prior to and after activation of the pressure relief function.	I	Harv Moskowitz, S0544 10/21/01	Verified at PL level

Table 3.1 – Verified Requirements

PLSE-12 #	Title	Requirement	Method	Compliance Data	Verification Status
3.3.6.2.3	Pressure Monitoring	All pressurized systems shall be designed so that supply and operating pressures can be monitored by gauges or other suitable indicators (i.e. remote monitors at a control station). During prelaunch pressurization, pressure monitoring must be provided by means of a hard-line umbilical cable or telemetry.	I	Harv Moskowitz, S0544 10/21/01	Verified at PL level
3.3.6.2.3.2	Remote Monitors	The payload electronics shall provide monitor signals for each separate line or vessel that can be statically pressurized. These signals shall be available on externally accessible test connectors.	I	Harv Moskowitz, S0544 10/21/01	Verified at PL level
3.3.6.3.1	Redundant Systems	Elements of safety-critical redundant systems shall not pass through the same connector as the primary system elements.	I	Harv Moskowitz, S0544 10/21/01	Verified at PL level
3.3.6.3.2	Marking of Connectors	Connectors shall be keyed, clearly marked, or color coded to minimize the possibility of incorrectly connecting systems.	I,A	Shestople, S0544, PLSE-12 Section 3.3.6 Verifications	Verified at PL level
3.3.6.4	Electroexplosive Subsystem	Electroexplosive Subsystem (EES) shall be designed, tested and certified according to MIL-STD-1576. EES includes all components, from the power source through the electroexplosive device (EED). EES will be designed so the sensitive or initiating elements can be installed in the system just prior to electrical hookup and as late in the countdown as possible. Sufficient inhibits shall be incorporated to meet the failure tolerance requirements and shall comply with sections 3.13.3 through 3.13.3.4 of EWRR 127-1.	I,T,S	Harv Moskowitz, S0544 10/21/01 Certified according to MIL-STD-1576. Pyrovalve #1 acceptance tests in 5835036 Vol. 3.	Verified at PL level
3.3.6.4.1	Prohibited Pyrotechnic Device	Exploding Bridgewire system initiators shall not be used.	I	Harv Moskowitz, S0544 10/21/01	Verified at PL level

Table 3.1 – Verified Requirements

PLSE-12 #	Title	Requirement	Method	Compliance Data	Verification Status
3.3.6.5	Mechanical/Electromechanical Devices	Mechanical or electromechanical devices used for structure deployment or actuating release mechanisms shall be evaluated to establish if damage to equipment or injury to personnel could occur in the event of inadvertent initiation. Sufficient inhibits shall be incorporated to meet the failure tolerance requirements.	I,A	Shestople, S0544, PLSE-12 Section 3.3.6 Verifications	Verified at PL level
3.3.6.6	Software and User-System Interface	Software shall comply with the requirements of section 3.16 of EWRR 127-1.	I	Harv Moskowitz, S0544 10/21/01 Requirement is not applicable to Probe, Dewar, or SIA.	Verified at PL level
3.3.6.8.1	Hazardous Operations	The system safety engineer shall identify all hazardous operations (e.g. operations involving liquid cryogens) which will require formally documented operating procedures. Hazardous operating procedures shall comply with section 6.2.2.3 of EWRR 127-1.	A	Shestople, S0544, PLSE-12 Section 3.3.6 Verifications	Verified at PL level
3.3.6.8.2	Computer Controlled Operations	All sequences, processes, and functions, which operate under computer control, shall be designed in such a manner that a critical failure mode or error condition will result in the system reverting to a known and safe state.	I	Shestople, S0544, PLSE-12 Section 3.3.6 Verifications	Verified at PL level
3.3.7	Human Engineering	The design of the Science Payload shall allow for necessary personnel operation, inspection and maintenance of the hardware with a minimum of risk of injury to personnel or damage/contamination of the flight hardware. Written procedures shall be developed to minimize the risk to personnel or hardware during all operations. Tethers shall be used when there is a potential for injury or program critical hardware damage due to a dropped tool or GSE.	I	Comply. Dewar AR, GPB-100155A, 26 Feb 97; Probe C AR, GPB-100269 v3, 15 May 98	Verified at PL level

Table 3.1 – Verified Requirements

PLSE-12 #	Title	Requirement	Method	Compliance Data	Verification Status
3.7.1.3.1.1.2	SIA Subassembly Temperature Requirements	The SIA thermal design shall meet the subassembly temperature requirements of Section 3.2.1.4.	A,T	Muhlfelder, S0583, QBS Thermal Stability P0862 Dewar Lifetime and Thermal Data Acquisition run in PL Phase D3. See PLSE-12 3.2.1.4 for further details.	Verified at PL level
3.7.1.3.2.2	Attenuation Factor	The SIA shall provide an attenuation consistent with the requirement of 3.2.1.3.2.	A,T	Mester, S0543 (verified when 3.2.1.3.2 is verified along with compliance to T003 1.5) P0860 AC Shielding Test was run in PL Phase: D2	Verified at PL level
3.7.1.3.2.3	Magnetic Noise from Conducting Loops	No metallic loop circuits having an enclosed area greater than or equal to 10 cm^2 shall be permitted in Magnetic Zones 1 or 2. Exceptions to this requirement are allowed if reviewed and approved by the Magnetics Committee.	A	Whelan, S0599	Verified at PL level
3.7.1.3.3.2	Vacuum After Spin Up and Bakeout	After spin up and low-temperature bakeout, the SIA shall be compatible with the vacuum required in Section 3.2.1.2.2.	T	Logan, S0594 discusses the achievements made in reaching ultra high vacuum levels after spin up and bakeout. Pressure after Bakeout = 1.9e-10 torr. P0872, Low Temp Bakeout Pressure Verification, run in PL Phase D3...	Verified at PL level
3.7.1.4.8.2	Spin-Up Exhaust Line Gas Conduction	The pressure drop along the spin-up exhaust plumbing line assembly from its interface with the gyroscope to its interface with the probe shall be <= 40 Pa assuming the pressure of 60 Pa at the SIA/probe interface (Section 3.7.2.3.6), the flow rate given in Section 3.2.1.7.1 of He-4 or He-3, and a temperature of <= 7 K.	A	Muhlfelder, S0545, Verification of Spin Up Gas Flow and Vacuum Requirements	Verified at PL level
3.7.1.6.2.1.4	Linear Range	The linear range and linearity shall meet the requirements of paragraph 7.2.3 in T003.	A	S0686 "Verification of Telescope Readout Linearity Requirements" The requirement from T003 #7.2.3 (from T002 #7.0) is 0.100 marcsec/yr. and the error in GR drift coefficients due to the nonlinearity of the Telescope System is 0.081 marcsec/yr. based on a greater than 99% confidence parameter.	Verified at PL level

Table 3.1 – Verified Requirements

PLSE-12 #	Title	Requirement	Method	Compliance Data	Verification Status
3.7.1.7.2.1.2	Noise at 130 Hertz	The SQUID sensor noise shall have a magnitude less than 60 marcsec/Hz^0.5 at 130 Hz, where the flux to angle scale factor assumes a rotating trapped dipole flux level equal to the London dipole moment at 130 Hz (this trapped flux level is an assumption only, and does not occur in fact).	T	Muhlfelder, S0575: shows conversion of 60 marcsec/Hz^0.5 at 130 Hz to 15.0 micro phi 0 / rt Hz; P0833 SQUID Noise Measurement was run in PL Phase B, with SRE (runs 1, 2, 3, and 14). Measured SQUIDS 1-4 at 10,4.6, 10, 3.3 micro phi 0 / rt Hz. Lower level Compliance per SQUID Pkg. VRCMs; May 14, 1998.	Verified at PL level
3.7.1.7.2.1.3.1	Harmonic Distortion	The harmonic distortion of the SQUID operating with flux-locked-loop electronics having a disturbance rejection of 100-200 for a 1 kHz signal with an amplitude of 2 flux quanta shall be less than 10^-4.	T	P0833 SRE Usage in PL Test II was run in PL Phase B. Run # 5 has the pertinent data: SQUID 1, per Table 12.6.3 (16.0, -71.6, -69.3, -76.3, -71.2) gives a minimum harmonic distortion of 16.0 - (-69.3) = 85.3 dB <note that less than 10^-4 = greater than 80 dB>; SQUID 2, Table 13.6.3 (16.1, -69.8, -68.8, -73.0, -70.4) gives a minimum harmonic distortion of 16.1 - (-68.8) = 84.9 dB; SQUID 3, Table 14.6.3 (16.0, -79.1, -67.5, -75.8, -70.8) gives a minimum harmonic distortion of 16.0 - (-67.5) = 83.5 dB; SQUID 4, Table 15.6.3 (16.1, -69.7, -68.7, -72.0, -70.9) gives a minimum harmonic distortion of 16.1 - (-68.7) = 84.8 dB; Lower level verification per SQUID Pkg. VRCMs; May 14, 1998.	Verified at PL level
3.7.1.7.2.1.4.2	SQUID Bias Temperature Coefficient	The SQUID shall have a bias temperature coefficient of less than 0.01 flux quanta/K over the temperature range 2.7 K - 3K	T	Muhlfelder, S0575 P0833 SQUID Bias Temperature Coefficient Procedure was run in PL Phase B, with SRE. Lower level verification per SQUID Pkg. VRCMs; May 14, 1998.	Verified at PL level
3.7.1.7.2.1.7	Damping of Cable to Package Joint	The decay time of the SQUID Package Input circuit and Cable to package joint shall be less than 1% in 10 min.	T	Muhlfelder, S0575 contains additional verification information. P0510 SQUID Functional and Pickup Loop Verification was run in PL Phase A, section L3, pages 9-11, dated 10/30/00. P0510, SQUID Functional and Pickup Loop Test was run in PL Phase: Post Acoustic Confidence. Pdoc Completed 3/22/01 comparison of Minute 0 and Minute 10 FLL output for all 4 gyros gives a changes of <.02 % Lower Level Compliance per: SQUID Pkg. VRCMs; May 14, 1998	Verified at PL level

Table 3.1 – Verified Requirements

PLSE-12 #	Title	Requirement	Method	Compliance Data	Verification Status
3.7.1.7.2.1.12	SQUID Bias Current	The SQUID sensor shall have a bias current between 20 microampere and 60 microampere.	T	P0510, SQUID Functional and Pickup Loop Test run in Phase A and Post Acoustic Confidence Test Phase. AS-RUN procedure section L3, pages 9-11, dated 10/30/00. Results: 24.1, 27.0, 22.7, 25.8 microampere. P0510, SQUID Functional and Pickup Loop Test was run in PL Phase Post Acoustic Confidence. Pdoc Completed 3/22/01. Results: 27.7, 32.4, 26.2, 27.3 microampere. Addition verification provided by P0833 Run #1, May 25, 2001 with values 26.2, 34, 25, 30.2 micro amperes for SQUIDs 1-4 respectively. Lower Level Compliance per: SQUID Pkg. VRCMs; May 14, 1998	Verified at PL level
3.7.1.7.2.1.14	Input Filter Capacitance	The capacitance from each contact block to ground shall be between 8 nF and 13 nF.	T	P0161 SQUID Capacitor Kit Assembly Lower Level Compliance per: SQUID Kit VRCM; Sept. 10, 1998 Capacitor Kit SM2 replaced with SM4 as part of Gyro 4 replacement. Delta VRCM dated 10-16-2001	Verified at PL level
3.7.1.7.2.1.17	Flux Slipping	It shall be possible to slip a flux quantum in the SQUID loop with a measurement error of less than 1 part in 10^5.	T	P0833 SRE Usage in Payload Test II was run in PL Phase B, with SRE (run #13) Lower Level Compliance per: SQUID Pkg. VRCMs; May 14, 1998	Verified at PL level
3.7.1.9.3	Platform Temperature Variation at Roll Frequency	The DMA platform temperature variation shall be less than or equal to 50 mK (as defined in T003, 7.6.2)	A,T	Farley, S0558 P0822 TRE Software Checkout was run in PL Phase B.	Verified at PL level
3.7.2.1.7	Telescope Detector Access Ports	The probe QBS shall provide detector access ports, and approximately 6.5 mm (1/4 in) wide slots between these access ports and the corresponding connector ports, as shown in drawings 1C34135, 1C34375, and ICD 1C34103. Access shall be provided (and telescope detector mount made) such that access to and removal of the detector dual mounting block is facilitated.	I	R. Pressburg and Ken Bower verified drawings on 11/12/01	Verified at PL level
3.7.2.2.2	SQUID Cable Interface	The probe connectors for the SQUID cables shall be fixed in orientation and keyed. The key slots shall be oriented radially outward with respect to the probe z* axis.	I	R. Pressburg verified compliant by design, and B. Muhlfelder verified the SQUID cable interface was built to radially outward. 11/12/01	Verified at PL level

Table 3.1 – Verified Requirements

PLSE-12 #	Title	Requirement	Method	Compliance Data	Verification Status
3.7.2.2.3	Grounding Interface	The ground interface between the probe and SIA shall be as described in the following subsections and as shown in LMMS drawing 1C34571.	I	R. Pressburg verified compliant to the drawings, and B. Clarke verified built to design. 11/12/01	Verified at PL level
3.7.2.2.3.6.2	Isolation Resistance	Components which are required to be electrically isolated shall have a resistance >= 1 Mohms.	T	The required components are the 1) Suspension Lines, 2) Squid Readout Lines, 3) TRE lines, 4) Instrumentation (Heaters/Temperature Sensors. 1) Suspension Lines - P0434-AB at greater than 20 MOhm, section 8, Table B (DR 279) 2)Squid Readout Lines - P0511 at greater than 20 MOhm 3) TRE Lines - P0411A-AB at greater than 10 MOhm sec 6.2 & 6.3 (R48997) 4) Instrumentation P0513/P0683 at greater than 20 MOhm	Verified at PL level
3.7.2.2.3.7.2	Grounding of the Sunshade	The sunshade shall be grounded to the Cross Flange to provide EMI shielding, for frequencies up into the GHz range. See section 3.7.3.7.4.1 for EMI filtration requirement.	T	OP Order INT-209 "Sunshade Installation and Preliminary Alignment" mounted the sunshade to the cross flange in accordance with DWG 1C34115. The electrical bond in step 195 was verified to be less than 2.5 milliohms.	Verified at PL level
3.7.2.3.1	Number of Spin-Up Circuits	There shall be 4 separate circuits for the spin-up of the science gyroscopes.	I	D. Ross - Compliant by design 11/08/01	Verified at PL level
3.7.2.3.2	Location of Interface Connection	The physical location of the spin-up interface shall be as described on LMMS drawing 1C34103.	I	R. Pressburg verified compliant to the drawings, and B. Clarke verified built to design. 11/12/01	Verified at PL level
3.7.2.3.3	Gas Flow Rate	The flow rate of the spin-up gas at the interface shall be as per 3.2.1.7.1.	A,S,T	Muhlfelder, S0545, Verification of Spin Up Gas Flow and Vacuum Requirements P0519 Gyro Flow and Thermal Testing P0522 Gyro Fast spin Speed Testing Procedure	Verified at PL level
3.7.2.3.4	Gas Pressure	The helium gas flow impedance of the probe and SIA shall be such that the spinup inlet gas pressure at the top hat interface shall not exceed 4.0 x 10^4 Pa (300 torr) for the spin-up gas flow rate specified in 3.2.1.7.1.	T	P0519 Gyro Flow and Thermal Testing was run in PL Phase: C Gyro 3: 45.96 torr; Gyro 4: 45.66 torr P0519 Gyro Flow and Thermal Testing was run in PL Phase: D Gyro 1: 49.11 torr; Gyro 2: 48.88 torr	Verified at PL level

Table 3.1 – Verified Requirements

PLSE-12 #	Title	Requirement	Method	Compliance Data	Verification Status
3.7.2.3.5	Gas Temperature	The temperature at temperature sensor of the spin-up gas filter assembly at the inlet interface shall be adjustable over the range of 4- 12 K and stable to +/- 0.25 K.	T	P0519 Gyro Flow and Thermal Testing was run in PL Phase: D2, with ECU This requirement only needs to be verified twice, once for the Gyro 1 & 2 set and once for the gyro 3 & 4 set, but was verified for each P0519 gyro test: Gyro 1: max capability = 205 K (12.9 K achieved) Gyro 2: max capability = 260 K (12.4 K achieved) P0519 Gyro Flow and Thermal Testing was run in PL Phase: C Gyro 3: capability = 4-145 K (8.9 K achieved) Gyro 4: capability = 4-160 K (8.0 K achieved)	Verified at PL level
3.7.2.3.7	Gas Leakage Into the Probe	The rate of spin-up gas leakage from the gyroscope into the probe interior shall be as per 3.2.1.2.1.	T	P0519 Gyro Flow and Thermal Testing was run in PL Phase C [dated 4/12/01] Gyro 3: page 14: 7.2 sccm vs. 37 sccm required (for He4) Gyro 4: page 14: 12.9 sccm vs. 37 sccm required (for He4) P0519 Gyro Flow and Thermal Testing was run in PL Phase D [dated 8/06/01] Gyro 1: page 15: 6.79 sccm (1%) vs. 37 sccm required (for He4) Gyro 2: page 15: 18.83 sccm (2.5%) vs. 37 sccm required (for He4)	Verified at PL level
3.7.2.3.8	Pressure at the SIA During Spin-up	The pressure within the probe at the SIA shall be as per 3.2.1.2.1 for a gas leakage rate as per 3.2.1.2.1.	T	Brumley P0519 Gyro Flow and Thermal Testing was run in PL Phase: C [section B, page 4, dated 4/12/01] Gyro 3: 2.7 x 10^-4 torr Gyro 4: 2.17 x 10^-4 torr P0519 Gyro Flow and Thermal Testing was run in PL Phase D [dated 8/06/01] Gyro 1: 1.03 x 10^-4 torr Gyro 2: 1.85 x 10^-4 torr	Verified at PL level

Table 3.1 – Verified Requirements

PLSE-12 #	Title	Requirement	Method	Compliance Data	Verification Status
3.7.2.3.9	Cleanliness of the Gas	The spin-up gas inlet line shall incorporate a final filter with an absolute rating of 0.5 micrometers. The inlet lines after the filters and the exhaust lines shall be clean per cleanliness zone II standards as described in 3.3.1.2.6.	T	(1) The 0.5 micrometer filter rating is compliant by design. The spin-up filter was built to drawing (1C34201) that calls out the porosity of 0.5 micron. (2) The test verification of the exhaust line cleanliness standard is provided in Probe C ADP (GPB-100269 V4) verification of Probe Specification requirement 3.7.3.10.1.2. The spinup lines were cleaned by LMMS Op Order PRC0738. The Probe Team verified the as-built hardware conformed to the as-designed drawings and for compliance to cleanliness requirements per GP-B General Procedure for Contamination Control and Precision Cleaning 4835033.	Verified at PL level
3.7.2.4.2	Location of Interface Connection	The physical location of the caging interface shall be as described on LMMS drawing 1C34103.	I	R. Pressburg verified compliant to the drawings, and B. Clarke verified built to design. 11/12/01	Verified at PL level
3.7.2.5.1.1	Support Flange Temperature	The temperature of the Quartz Block Support (QBS) fingers shall meet the requirement specified in 12.8 of T003.	A,T	Muhlfelder, S0583, QBS Thermal Stability T003 part b of 12.8 (ref. PLSE-12 3.7.2.5.1.3 verification) is discussed in S0575 P0862 "Dewar Lifetime and Thermal Data Acquisition," run in PL Phase D3.	Verified at PL level
3.7.2.5.1.2	Support Flange Temperature Stability	The temperature stability of the QBS fingers shall meet the requirement specified in 12.8 of T003	A,T	Muhlfelder, S0583, Thermal Verification P0862 "Dewar Lifetime and Thermal Data Acquisition" , run in PL Phase D3.	Verified at PL level
3.7.2.5.1.3	SQUID Attachment Point Temperature	The temperature of each SQUID platform's attachment points shall meet the requirements specified in 12.8 of T003.	A, T	Muhlfelder, S0575: Bracket temperatures = 2.77K P0833 SQUID Readout Electronics (SRE) Usage in Payload Test II, Run #10	Verified at PL level
3.7.2.5.2.1	SQUID Temperature	The temperature of the SQUID packages shall be <= 3.3 K.	T	Muhlfelder, S0575 provides additional verification information. P0833 SQUID Bracket ID Procedure was run in PL Phase B. Run #15 has the pertinent data: 2.7 K for each of 4 SQUID brackets.	Verified at PL level
3.7.2.5.3	Support Flange Thermal Resistance	The thermal resistance of the SIA/support flange during "normal operation" shall be such that the temperature of the QB flange does not exceed that of the QBS fingers by more than 50 mK.	A	Muhlfelder, S0546, Thermal Verification P0862 Dewar Lifetime and Thermal Data Acquisition, run in PL Phase D3. Test result is 41 mK (actual QBS temp = 2.798 K at T017Q, corrected). PCB 457 changed this to analysis only.	Verified at PL level

Table 3.1 – Verified Requirements

PLSE-12 #	Title	Requirement	Method	Compliance Data	Verification Status
3.7.2.5.6	Radiation Heat Input to the SIA	The radiation heat load into the SIA during normal operation shall be <= 0.25 mW.	A,T	Muhlfelder, S0600, (LM EM TCS 342A, K. Burns) P0544 ECU Test Support Procedure, run in PL Phase D3.	Verified at PL level
3.7.2.5.7.1	Heat Power to QBS in SQUID Bracket Assembly	The maximum heat power into the QBS shall not exceed the values given in the following while Science Data is being collected. Item: #of Items Power(mW)/item Power(mW) SQUID Bracket Assy 2 0.250 0.500	T	Muhlfelder, S0575 provides additional verification information. P0833 SQUID Bracket ID Procedure was run in PL Phase B. Run #2 provides the data that shows the maximum on-orbit heat power in the QBS from the SQUID brackets to be < 0.01 mW total.	Verified at PL level
3.7.2.5.7.2	Heat Power to QBS in QB GRTs (lot)	The maximum heat power into the QBS shall not exceed the values given in the following while Science Data is being collected. Item: #of Items Power(mW)/item Power(mW) QB GRTs (lot) 1 0.001 0.001	A	Turneaure, S0516, released 06/11/2001 Heat power = 0.0002 mW	Verified at PL level
3.7.2.5.7.3	Heat Power to QBS in SDs (lot) not used	The maximum heat power into the QBS shall not exceed the values given in the following while Science Data is being collected. Item: #of Items Power(mW)/item Power(mW) SDs(lot) not used 1 0.000 0.000	A	Turneaure, S0516, released 06/11/2001 Heat power = 0 mW	Verified at PL level
3.7.2.5.7.4	Heat Power to QBS in Thermal Radiation on QB	The maximum heat power into the QBS shall not exceed the values given in the following while Science Data is being collected. Item: #of Items Power(mW)/item Power(mW) Thermal Radiation on QB 1 0.250 0.250	A, T	Muhlfelder, S0600, (LM TCS 342A, K. Burns) P0544 ECU Test Support Procedure, run in PL Phase D3. Note that this is the same as 3.7.2.5.6	Verified at PL level

Table 3.1 – Verified Requirements

PLSE-12 #	Title	Requirement	Method	Compliance Data	Verification Status
3.7.2.5.7.5	Heat Power to QBS in Gyroscope Assemblies	The maximum heat power into the QBS shall not exceed the values given in the following while Science Data is being collected. Item: #of Items Power(mW)/item Power(mW) Gyroscope Assemblies 4 0.001 0.004	A	Turneaure, S0520, John Turneaure, July 2001 Heat power = 1x10^-7 mW (total)	Verified at PL level
3.7.2.5.7.6	Heat Power to QBS in Telescope DPA (2 each DMAs)	The maximum heat power into the QBS shall not exceed the values given in the following while Science Data is being collected. Item: #of Items Power(mW)/item Power(mW) Telescope DPA (2 ea. DMAs) 2 3.000 6.000	T	P0822 TRE Software Checkout was run in PL Phase B. Reference S0558 for additional verification information. Total Heat Power = 5.2 mW	Verified at PL level
3.7.2.5.7.7	Heat Power to QBS in QBS Heater	The maximum heat power into the QBS shall not exceed the values given in the following while Science Data is being collected. Item: #of Items Power(mW)/item Power(mW) QBS Heater 1 2.000 2.000	T	P0544 ECU Test Support Procedure, run in PL Phase D3. Test data contained in ECU_P0544_voltage2.xls (see S0583 for details). A 3mW power in ground test corresponds to 0.2mW on-orbit: comply.	Verified at PL level
3.7.2.5.8	Low Temperature Bake-Out of the SIA	During the special operation of low temperature bake-out, it shall be possible to raise the temperature of a sufficiently large (90%) area of the SIA to >= 6 K, by heating the QBS, without raising the temperature of any part of the lead bag above the temperature specified in 3.7.5.5.7.	A,T	Muhlfelder, S0546, Thermal Verification Taber, Meriwether P0547, Low temp ultra high vacuum bakeout. [Book 16] Cryopump temperature reached 6.1K. Area of cryopump per LM/EM 226 (F428543) >> 90% of interior surface area.	Verified at PL level
3.7.2.5.9	Flux Flushing of the SIA	During the special operation of flux-flushing, it shall be possible to raise the temperature of the SIA (exclusive of the telescope) to >= 12K in <= 12 hours, by heating the QBS, without raising the temperature of any part of the lead bag above the temperature specified in 3.7.5.5.7.	A,T	Muhlfelder, S0546 P0862 "Dewar Lifetime and Thermal Data Acquisition" , run in PL Phase D3. QBS temperature raised to 12.5 - 14K in 2 hours.	Verified at PL level

Table 3.1 – Verified Requirements

PLSE-12 #	Title	Requirement	Method	Compliance Data	Verification Status
3.7.2.6.1	DC Magnetic Field	The steady state magnetic field shall be as specified in 3.2.1.3.1.	A,T	Whelan, S0564 verifies trapped flux levels. P0575 Trapped Flux Measurement Procedure. Steady state field below mouth of lead bag verified in Engineering Memorandum (EM) from E. Lufer on cryoperm performance: LM/5834101 and 5835036 (from SMD ADP). RT measured field was 0.0574 G at the wall, 0.1367 G at the centerline; cryoperm reduces fields by factor of 1.5 at 4K, therefore field is 0.038 G at wall, 0.091 G at centerline.	Verified at PL level
3.7.2.7	UV Fiber-Optic Cable Interface	The UV fiber-optic cable interface shall be per LMMS drawing 1C34103.	I	R. Pressburg verified compliant to the drawings, and B. Clarke verified built to design. 11/12/01	Verified at PL level
3.7.3.2.5	Cryogenic Integration Capability	The probe shall be designed to be inserted and removed from the dewar while the dewar is at or above 4.2 K and the dewar well is filled with liquid helium at a pressure of >= 101 kPa (14.7 psia). It is not necessary to precool the probe prior to integration.	T	P0135, Probe Insertion (8/11/99), P0136, Probe removal (12/17/99), P0135, Probe Insertion (10/18/00).	Verified at PL level
3.7.3.2.7	Sunshade	The sunshade shall be a fixed length design with a sun-avoidance angle as close as possible to 18 deg within the space restrictions defined by the booster fairing and the mounting interface shown in 5833115.	I	R. Pressburg, B. Clarke, and A. Logan verified angle to be 16.46 degrees with the released document 5833115 on 11/12/01. Use Probe Sunshade and Boeing Launch Docs Need Ted Gill to provide Drawing demonstrating Sun Avoidance angle; need Jeff VB to show that sunshade fits in booster fairing.	Verified at PL level
3.7.3.4.1	Heat Radiated Down the Neck	The probe shall be designed to meet the thermal interface requirement of 3.7.2.5.6.	A,T	Muhlfelder, S0600, (LM TCS 342A, K. Burns) P0544 ECU Test Support Procedure, run in PL Phase D3. Note that this is the same as 3.7.2.5.6	Verified at PL level
3.7.3.4.3	SIA Temperature Elevation	The probe shall be designed to allow SIA temperature elevation per the thermal interface requirements of 3.7.2.5.8 and 3.7.2.5.9.	A,T	Muhlfelder, S0546, Thermal Verification P0582 SIA Flux Flush was run in PL Phase: A P0547, Low temp ultra high vacuum bakeout. Functional test at PL level is the test: comply. Analysis was complete at Probe C VRCD (GPB-100269 v3, 15 May 98).	Verified at PL level
3.7.3.4.5	Low Temperature Bakeout	The probe shall meet the requirements of the following subsections while maintaining the lead bag temperature requirement of 3.7.5.5.7 and the lifetime requirement of 3.2.1.10.	A,T	Muhlfelder, S0546, Verification of Payload Thermal Requirements & Logan, S0594, SIA Vacuum Pressure After Bake-Out P0546/P0872 Low temp ultra high vacuum bakeout, run in PL Phase D3. Analysis was complete at Probe C VRCD (Probe C AR, GPB-100269 v3, 15 May 98).	Verified at PL level

Table 3.1 – Verified Requirements

PLSE-12 #	Title	Requirement	Method	Compliance Data	Verification Status
3.7.3.4.5.1	Warm Surface Area	The probe shall provide the capability to warm >= 90 percent of the probe internal surface area which operates at a nominal temperature < 6 K to a temperature >= 6 K.	A,T	Muhlfelder, S0546, Thermal Verification P0547, Low temp ultra high vacuum bakeout. [Book 16] Cryopump temperature reached 6.1K; nominally runs at a temperature << 6 K: comply. Area of cryopump per LM/EM 226 (F428543) >> 90% of interior surface area.	Verified at PL level
3.7.3.4.5.1.1	Cryopump	The probe shall provide a bakeable cryopump at a location close to Station 200, with an effective surface area >= 30 m^2, and a bakeable temperature >= 6 K for a duration of 4-12 hrs.	A,T	Muhlfelder, S0546, Thermal Verification P0547, Low temp ultra high vacuum bakeout. [Book 16] Cryopump temperature reached 6.1K, maintained > 4 hours: comply Area of cryopump per LM/EM 226 (F428543) >> 90% of interior surface area.	Verified at PL level
3.7.3.4.5.2	Spin-up Inlet Line Filter Heating	The probe shall provide heaters with the capability to warm the spinup inlet filter to >= 10 K.	T	P0519 Gyro Flow and Thermal Testing was run in PL Phase: D2, with ECU This requirement only needs to be verified twice, once for the Gyro 1 & 2 set and once for the gyro 3 & 4 set, but was verified for each P0519 gyro test: Gyro 1: max capability = 205 K (12.9 K achieved) Gyro 2: max capability = 260 K (12.4 K achieved) P0519 Gyro Flow and Thermal Testing was run in PL Phase: C Gyro 3: capability = 4-145 K (8.9 K achieved) Gyro 4: capability = 4-160 K (8.0 K achieved)	Verified at PL level
3.7.3.4.5.3	Spin-up Exhaust Lines	The probe shall provide heaters with the capability to warm the spin-up exhaust lines to >= 6 K to within 15 cm (6 inches) of STA 200.	A,T	Muhlfelder, S0546, Thermal Verification P0544 ECU Test Support Procedure, run in PL Phase D3. Achieved 6.9 K: comply.	Verified at PL level
3.7.3.4.5.4	Pressure Sense Line Heating	The probe shall provide heaters with the capability to warm the entire length of the pressure sense line to >= 6 K during helium partial pressure measurements.	A,T	Muhlfelder, S0546, Thermal Verification P0547 Low temp ultra high vacuum bakeout, run in PL Phase D3. Achieved 7.1K: comply.	Verified at PL level

Table 3.1 – Verified Requirements

PLSE-12 #	Title	Requirement	Method	Compliance Data	Verification Status
3.7.3.4.7	Lead Bag Temperature	The probe shall be able to meet all of the requirements of 3.7.3 while maintaining the lead bag temperature below the requirement of 3.7.5.5.7.	A,T	Whelan, S0571 verifies temperatures during transport to, from, and during acoustic test of Feb 2001. Analysis covers events that occurred after the post-repair flux flush operations that heated the quartz block. The ability to achieve acceptable trapped flux levels after those flux flush operations is verification that the integrity of the lead bag has not been, nor will it be, compromised. P0575, Trapped Flux Measurement was run in PL Phase B. Capability to achieve trapped flux levels is evidence that this requirement (a design guideline for lower level components) has been met.	Verified at PL level
3.7.3.4.8	Window Bakeout	The probe shall provide the capability of raising the temperature of the windows, through attached heaters, to the following temperatures within 8 hrs/window: 1) Window 1 (coldest) >= 60 K; 2) Window 2 >= 95 K; 3) Window 3 >= 220 K; 4) Window 4 (warmest) >= 280 K	A,T	P0513 Low Temperature Checkout of Probe C Instrumentation Cables (3/23/2001)Test demonstrated that heaters are functional. Analysis per EM TCS 245: With heaters for each window, and window 3 must have heaters 3 and 4 on to meet the required temp. Window 1 = 165 Window 2= 169 Window 3= 223 Window 4= 294 Note: seasonal constraint on window bakeout +/-30 days from Sept. 1st 2002 & March 1st 2003.	Verified at PL level
3.7.3.5.2	Vacuum at End of Low Temperature Bakeout Heating	The probe shall provide the capability to reach <= 1.3 x 10-5 Pa (1 x 10-7 torr) after 4-12 hours of pumping during the low-temperature bakeout before temperature is reduced.	T	P0872, Low Temp Bakeout Pressure Verification, run in PL Phase D3, completed 8/10/2001. Achieved 9.9x10^-8 torr.	Verified at PL level
3.7.3.7.4	Optical System EMI Filtration	The probe shall provide EMI shielding as listed in the following subsections and the ground surface requirement of 3.7.2.2.3.7.	A,T	Header; 3.7.2.2.3.7 is compliant by test and analysis (except final grounding of sunshade to Probe). Requirements below are compliant by test and analysis.	Verified at PL level

Table 3.1 – Verified Requirements

PLSE-12 #	Title	Requirement	Method	Compliance Data	Verification Status
3.7.3.8.3	Instrumentation	The instrumentation shall meet the requirements of tables 3.7.3-9 through 3.7.3-19 and the following subsections. Legend for all tables 3.7.3-9 to 3.7.3-19: GRT Germanium Resistance Thermometer SD Silicon Diode PRT Platinum Resistance Thermometer QB Quartz Block P Probe Notes for all tables 3.7.3-9 to 3.7.3-19: (1) All SD's to conform to standardized curve to within 0.1 K at 4.2 K, 1 K at 77 K, and 1% at 300 K (See OLE tab.)	I,A,T	S0623 “Verification of the ECU & SRE Filters Capacitance” shows using vendor data that the Probe Filters meet the capacitance stability over the expected on-orbit thermal environment. Probe C VRCD (Probe C AR, GPB-100269 v3, 15 May 98) verified all but Capacitance Stability. This requirement is verified with vendor data for the filters built into ECU and SRE cables.	Verified at PL level
3.7.4.2.1	Top Hat to Top Plate Resistance	The resistance across the interface between the probe top hat and the top plate of the dewar vacuum shell shall be <= 10 mohms.	T	P0507 Measurement of Top Hat to Top Plate resistance was run in PL Phase A. section L.5, page ,6 dated 10/30/00 P0507 Measurement of Top Hat to Top Plate Resistance was run in PL Phase Post Acoustic Confidence. Pdoc Completed 3/16/01 Measured resistance as < 0.01 mohms.	Verified at PL level
3.7.4.4.3	Temperature Exposure During Probe Insertion	The probe shall be capable of experiencing the temperatures during a cold insertion into the dewar, estimated to be as shown in figure 3.7.4-1 (See OLE tab.)	T	P0135, Probe Insertion (8/11/99), P0136, Probe removal (12/17/99), P0135, Probe Insertion (10/18/00)	Verified at PL level
3.7.5.2.3	Dimensions	The SMD shall conform to the maximum envelope dimensions, mechanical and electrical interface locations, fluid interface locations and vent locations given in drawings 5833115 and 5833117.	I	R. Pressburg verified drawings, B. Clarke and B. Muhlfelder verified built to design on 11/12/01. Additional proof is found in the spacecraft mating to the SMD (LMMS INT-167 on 10/20/01) and the Probe-C mating to the SMD (P0135), thus it must be compliant by design. See SMD Acceptance Test Procedure, Vol.2, ICD Verification, 5835036.	Verified at PL level
3.7.5.3.1.2	Lead Bag Plus Cryoperm Shield Steady State Shielding	The steady state shielding of the combined lead bag and Cryoperm shield shall yield a flux density <=2x10-10 tesla (2x10-6 Gauss) at the science gyro locations.	T	Mester, S0543 documents results of P0191, which measured steady state shielding on 3 different occasions. Max reading (with max error = 1.78 microgauss)	Verified at PL level

Table 3.1 – Verified Requirements

PLSE-12 #	Title	Requirement	Method	Compliance Data	Verification Status
3.7.5.3.3.1	Cryoperm+Lead Bag Longitudinal Shielding Factor	The lead bag + cryoperm shall provide an attenuation factor consistent with the requirements of 3.2.1.3.2.	A,T	Mester, S0543 P0192	Verified at PL level
3.7.5.3.3.2	Cryoperm+Lead Bag Transverse Shielding Factor	The lead bag + cryoperm shall provide an attenuation factor consistent with the requirements of 3.2.1.3.2.	A,T	Mester, S0543 P0192	Verified at PL level
3.7.5.5.1	Temperature at Station 200	The dewar Station 200 shall be maintained below 1.85 K with a heat load from the probe of <= 65 mW, and the bath temperature <= 1.8 K.	A,T	Logan, S0608, Thermal Verification part 3 P0862 Dewar Lifetime and Thermal Data Acquisition, run in PL Phase D3. He Bath Temperature <= 1.76 K , Station 200 <= 1.78 with a heat transfer rate <= 22 mW during a 10 hour temperature reading done on 7/20/01. This is done with Payload horizontal (which is closer to on-orbit state).	Verified at PL level
3.7.5.7.1.1	Conditioning and Top-off of the Main Tank	With the SMD vertical, it shall be possible to condition the liquid helium in the main tank from NBPHe to He II, and top-off up to 95% full of He II at a bath temperature consistent with 3.2.1.9.	T	P0831 Prepare Main Tank For Launch was run in PL Phase: 95% Fill. Pdoc completion date = 05/25/01 Fill MT at NPB P0442 was the first step in P0831 section G.4.2. The final conditioned Fill Level achieved = 96.4% MT and 95.6% GT; bath temp MT = 1.69K as found in P0831 section G.12.7.	Verified at PL level
3.7.5.8	Horizontal Hold Times	For ground operations, with the SMD horizontal, and either -x*, or -y* up, the SMD hold time shall support SMD ground operations for Test and Verification (nominally 1 month horizontal hold is adequate).	A,T	Logan, S0593 SMD Horizontal Hold Times. P0524 Rotate Payload and Position to Horizontal Procedure P0594 SMD Lift and Rotate 90 degrees P0633 Upright SMD (Rotate from Horizontal to Vertical Orientation) '-X already Done in Phase C. -Y to be done in Phase D. PCB away 2.5 months. The requirement is to support SMD ground operations for PL Test and Verification needs (nominally 1 month horizontal hold is adequate).	Verified at PL level

Table 3.1 – Verified Requirements

PLSE-12 #	Title	Requirement	Method	Compliance Data	Verification Status
3.7.5.9.1.4	Pyrotechnic Valves	Pyrovalves shall be provided for venting the guard vacuum and well to space. They shall comply with the safety requirements of Section 3.3.6.4.	I,T	Pyrotechnic Valves: 1) 1/2" dia. well valve, 2) 1" dia. dewar valve The valves were built and tested to drawings, which were used to build the devices. Q.E. inspectors reviewed and signed off on all drawings: 1) 5833904, 2) 5833438, and build paper. The testing, handling and circuit check out of the Pyro Initiators is covered under Lockheed safety document MSPSP - LM/9479945 and the Tailoring/Compliance/Non-compliance Checklist - LMSSC/P480508	Verified at PL level
3.7.5.9.1.7	Fill Line Relief Valve	A relief valve on the fill line shall be provided to protect the fill line from damage due to over pressurization.	I	LMMS installed the relief valve, and the Stanford Cryogenics team and QA verified the installation in P0795 "Install Fill Line Burst Disk on SMD" (SMD Op. Log No. 1930, started 8/17/02).	Verified at PL level
3.7.5.11.1	Heat Pulse Meter	A heat pulse meter shall be provided for measuring the residual superfluid helium in the main tank while in orbit, to within +/- 5% of its true value.	T	S0612 "Heat Pulse Meter Verification" (PL Ver II) provides the calculations required to determine the accuracy. P0842 Heat Pulse Meter Test Procedure was run in PL Phase B. The Heat Pulse test was successful. The liquid level sensor is compared to a solid model and the residual superfluid helium stayed within 5% of its value. This Test is repeated again with ECU. This test verified the 5%. P0540 Heat Pulse Meter Test Procedure was run in PL Phase B, with ECU. 1/2 data is complete (per Dave Murray, this is compliant); 1/2 data comes from ECU tests with Dave Merriwether (pass/fail). Lower level verification per SMD Acceptance Test Procedure, Vol.1, System Level Tests, 5835036.	Verified at PL level
3.7.5.11.2	Flow Meter	A flow meter shall be provided for measuring the helium flow rate to the spacecraft thrusters while in orbit, to within +/- 5% of its true value.	I,T	S0547 "Flow Meter Verification" (PL Ver II) provides the calculations required to determine the accuracy. P0841 SMD Flow Meter Calibration was run in PL Phase B. The intent of this requirement is a calibration exercise of the flowmeter. This procedure also demonstrates the prelaunch hold time of the Main Tank and Guard Tank.	Verified at PL level
3.7.6.1.3	Fiber Optic Interface	The fiber optic interface between the probe and the electronics shall be per LMMS drawing 1C34355.	I	R. Pressburg verified drawings and B. Clarke verified built to design. 11/12/01	Verified at PL level
3.7.6.1.7	Magnetometer Mechanical Interface	Payload Magnetometer shall be located as shown in 8A02025, Payload Magnetometer Installation Drawing	I	Op Order # INT-280 for the Payload Magnetometer relocation, verifies that the four Payload Magnetometers were installed to DWG 8A02025. Inspected by Q.E. 688847B on 7/15/2002.	Verified at PL level

Table 3.1 – Verified Requirements

PLSE-12 #	Title	Requirement	Method	Compliance Data	Verification Status
3.7.6.1.8	Dewar Interfaces with Ground Servicing Equipment	The dewar interface with the SMD cryogen ground servicing equipment shall be as described in layout drawings 5833828, 5833829, and 5833830.	I	R. Pressburg verified drawings, and B. Clarke and B. Muhlfelder verified built to design. 11/12/01	Verified at PL level
3.7.6.2.3	Probe Instrumentation Interface Data	Probe heater data shall be as shown in Table 3.7.6-4. (See OLE tab.)	I	D. Ross to verify data from: P0540 Payload Verification II (PTP) ECU Checkout P0544 ECU Test Support - all channels and locations match Table 3.7.6-4, and all heaters tested. Data found in Hardware\dmurray\	Verified at PL level
3.7.6.3	Maximum Pressure at Spin-up Exhaust Exit	The maximum local pressure at the exit of the spin-up exhaust valves shall be 0.01 torr.	A,T	Muhlfelder, S0591 P0519 Gyro Flow and Thermal Testing	Verified at PL level
3.7.8.13.5.2.1	2.5 Inch Vatterfly Closing Force Margin	The mechanical margin of safety to close the valve shall be >= 3.0 throughout the temperature range 210 K to 313 K.	T	**STP-3179** Pacific Design Technologies Force Margin Capability of HFS Model 3179 2.5” Vacuum Valves Closing force margin “Actual Minimum: Actual Maximum = 41.5:1” at 210 K.	Verified at PL level
3.7.8.13.5.2.2	2.5 Inch Vatterfly Opening Force Margin	The mechanical margin of safety to open the valve shall be >= 5.0 throughout the temperature range 210 K to 313 K.	T	**STP-3179** Pacific Design Technologies Force Margin Capability of HFS Model 3179 2.5” Vacuum Valves Opening force margin “Actual Minimum: Actual Maximum = 22.6:1” at 210 K.	Verified at PL level
3.7.8.13.5.2.3	6 inch Vatterfly Closing Force Margin	The mechanical margin of safety to close the valve shall be >= 1.5 throughout the temperature range 210 K to 313 K.	T	**STP-3223** Pacific Design Technologies Force Margin Capability of HFS Model 3223 6.0” Vacuum Valves Closing force margin “Actual Minimum: Actual Maximum = 22.4:1” at 210 K.	Verified at PL level
3.7.8.13.5.2.4	6 inch Vatterfly Opening Force Margin	The mechanical margin of safety to open the valve shall be >= 5.0 throughout the temperature range 210 K to 313 K.	T	**STP-3223** Pacific Design Technologies Force Margin Capability of HFS Model 3223 6.0” Vacuum Valves Opening force margin “Actual Minimum: Actual Maximum = 13.8:1” at 210 K.	Verified at PL level

Table 3.1 – Verified Requirements

PLSE-12 #	Title	Requirement	Method	Compliance Data	Verification Status
3.8.2.1	NBPHe Transfers from External Supply	The GSE shall be capable of filling and topping-off the main tank, guard tank, and well with NBPHe from an external Liquid Helium Supply Dewar (LHSD).	I,T	P0791 & P0674 Connect GSE to Payload 10/11/01 P0648d NBP Main Tank Fill / GT empty 10/12/01 P0442C MT Fill with GT Precool 10/15/01 P0831 Prepare Main Tank for Launch P0798 MT sub-atmospheric Fill from NBP w/ GT pre-cool, 5/18/01.	Verified at PL level
3.8.2.2	He II Top-off from External Supply	The GSE shall be capable of filling and topping-off the main tank with He II from an external Liquid Helium Supply Dewar containing subatmospheric liquid helium.	I,T	P0831 Prepare Main Tank for Launch P0798 MT sub-atmospheric Fill from NBP w/ GT pre-cool, 5/18/01.	Verified at PL level
3.8.3.4	Conditioning LHe in Main Tank to He II	The GSE shall include a Pump Module, based on a Roots pump with a nominal displacement of >= 700 cfm (330 l/s) (which can be started at one atmosphere) and a vane forepump with a displacement >= 200 cfm (94 l/s), for the function of conditioning the liquid helium in the main tank from He I to He II.	I,T	P0831 Prepare Main Tank for Launch P0798 MT sub-atmospheric Fill from NBP w/ GT pre-cool, 5/18/01.	Verified at PL level
3.8.3.6	Reconditioning LHe in Main Tank from He II to NBPHe	The GSE shall be capable of reconditioning the LHe in the main tank from He II to NBPHe.	I,T	Demonstrated by completion of P0216B, Pressurization of MT from Subatmospheric to NBP 8/13/01 .	Verified at PL level
3.8.7.4	Alarms	The GSE shall provide alarms for critical pressures, temperatures, and liquid levels.	I	TM & A used in Payload Transport to LM B 205; certified per P0775	Verified at PL level
3.8.9	Temperature Monitor and Alarm	The GSE shall provide a portable system for collecting, reducing, and storing SMD data , and providing an alarm system.	I,T	TM & A used in Payload Transport to LM B 205; certified per P0775	Verified at PL level

3.2 Requirements To Go (due at Payload level)

NONE

Table 4: Requirements Verified at a lower level:

Table 4: Lower Level Verifications

PLSE-12 #	Title	Requirement	Method	Compliance Data
3.2.2.6	Science Magnetometers	The Science Payload shall provide 4 three-axis fluxgate magnetometers on the forward cone of the dewar, located axially near the top of the lead bag, and radially approximately 90+/- apart, to measure the local external field. The alignment of each magnetometer relative to the spacecraft truss shall have maximum error in knowledge <= 0.5 degree, rotation and <= 1.75 mm, translation, for X, Y, and Z axes.	I	Lower Level verification per Magnetometer VRCM, Magnetometer ADP.
3.7.1.2.1.1	Mass Allocation	The total mass of the SIA shall not exceed 41.0 kilograms (90.4 pounds).	A	Lower Level Compliance per: SIA/ Probe Integration VRCM 7/6/99; PA-05-SIA-25771-101-SM-1
3.7.1.2.1.2	Mass Measurement	The total mass of the as-built SIA shall be measured and reported to within 0.2 kg.	A	Lower Level Compliance per: SIA/ Probe Integration VRCM 7/6/99; PA-05-SIA-25771-101-SM-1
3.7.1.2.1.3	Center of Mass Position	The SIA center of mass shall be located at a point on the z-axis located at Station 157.01 (3988.1 mm from reference plane) within a 20.32 mm (0.8 inch) radius sphere. The SIA center of mass position shall be verified by a combination of measurement and analysis to an accuracy of less than or equal to 1.27 mm (0.05 inch).	A	Lower Level Compliance per: SIA/ Probe Integration VRCM 7/6/99; PA-05-SIA-25771-101-SM-1
3.7.1.2.3	Structural Characteristics	The SIA shall be designed to withstand the launch loads as described in Section 3.2.5.5. More detailed requirements on the allowable limit stress for fused quartz can be found in Section 3.7.1.2.3.1.	A,S	Lower Level Compliance per: SIA/ Probe Integration VRCM 7/6/99; PA-05-SIA-25771-101-SM-1 Design Verification Shake test after GTU-1 and shake in GTU-2 (Gyro Retention by Shake test prior to GTU-2) Flight Unit Acceptance Similarity to GTU-2 Hardware
3.7.1.2.3.1	Maximum Allowable Limit Stress for Fused Quartz	The maximum allowable limit stress in the fused quartz structure shall be 5.00 MPa (725 psi) in tension and shear and 1100 MPa (160 kpsi) in compression. The maximum allowable limit stress in tension and shear shall include a safety factor of 10.	A	Lower Level Compliance per: SIA/ Probe Integration VRCM 7/6/99; PA-05-SIA-25771-101-SM-1
3.7.1.2.4.1	SIA Interfaces with Probe	The SIA design shall be in accord with Section 3.7.2, which includes the SIA/Probe ICD, LMMS 1C34103, by reference.	I	Lower Level Compliance per: SIA/ Probe Integration VRCM 7/6/99; PA-05-SIA-25771-101-SM-1

Table 4: Lower Level Verifications

PLSE-12 #	Title	Requirement	Method	Compliance Data
3.7.1.3.1.1.1	Thermal Bending Stability of ST/QBA Assembly	The ST/QBA Assembly shall undergo thermal bending in inertial space of <= 0.1 marcsec while Science Data is collected (SV rolling at roll frequency about the line-of-sight to the Guide Star).	A	Lower Level Compliance per: SIA/ Probe Integration VRCM 7/6/99; PA-05-SIA-25771-101-SM-1
3.7.1.3.2.4	Electrical Conductivity of Materials	Normal conductors and superconductors used in the SIA design shall be in accordance with the Magnetics Control Plan P0057.	I	Lower Level Compliance per: SIA/ Probe Integration VRCM 7/6/99; PA-05-SIA-25771-101-SM-1
3.7.1.3.2.5	Magnetic Control of Materials	All SIA parts shall be screened in accordance with the Magnetics Control Plan P0057.	I,T	Design Verification: Magnetic screening of all materials used in SIA and probe assembly. Flight Unit Acceptance: Magnetic testing during Science Payload assembly and Science Payload Test Lower Level Compliance per: SIA/ Probe Integration VRCM 7/6/99; PA-05-SIA-25771-101-SM-1
3.7.1.3.4	Cleanliness Requirements	The SIA shall meet the cleanliness requirements in Section 3.3.1.2.6, but with the exceptions and verification approaches allowed as given in the Contamination Control Plan P0121 (formerly S0139).	I,T,S	Design Verification: Inspection during assembly of GTU-1, GTU-2 components. Gas flush and other tests prior to GTU-1 activities. Flight Unit Acceptance: Inspections during assembly and gas flush tests prior to full integration. Lower Level Compliance per: SIA/ Probe Integration VRCM 7/6/99; PA-05-SIA-25771-101-SM-1
3.7.1.4.1.1	Axial Position	The knowledge of the axial distance between the centers of adjacent gyroscopes shall meet the requirement given in section 1.7.2 of T003.	A	Lower Level Compliance per: QBA VRCM 4/8/99; PA-05-SIA-23171-101-SM1
3.7.1.4.1.2	Positioning Transverse to Z-axis	The distance of the centers of all gyroscope cavities from the Roll Axis shall meet the requirement given in Section 1.7.1 of T003.	A	Lower Level Compliance per: QBA VRCM 4/8/99; PA-05-SIA-23171-101-SM1
3.7.1.4.2.1.1	Accuracy of Perpendicularity	The axes of all readout loops shall be perpendicular to the science telescope axis within the error given in Section 11.2.1 of T003.	A	Lower Level Compliance per: QBA VRCM 4/8/99; PA-05-SIA-23171-101-SM1
3.7.1.4.2.1.2	Stability of Perpendicularity	The orientation of the Science Gyroscope readout loops with respect to the Telescope axis shall be stable as stated in Section 11.2.1 of T003.	A	Lower Level Compliance per: SIA/ Probe Integration VRCM 7/6/99; PA-05-SIA-25771-101-SM-1

Table 4: Lower Level Verifications

PLSE-12 #	Title	Requirement	Method	Compliance Data
3.7.1.4.2.1.3	Rotation	The Science Gyroscope and Science Telescope readout axes shall be aligned in rotation about the z-axis with the accuracy given in Section 11.3 of T003.	A	Lower Level Compliance per: QBA VRCM 4/8/99; PA-05-SIA-23171-101-SM1
3.7.1.4.2.2	Gyroscope Readout Axes in Space Vehicle Frame	The gyroscope readout axes shall be oriented to measure pitch (rotation about y-axis) for gyroscopes #1 and #2, and to measure yaw (rotation about x-axis) for gyroscopes #3 and #4.	I	Lower Level Compliance per: QBA VRCM 4/8/99; PA-05-SIA-23171-101-SM1
3.7.1.4.2.3	Parallelism between Pairs of Readout Loops	The axes of readout loops #1 and #2 shall be parallel to each other within the error given in Section 11.2.2 of T003. The same requirements apply to the axes of readout loops #3 and #4.	I,A,T	Lower Level Compliance per: QBA VRCM 4/8/99; PA-05-SIA-23171-101-SM1
3.7.1.4.2.4	Perpendicularity between Readout Loops	The angles between the effective axes of each one of Readout Loops #1 and #2, including the effects of the mechanical misalignment and of electrical misalignment due to the out-of-plane stray area of the wire connecting the readout loops, and the effective axes of each one of Readout Loops #3 and #4 are nominally 90 degree. These angles shall be known to within the error given in section 11.2.3 of T003.	A	Lower Level Compliance per: QBA VRCM 4/8/99; PA-05-SIA-23171-101-SM1
3.7.1.4.3	Reticle Plate	The reticle plate at the front of the telescope shall be in accord with the ICD drawing 25446, "Plate, Reticle"	I	Lower Level Compliance per: Science Tele. VRCM 10/14/98; PA-05-SAI-25091-201-3 Design Verification: Measurements during assembly and measurements of completed Telescope-2 (GTU-2 test) verify cross-hair to QB location. Flight Unit Acceptance: Measurements during assembly and measurements of completed Telescope-3 (Science Mission) verify cross-hair to QB location. On-orbit testing and science mission data verify final location.
3.7.1.4.3.1	X-Y Location of Reticle Pattern Center	The x-y position of the reticle pattern center with respect to a point determined by the intersection of the nominal Roll Axis with the reticle plate plane shall be known to 0.25 mm (0.010 inch).	A	Lower Level Compliance per: QBA VRCM 4/8/99; PA-05-SIA-23171-101-SM1
3.7.1.4.3.2	Z Location of Reticle Reflecting Plane	The Z location of the Reticle Reflecting Plane relative to Gyroscope #1 shall be known to within 0.5 mm.	A	Lower Level Compliance per: QBA VRCM 4/8/99; PA-05-SIA-23171-101-SM1
3.7.1.4.3.3	Rotation of Reticle Pattern	The reticle pattern rotation about the z-axis relative to the readout loop planes shall be known within 1.1 degree (see EM No. ATCS 215, 6/20/96).	A	Lower Level Compliance per: QBA VRCM 4/8/99; PA-05-SIA-23171-101-SM1

Table 4: Lower Level Verifications

PLSE-12 #	Title	Requirement	Method	Compliance Data
3.7.1.4.3.4	Orientation of Reflecting Surface	The perpendicular to the reflecting surface of the reticle plate shall be parallel to the telescope optical axis within 10 arcsec and be known to within 5 arcsec.	T	Lower Level Compliance per: Sci.Tele.VRCM 10/14/98; PA-05-SAI-25091-201-3 P0246 per 3/2/99 VRCM attached to Sci. Tele. VRCM package
3.7.1.4.3.5	Reflectivity	The reflecting surface of the reticle shall have a reflectivity of greater than or equal to 70% (intensity).	I	Lower Level Compliance per: Sci.Tele.VRCM 10/14/98; PA-05-SAI-25091-201-3
3.7.1.4.4.2.3	Rotor Composition	The composition and location of each gyro rotor shall meet the requirement of Section 1.2 of T003.	I	Lower Level Compliance per: QBA VRCM 4/8/99; PA-05-SIA-23171-101-SM1
3.7.1.4.4.2.4	Spin Direction	The QBA design allows the spin direction of any gyroscope to be in the + z or - z direction. The spin directions shall be those given in Section 1.1 of T003. The gyroscope shall be installed so the symmetry plane of the gyro spin-up channel is perpendicular to the z-axis within 0.005 rad (0.27 degree).	A	Lower Level Compliance per: QBA VRCM 4/8/99; PA-05-SIA-23171-101-SM1
3.7.1.4.4.2.5	Orientation of Electrodes	The gyroscope shall be installed so the gyroscope electrode symmetry axis equidistant between two electrodes is parallel to the z-axis within 0.005 rad (0.27 degree).	A	Lower Level Compliance per: QBA VRCM 4/8/99; PA-05-SIA-23171-101-SM1
3.7.1.4.7.1	Force Applied to Gyroscope by Caging Pin	The caging mechanism shall apply a force of 57.8 N +/- 4.4 N (13.0 lb +/- 1.0 lb).	T	Lower Level Compliance per: Caging VRCM 4/19/99
3.7.1.4.7.2	Surface of Caging Pin	The surface of the caging pin in contact with the gyroscope shall have a surface finish and curvature compatible with applying the caging force to the gyroscope without affecting gyroscope performance requirements.	I,T	Lower Level Compliance per: Caging VRCM 4/19/99
3.7.1.4.7.3	Actuation Pressure	The caging mechanism shall operate with a helium gas pressure in accordance with the requirement in section 3.7.2.4.3.	T	Lower Level Compliance per: Caging VRCM 4/19/99
3.7.1.4.7.4	Volume of Caging Circuit	The volume of each caging circuit on the SIA side of the probe to SIA interface (up to two caging mechanisms per circuit) shall be in accord with the requirement in Section 3.7.2.4.4.	I,A	Lower Level Compliance per: Caging VRCM 4/19/99
3.7.1.4.7.5	Interface of Helium Gas Actuation Line with Probe	The demountable connection of the helium gas line to the probe shall be in accord with the SIA to Probe ICD, LMMS 1C34103.	I	Lower Level Compliance per: SIA/ Probe Integration VRCM 7/6/99; PA-05-SIA-25771-101-SM-1

Table 4: Lower Level Verifications

PLSE-12 #	Title	Requirement	Method	Compliance Data
3.7.1.4.7.7	Position of Caging Pin with Zero Applied Pressure	The caging pin shall be withdrawn from the surface of the gyroscope housing (ID of spherical surface of uncoated housing) greater than or equal to 0.25 mm (0.010 inch) when a differential pressure of 0.00 MPa is applied to the mechanism.	T	Lower Level Compliance per: Caging VRCM 4/19/99
3.7.1.4.7.8	Position of Caging Pin at 0.12 Mega Pascal (17 PSID	The caging pin shall be withdrawn from the surface of the gyroscope housing (ID of spherical surface of uncoated housing) greater than or equal to 0.05 mm (0.002 inch) when a differential pressure is applied to the mechanism of 0.12 MPa (17 psid).	T	Lower Level Compliance per: Caging VRCM 4/19/99
3.7.1.4.9.1	Superconducting Transition Temperature	The local superconducting magnetic shield shall have a superconducting transition temperature greater than 8.5 K and less than 10.5 K.	I,S	Lower Level Compliance per: QBA VRCM 4/8/99; PA-05-SIA-23171-101-SM1
3.7.1.4.9.2	Transverse Centering	The distance between the axis of the inside diameter of the local shield and the center of the gyroscope housing shall be less than or equal to 0.25 mm (0.010 inch).	I	Lower Level Compliance per: QBA VRCM 4/8/99; PA-05-SIA-23171-101-SM1
3.7.1.4.9.3	Longitudinal Centering	The distance between the center of the shield in the longitudinal direction and the center of the gyroscope housing shall be less than or equal to 2.5 mm (0.10 inch).	I	Lower Level Compliance per: QBA VRCM 4/8/99; PA-05-SIA-23171-101-SM1
3.7.1.4.10.1	Germanium Resistance Thermometer Characteristics	The GRTs shall have a nominal resistance of 1000 ohm to 2500 ohm at 4.2 K and be calibrated over the temperature range 1.4 K to 100 K with an accuracy of 5 mK over the temperature range from 1.4 K to 10 K.	I,T	Lower Level Compliance per: QBA VRCM 4/8/99; PA-05-SIA-23171-101-SM1
3.7.1.4.10.2	Silicon Diode Thermometer Characteristics	The SDs shall have a nominal voltage of 0.5 V to .055 V at 300 K and be calibrated, at an excitation current of 10 microampere, over the temperature range of 1.4 K to 325 K with an accuracy of 0.1 K over the this temperature range.	I,T	Lower Level Compliance per: QBA VRCM 4/8/99; PA-05-SIA-23171-101-SM1

Table 4: Lower Level Verifications

PLSE-12 #	Title	Requirement	Method	Compliance Data
3.7.1.5.1.1.2	Signal Interfaces	Each Science Gyroscope Assembly shall have the following electrical inputs and outputs. 1) Six Electrodes - for electrostatic suspension and capacitive position readout of the rotor 2) Charge Control Bias electrode - for photoelectric control of the rotor charge 3) Readout Hardware - for pickup and detection of the London moment signal associated with the Gyro rotor spin axis 4) Input deflux heater current for a heater on the superconducting readout cable 5) Housing Ground 6) Heater 7) Thermometer	I	Lower Level Compliance per: SIA/ Probe Integration VRCM 7/6/99; PA-05-SIA-25771-101-SM-1
3.7.1.5.2.1.1	Trapped Flux	The assembled gyroscopes shall be compatible with the trapped magnetic flux requirement of Section 1.5 of T003.	T	Lower Level Compliance per: Gyro VRCM PA-05-SIA-23185-202-FQH61, 46, 58, 44
3.7.1.5.2.1.2	Spin Speed	The set of Gyros as installed in the SIA shall be capable of achieving final spin speeds for all four Gyros in the range specified in Section 4.1 of T003 under the constraints of Sections 3.2.1.7 and 3.7.8.7.1.2. The maximum gyroscope temperature during spinup (measured at the housing) must be less than 8K. The spinup gas must exert a force of less than or equal to 0.05N on the Gyroscope Rotor.	A,T	Lower Level Compliance per: Gyro VRCM PA-05-SIA-23185-202-FQH61, 46, 58, 44
3.7.1.5.2.1.4	Spin-Down Rate	The one-g spin-down rate shall be less than or equal to (df/dt)/f = 2.0e-3 per hour in the spin speed range 0.3 Hz to 3 Hz.	T	Lower Level Compliance per: Gyro VRCM PA-05-SIA-23185-202-FQH61, 46, 58, 44
3.7.1.5.2.1.5.1	Initial Alignment	The geometry of the gas spin-up system shall be compatible with the initial alignment required in Section 4.3 of T003 assuming a rolling spacecraft.	A	Lower Level Compliance per: Gyro VRCM PA-05-SIA-23185-202-FQH61, 46, 58, 44
3.7.1.5.2.1.5.2	Final Alignment	The rotor shape for spin speeds in the range specified in Section 4.1 of T003 shall be compatible with final spin alignment given in Section 5.2 of T003 assuming a 10% modulation of the 0.1 g suspension preload at roll frequency in less than 50 hour. Lower levels of suspension preload may be used for the final fine adjustment.	A	Lower Level Compliance per: Gyro VRCM PA-05-SIA-23185-202-FQH61, 46, 58, 44

Table 4: Lower Level Verifications

PLSE-12 #	Title	Requirement	Method	Compliance Data
3.7.1.5.2.1.6.1	Decay Time	The decay of the signal produced by magnetic flux injected into the superconducting input circuit shall be less than 1% in a 10 min period, under the condition that the R/O loop is connected to the input of a dc SQUID through the readout cable. The dc SQUID supporting this test shall have an input inductance and coupling equal to the requirements for the flight dc SQUID.	T	Lower Level Compliance per: Gyro VRCM PA-05-SIA-23185-202-FQH61, 46, 58, 44
3.7.1.5.2.2.1.1.1	Material	The rotor substrate material shall be as specified in Section 1.2 of T003.	I	Lower Level Compliance per: Gyro VRCM PA-05-SIA-23185-202-FQH61, 46, 58, 44
3.7.1.5.2.2.1.1.2	Homogeneity	The density homogeneity d(rho)/(rho) across any diameter shall be less than or equal to 1.0e-5	I,A	Lower Level Compliance per: Gyro VRCM PA-05-SIA-23185-202-FQH61, 46, 58, 44
3.7.1.5.2.2.1.1.3	Diameter	The diameter of the substrate shall be within +/- 750 nm (+/- 30 microinch) of the diameter of the reference sphere 93H57 at 22 degree C +/- 4 degree C.	T	Lower Level Compliance per: Gyro VRCM PA-05-SIA-23185-202-FQH61, 46, 58, 44
3.7.1.5.2.2.1.1.4	Asphericity of substrate	The substrate shall have a peak-to-valley asphericity less than or equal to the following: For the l=2 (oblateness) term, 30 nm (1.2 microinch) For odd harmonics l = 3 to 15, 23 nm (0.9 microinch) For even harmonics l = 4 to 16, 23 nm (0.9 microinch) The accuracy of the measurement of the roundness of any one of the great circles used to determine the asphericity shall be less than 17 nm (0.65 microinch).	T	Lower Level Compliance per: Gyro VRCM PA-05-SIA-23185-202-FQH61, 46, 58, 44
3.7.1.5.2.2.1.2.1	Coating Material	The coating material shall be niobium.	I	Lower Level Compliance per: Gyro VRCM PA-05-SIA-23185-202-FQH61, 46, 58, 44
3.7.1.5.2.2.1.2.2	Coating Uniformity	Coating uniformity shall be less than or equal to 50nm (p-v). The accuracy of the p-v coating uniformity measurement shall be less than 25 nm.	T	Lower Level Compliance per: Gyro VRCM PA-05-SIA-23185-202-FQH61, 46, 58, 44
3.7.1.5.2.2.1.2.3	Superconducting Transition Temperature	The superconducting transition temperature shall be greater than or equal to 8 K.	S	Lower Level Compliance per: Gyro VRCM PA-05-SIA-23185-202-FQH61, 46, 58, 44
3.7.1.5.2.2.1.2.4	Electron Field Emission	The electron field emission current shall be compatible with 1 g operation and testing.	T	Lower Level Compliance per: Gyro VRCM PA-05-SIA-23185-202-FQH61, 46, 58, 44
3.7.1.5.2.2.1.2.5	Thermal Emissivity	The thermal emissivity shall be greater than or equal to 0.01.	S	Lower Level Compliance per: Gyro VRCM PA-05-SIA-23185-202-FQH61, 46, 58, 44

Table 4: Lower Level Verifications

PLSE-12 #	Title	Requirement	Method	Compliance Data
3.7.1.5.2.2.1.2.6	UV 254 nanometer Photoemissivity of Rotor	The photo emission coefficient shall be greater than or equal to 1.0e-7 electrons/photon for 254 nm photons.	T	Lower Level Compliance per: Gyro VRCM PA-05-SIA-23185-202-FQH61, 46, 58, 44
3.7.1.5.2.2.1.3	Mass Unbalance	Gyro: The coated rotor mass unbalance shall meet the requirement in Section 1.3.2 of T003.	A,T	Lower Level Compliance per: Gyro VRCM PA-05-SIA-23185-202-FQH61, 46, 58, 44
3.7.1.5.2.2.1.4	Rotor Shape	The coated rotor shall meet the rotor shape requirements of T003 (System Design and Performance Requirements) Section 1.4.	A,T,S	Lower Level Compliance per: Gyro VRCM PA-05-SIA-23185-202-FQH61, 46, 58, 44
3.7.1.5.2.2.2.1.1	Material	The housing substrate shall be made from the material specified in Section 1a.1 of T003.	I	Lower Level Compliance per: Gyro VRCM PA-05-SIA-23185-202-FQH61, 46, 58, 44
3.7.1.5.2.2.2.1.2	Cavity Diameter	The cavity diameter shall be 38.070 mm (1.4988 inch) with the accuracy given in Section 1a.2 of T003.	I	Lower Level Compliance per: Gyro VRCM PA-05-SIA-23185-202-FQH61, 46, 58, 44
3.7.1.5.2.2.2.1.3	Cavity Asphericity	The internal spherical surface of the cavity shall meet the asphericity requirement of Section 1a.2 of T003.	I	Lower Level Compliance per: Gyro VRCM PA-05-SIA-23185-202-FQH61, 46, 58, 44
3.7.1.5.2.2.2.1.4	Cavity Centering to Parting Plane	The center of the cavity shall coincide with the parting plane within 2.5 micrometer .	I	Lower Level Compliance per: Gyro VRCM PA-05-SIA-23185-202-FQH61, 46, 58, 44
3.7.1.5.2.2.2.1.5	Electrodes Position Accuracy	The positions of the six electrodes shall meet the requirement of Section 1a.3.3 of T003.	I	Lower Level Compliance per: Gyro VRCM PA-05-SIA-23185-202-FQH61, 46, 58, 44
3.7.1.5.2.2.2.1.6	Electrodes Area Variation	The area variations of the six electrodes shall meet the requirement in Section 1a.3.2 of T003.	I	Lower Level Compliance per: Gyro VRCM PA-05-SIA-23185-202-FQH61, 46, 58, 44
3.7.1.5.2.2.2.2.1	Uniformity	The electrode coating uniformity shall meet the requirements of Section 1a.3.1 of T003.	S	Lower Level Compliance per: Gyro VRCM PA-05-SIA-23185-202-FQH61, 46, 58, 44
3.7.1.5.2.2.2.2.2	Electron Field Emission	The electron field emission current shall be compatible with 1 g operation and testing.	T	Lower Level Compliance per: Gyro VRCM PA-05-SIA-23185-202-FQH61, 46, 58, 44
3.7.1.5.2.2.2.2.3	Electrical Resistivity	The electrode coating resistivity shall be less than or equal to 25 microohm-m at 2.5 K.	S	Lower Level Compliance per: Gyro VRCM PA-05-SIA-23185-202-FQH61, 46, 58, 44
3.7.1.5.2.2.2.3	Support Land Coatings	The support land coatings shall insure that rotors and electrodes do not come in contact.	T	Lower Level Compliance per: Gyro VRCM PA-05-SIA-23185-202-FQH61, 46, 58, 44
3.7.1.5.2.2.2.4	Caging Land Coatings	The caging land coatings shall insure rotor positioning while caged.	A	Lower Level Compliance per: Gyro VRCM PA-05-SIA-23185-202-FQH61, 46, 58, 44
3.7.1.5.2.2.2.5	Spinup Land Coating	The spinup land coatings shall insure functional leakage rate of <=110 micrograms/second with flow rate of 725 scc/m during spinup.	I,T	Lower Level Compliance per: Gyro VRCM PA-05-SIA-23185-202-FQH61, 46, 58, 44

Table 4: Lower Level Verifications

PLSE-12 #	Title	Requirement	Method	Compliance Data
3.7.1.5.2.2.2.6	Cavity Grounding Coating	A cavity grounding coating shall be provided for all surfaces less than 125 micrometer (5 milliinch) from the rotor surface with the exception of : suspension and charge management electrodes, and the isolating areas around these electrodes. (Up to 50 missing areas not exceeding 5 mill are allowed in the grounding coating.)	I	Lower Level Compliance per: Gyro VRCM PA-05-SIA-23185-202-FQH61, 46, 58, 44
3.7.1.5.2.2.2.7.1	Geometry	The readout loop shall be located on the parting plane of the readout housing half and consist of 4 turns.	I	Lower Level Compliance per: Gyro VRCM PA-05-SIA-23185-202-FQH61, 46, 58, 44
3.7.1.5.2.2.2.7.2	Materials and Composition	The readout loop shall be made from niobium.	I	Lower Level Compliance per: Gyro VRCM PA-05-SIA-23185-202-FQH61, 46, 58, 44
3.7.1.5.2.2.2.7.3	Thickness	The readout loop thickness shall be 400 nm +200 /- 100 nm.	I	Lower Level Compliance per: Gyro VRCM PA-05-SIA-23185-202-FQH61, 46, 58, 44
3.7.1.5.2.2.2.7.4	Superconducting Transition Temperature	The readout loop shall have a superconducting transition temperature greater than or equal to 4.2 K .	T	Lower Level Compliance per: Gyro VRCM PA-05-SIA-23185-202-FQH61, 46, 58, 44
3.7.1.5.2.2.2.7.5	Centering to Cavity	The readout loop shall be centered on the gyro housing cavity within 10 micrometer.	T	Lower Level Compliance per: Gyro VRCM PA-05-SIA-23185-202-FQH61, 46, 58, 44
3.7.1.5.2.2.2.7.6	In-Plane Asymmetry	The in-plane asymmetric loop area of the pickup loop shall be less than or equal to 0.6% of the total pickup loop area. This includes both geometric and diamagnetic contributions to the asymmetry.	I,A	Lower Level Compliance per: Gyro VRCM PA-05-SIA-23185-202-FQH61, 46, 58, 44
3.7.1.5.2.2.2.7.7	Inductance	The readout loop inductance shall be less than or equal to 2 microhenry.	S	Lower Level Compliance per: Gyro VRCM PA-05-SIA-23185-202-FQH61, 46, 58, 44
3.7.1.5.2.2.2.7.8	Diameter	Inside diameter of inner turn >= 19.81 mm (0.780 inch). Outside diameter of outer turn <= 20.68 mm (0.814 inch).	I	Lower Level Compliance per: Gyro VRCM PA-05-SIA-23185-202-FQH61, 46, 58, 44
3.7.1.5.2.2.2.8.1	Inductance	The readout cable shall have an inductance of less than 0.1 microhenry, and the inductance shall be stable to 5 parts in 1.0e5 per year.	A	Lower Level Compliance per: Gyro VRCM PA-05-SIA-23185-202-FQH61, 46, 58, 44
3.7.1.5.2.2.2.8.2	Out of Plane Asymmetry	Asymmetric loop area perpendicular to the plane of the pickup loop times the cosine of the angle between the spin axis and out of plane asymmetry shall be less than 6.0e-5 of the loop area.	I	Lower Level Compliance per: Gyro VRCM PA-05-SIA-23185-202-FQH61, 46, 58, 44
3.7.1.5.2.2.2.8.3	Transition Temperature	The readout cable shall have a superconducting transition temperature of greater than 8.5 K.	S	Lower Level Compliance per: Gyro VRCM PA-05-SIA-23185-202-FQH61, 46, 58, 44
3.7.1.5.2.2.2.8.4	Flux Coupling from Applied External Field	The flux coupling from an applied external field shall be less than or equal to 1.0e-7 flux-quanta/pT (flux is referred to flux in SQUID loop). The applied external field is the free magnetic field applied to the shield of the readout cable.	A	Lower Level Compliance per: Gyro VRCM PA-05-SIA-23185-202-FQH61, 46, 58, 44

Table 4: Lower Level Verifications

PLSE-12 #	Title	Requirement	Method	Compliance Data
3.7.1.5.2.2.3.1	Rotor Gap to Electrodes	When the rotor is centered, the gap between the rotor and electrodes shall be as required in Section 1.6.1 of T003.	I	Lower Level Compliance per: Gyro VRCM PA-05-SIA-23185-202-FQH61, 46, 58, 44
3.7.1.5.2.2.3.2	Rotor Gap to Support Lands	When the rotor is centered, the gap between the rotor and the support lands shall be as required in Section 1.6.2 of T003 with a tolerance of +/- 3.7 micrometer.	I	Lower Level Compliance per: Gyro VRCM PA-05-SIA-23185-202-FQH61, 46, 58, 44
3.7.1.5.2.2.3.3	Rotor Gap to Caging Lands	When the rotor is centered, the gap between the rotor and the caging lands shall be 21 micrometer +/- 3.7 micrometer.	I	Lower Level Compliance per: Gyro VRCM PA-05-SIA-23185-202-FQH61, 46, 58, 44
3.7.1.5.2.2.4.1	Photo Emissivity from UV Electrode	The photoemission from the UV electrode shall be greater than or equal to 1.0e-7 electron/photon.	T	Lower Level Compliance per: Gyro VRCM PA-05-SIA-23185-202-FQH61, 46, 58, 44
3.7.1.5.2.2.5.1	Germanium Resistance Thermometer Characteristics	The GRTs shall have a nominal resistance of 1000 ohm to 2500 ohm at 4.2 K and be calibrated over the temperature range 1.4 K to 100 K with an accuracy of 5 mK over the temperature range from 1.4 K to 10 K.	I	Lower Level Compliance per: QBA VRCM 4/8/99; PA-05-SIA-23171-101-SM1
3.7.1.5.2.2.5.2.1	Resistance	The resistance shall be 1320 ohm +/- 100 ohm at 4.2 K.	T	Lower Level Compliance per: QBA VRCM 4/8/99; PA-05-SIA-23171-101-SM1
3.7.1.5.2.2.5.2.2	Dipole Moment due to Current	The current induced magnetic dipole moment shall be less than 2.0e-9 A-m^2/mA (2.0e-6 emu/mA).	S	Lower Level Compliance per: QBA VRCM 4/8/99; PA-05-SIA-23171-101-SM1
3.7.1.6.1.2.2	Signal Interfaces	The ST shall output to the Telescope Readout Electronics eight optical signals as listed below. Positive Pitch Axis Alternate Positive Pitch Axis Negative Pitch Axis Alternate Negative Pitch Axis Positive Yaw Axis Alternate Positive Yaw Axis Negative Yaw Axis Alternate Negative Yaw Axis The detailed electrical interface to the probe with identification of the electrical function is given in Section 3.7.6.2.2.	I	Lower Level Compliance per: Sci.Tele.VRCM 10/14/98; PA-05-SAI-25091-201-3
3.7.1.6.2.1.1	Perpendicularity of Readout Axes	The perpendicularity between the two readout axes shall meet the requirement of Section 7.3 of T003.	A	Lower Level Compliance per: Sci.Tele.VRCM 10/14/98; PA-05-SAI-25091-201-3

Table 4: Lower Level Verifications

PLSE-12 #	Title	Requirement	Method	Compliance Data
3.7.1.6.2.1.2.1	Misalignment of Optical Center from Center of Aperture Stop	The misalignment of the optical center of the telescope is defined to be the angle between the direction to a distant star which centers the image of the star on both of the image splitting roof prisms and the direction to a distant star which centers the image of the star on the center of the aperture stop. This misalignment shall be less than 10 arc sec.	A,T	Lower Level Compliance per: Sci.Tele.VRCM 10/14/98; PA-05-SAI-25091-201-3
3.7.1.6.2.1.2.4	Minimum Aperture Stop for 10% of the Light	The aperture stop shall have a radius so as to include at least 10% of the light from any star at an angle less than 60 arc sec from the direction which centers the image of a distant star on the center of the aperture stop.	A,T	Lower Level Compliance per: Sci.Tele.VRCM 10/14/98; PA-05-SAI-25091-201-3
3.7.1.6.2.1.3	Unsaturated Range	The unsaturated range shall meet the requirements of Section 7.2.2.	A,T	Lower Level Compliance per: Sci.Tele.VRCM 10/14/98; PA-05-SAI-25091-201-3
3.7.1.6.2.1.5	Strehl Ratio	The Strehl Ratio shall be >= 72%.	A	Lower Level Compliance per: Sci.Tele.VRCM 10/14/98; PA-05-SAI-25091-201-3
3.7.1.6.2.1.6	Optical Transmissibility	The power transmissibility collectively to all of the photodetectors shall be greater than or equal to 20% of the total light incident on the clear aperture of the telescope over an optical bandwidth from 400 nm to 1000 nm.	A	Lower Level Compliance per: Sci.Tele.VRCM 10/14/98; PA-05-SAI-25091-201-3
3.7.1.6.2.1.7	Reticle Plate	The reticle plate shall meet the requirements of Section 3.7.1.4.3.	I	Lower Level Compliance per: Sci.Tele.VRCM 10/14/98; PA-05-SAI-25091-201-3
3.7.1.7.1.2.1	Functional Interfaces	The SQUID kit shall interface through the probe cables to the SQUID forward Electronics for power and operational control (Section 3.7.1.7.1.2.2), for thermal control (Section 3.7.1.7.1.2.4), and to deliver Science Signals (Section 3.7.1.7.1.2.2). It shall interface to each Science Gyroscope through its Superconductive Cable. It shall interface to the structure of the Probe through the SQUID Mounting Bracket.	I	Lower Level Compliance per: SIA/ Probe Integration VRCM; PA-05-SIA-25771-101-SM-1 Lower Level Compliance per: SQUID Kit/Readout VRCM, 5/27/98, PA-05-SIA-25017-201-(SM1, SM6, SM7,SM8)

Table 4: Lower Level Verifications

PLSE-12 #	Title	Requirement	Method	Compliance Data
3.7.1.7.1.2.2	Signal Interfaces	Each SQUID kit shall have the following electrical inputs and outputs. 1. Bracket instrumentation inputs and outputs a. Input drive currents to two GRTs. b. Output signal voltages from two GRTs. c. Two SQUID bracket heater current inputs (one prime & one spare). 2. The following inputs and output to/from each of the two SQUID packages contained in a SQUID kit for connection to the SQUID forward electronics. a. Bias current input. b. Modulation signal input. c. Feedback signal input. d. Voltage signal output. 3. The following input to each of the two SQUID packages contained in a SQUID kit for connection to the gyroscope pickup loop. a. Gyroscope pickup loop flux signal.	I	Lower Level Compliance per: SIA/ Probe Integration VRCM; PA-05-SIA-25771-101-SM-1
3.7.1.7.1.2.3	Electrical Interfaces	The SQUID hardware shall interface to the cold end connectors as shown in LMSC drawing 1C34103	I	Lower Level Compliance per: SQUID Kit VRCM; PA5-SIA-25017-201 (SM1, SM6,SM7, SM8), Sept. 10, 1998
3.7.1.7.1.2.5	Mechanical Interfaces	Each SQUID Bracket shall interface to the Probe Quartz Block Support structure as shown in LMMS drawing 1C34103 .	I	Lower Level Compliance per: SQUID Kit VRCM; PA5-SIA-25017-201 (SM1, SM6,SM7, SM8), Sept. 10, 1998
3.7.1.7.2.1.1	Noise at 5.5 milliHertz	The SQUID sensor noise shall have a magnitude less than 140 marcsec/Hz^0.5 equivalent at 5.5 mHz (single-sided)with a measurement error of <=20 marcsec/Hz^0.5.	T	Lower Level Compliance per SQUID Pkg. VRCMs; May 14, 1998 The PL level requirement is T002 5.0
3.7.1.7.2.1.4.1	Operating Temperature Range	(a) The nominal operation temperature is defined in 3.4 of T003, and it is the range over which all other performance requirements must be met. (b) The functional operation temperature range is from 2.5 K to 4.2 K, and it is the range over which the only requirement is that the SQUID shall be able to flux locked.	T,S	Lower Level Compliance per: SQUID Pkg. VRCMs; May 14, 1998

Table 4: Lower Level Verifications

PLSE-12 #	Title	Requirement	Method	Compliance Data
3.7.1.7.2.1.4.3	SQUID Scale Factor Temperature Coefficient	The SQUID shall have an input current-to-SQUID flux transfer coefficient whose temperature coefficient is less than 3.0x10^-4 in the range 2.7 - 3K	T	Lower Level Compliance per: SQUID Pkg. VRCMs; May 14, 1998
3.7.1.7.2.1.5	Flux Jumps	There shall be no more than 1 flux jump per 6 hours with an amplitude in the range of 1 to 20 arcsec. There shall be no flux jumps with an amplitude exceeding 20 arcsec.	T,S	Lower Level Compliance per: SQUID Pkg. VRCMs; May 14, 1998
3.7.1.7.2.1.6	Input Coil Impedance	The SQUID sensor input coil shall have an inductance less than 2.0 microhenry and shall be stable to 5 parts per million per year.	A,S	Lower Level Compliance per: SQUID Pkg. VRCMs; May 14, 1998
3.7.1.7.2.1.8	Feedback Transformer Coupling	The SQUID Feedback Transformer shall have mutual inductance of 0.35 microhenry to 0.45 microhenry and shall be stable to 5 parts per million per year.	A,S	Lower Level Compliance per: SQUID Pkg. VRCMs; May 14, 1998
3.7.1.7.2.1.9	Electrical Isolation	The resistance between any two of the following shall be greater than 20 megaohms: bias, modulation, feedback, and signal.	T	Lower Level Compliance per SQUID Pkg. VRCMs; P0160, May 14, 1998. Additional testing performed in Payload Verification II: P0511, Low Temperature Check Out of Probe C SQUID Cables was run in PL Phase A. [section 5.2, page 4, dated 10/24/00] P0511, Low Temperature Check Out of Probe C SQUID Cables was run in PL Phase: Post Acoustic Confidence. Pdoc Completed 3/16/01. P0511 Cable Definitions: SS# = Signal Cable “Pin 1-2 / 2-1” connections are the signal function center tap output transformer connection to ground. The ground intentionally has a low resistance and provides EMI abatement of common mode RF interference. FB# = Feed Back & Bias Cable MS# = Modulation Cable XS# or X# = GRT Cable The GRT thermocouple resistance is designed to vary with temperature, and “nominal roundtrip resistance” values greater than 2,000 ohms are acceptable.

Table 4: Lower Level Verifications

PLSE-12 #	Title	Requirement	Method	Compliance Data
3.7.1.7.2.1.10	Pickup Loop to SQUID Coupling	The Pickup Loop shall have a coupling to the SQUID better than 40 fA/marcsec.	A	Lower Level Compliance per: SQUID Pkg. VRCMs; May 14, 1998
3.7.1.7.2.1.11	Input Circuit Mutual Inductance Stability	The mutual inductance of input coil to SQUID loop shall be stable to better than 5 parts in 1.0e6 per year.	A	Lower Level Compliance per: SQUID Pkg. VRCMs; May 14, 1998
3.7.1.7.2.1.13	Modulation Coil to SQUID Mutual Inductance	The mutual inductance shall be between 1.3 nH and 1.5 nH.	S	Lower Level Compliance per: SQUID Pkg. VRCMs; May 14, 1998
3.7.1.7.2.1.15	SQUID Package AC Magnetic Shielding	The SQUID package shall provide ac shielding such that flux coupling from an applied external magnetic field shall be <= 4.0e-7 flux-quanta/pT (flux is referred to flux in SQUID loop). The applied external field is the free magnetic field applied to the exterior of the SQUID package.	T	Lower Level Compliance per: SQUID Pkg. VRCMs; May 14, 1998
3.7.1.7.2.1.16	SQUID Bracket Thermal Characteristics	The thermal design of the SQUID bracket (including GRTs & heaters), SQUID packages, and related electrical cables shall have the capability to meet the requirements in 3.4 of T003.	A	Lower Level Compliance per: SQUID Kit/Readout VRCM, 5/27/98, PA-05-SIA-25017-201-(SM1, SM6, SM7,SM8)
3.7.1.7.2.1.16.1	Germanium Resistance Thermometer Characteristics	The GRTs shall have a nominal resistance of 1500 ohm to 2500 ohm at 4.2 K and be calibrated over the temperature range 2.5 K to 20 K with an accuracy of 5 mK over the temperature range from 2.5 K to 10 K	I	Lower Level Compliance per: SQUID Kit/Readout VRCM, 5/27/98, PA-05-SIA-25017-201-(SM1, SM6, SM7,SM8)
3.7.1.7.2.1.16.2	Heater Resistance	The heaters shall have a resistance of 1320 ohm +/- 100 ohm at 4.2 K.	T	Lower Level Compliance per: SQUID Kit/Readout VRCM, 5/27/98, PA-05-SIA-25017-201-(SM1, SM6, SM7,SM8)
3.7.1.7.2.1.16.3	Heater Dipole Moment due to Current	The heaters shall have a current induced magnetic dipole moment < 2.0e-9 A-m^2/mA (2.0e-6 emu/mA).	S	Lower Level Compliance per: SQUID Kit/Readout VRCM, 5/27/98, PA-05-SIA-25017-201-(SM1, SM6, SM7,SM8)
3.7.1.7.2.1.16.4	Thermal Delay Time	The time delay from heat applied to the SQUID bracket to the response at the GRT on the bracket shall be less than 1.0s. Will be tested in component-level tests for the Science Mission. Will be tested in GTU-2 integrated test.	A	Lower Level Compliance per: SQUID Kit/Readout VRCM, 5/27/98, PA-05-SIA-25017-201-(SM1, SM6, SM7,SM8)

Table 4: Lower Level Verifications

PLSE-12 #	Title	Requirement	Method	Compliance Data
3.7.1.9.1	Vibration Environment	DPA shall perform as specified after exposure to the following vibration testing levels Frequency (Hz) Qual (g^2/Hz) 20 0.016 20-50 +8.3 dB/Octave 50-150 0.1 150-1000 -9.8 dB/Octave > 1000 0.0	S	Lower Level Compliance per: DPA VRCM Feb 99 SIA/ Probe Integration VRCM 7/6/99; PA-05-SIA-25771-101-SM-1 P0358 DMA vibration test procedure
3.7.1.9.5	Diameter of Photoactive Area	The diameter of DPA photoactive area shall be less than 0.8 +/-0.1 mm.	S	Lower Level Compliance per: DPA VRCM Feb 99 Measurement of samples from the same lot.
3.7.1.9.7.1	Total Telescope Detector Power (All Detectors)	The total detector power shall be less than or equal to 6 mW (1.5 mW/DMA).	T	Lower Level Compliance per: DPA VRCM Feb 99 P0392 - Power Dissipation Test Reverified in PL Ver II - See S0558 for additional information.
3.7.1.9.10.1	External Quantum Efficiency Over Operating Bandwidth	The photocell quantum efficiency shall be greater than 60%	T	Lower Level Compliance per: DPA VRCM Feb 99 P0392 - Optical Responsivity test DR224 closed with Use as is. See S0363 and S0365
3.7.1.9.10.2	Dark Current	The photocell dark current shall be less than 0.01 fA at 80 K.	T	Lower Level Compliance per: DPA VRCM Feb 99 P0392 - Electrical Leakage Current Test
3.7.1.9.10.3	Operating Temperature (Si JFETs)	The JFET operating temperature shall be 85K +/- 5K.	T	Lower Level Compliance per: DPA VRCM Feb 99 P0392 - Temperature Stability Test
3.7.1.9.10.4	Random Noise	The DPA random noise shall be less than 100 electrons (rms)/(0.1 sec read) per photocell.	A	Lower Level Compliance per: DPA VRCM Feb 99 P0392 - Noise Test
3.7.1.9.10.5	Temperature Stability	The DPA shall have a temperature coefficient of less than 440 electron/(read)/K	T	Lower Level Compliance per: DPA VRCM Feb 99 P0392 - Thermal Coefficient Stability Test
3.7.2.1	Mechanical Interface Requirements	The dimensional interface between the probe and SIA shall be as described on LMMS drawing 1C34103.	I	Lower Level Compliance per: SIA/ Probe Integration VRCM 7/6/99; PA-05-SIA-25771-101-SM-1

Table 4: Lower Level Verifications

PLSE-12 #	Title	Requirement	Method	Compliance Data
3.7.2.1.4	Stress in the SIA Flange	Tensile and shear stresses in the quartz flange at the finger interface shall be < 725 psi, under all expected conditions.	A	Lower Level Compliance per: SIA/ Probe Integration VRCM 7/6/99; PA-05-SIA-25771-101-SM-1
3.7.2.1.5	Contact Between the SIA Flange and the Birdcage Ring	During integration of the SIA into the probe, the four radial gaps between the Quartz Block mounting flanges and the birdcage ring shall be shimmed such that the gap is 0.10 - .18 mm (0.004 -0.007") when the assembly is at 4.2 K.	I	Lower Level Compliance per: SIA/ Probe Integration VRCM 7/6/99; PA-05-SIA-25771-101-SM-1
3.7.2.1.6	Telescope Keepout Zone	The probe shall have a telescope keepout zone as shown in interface control drawing 1C34103.	I	Lower Level compliance per: Probe C AR, GPB-100269 v3, 15 May 98
3.7.2.2	Electrical Interface	The number, type, location, orientation, and pin allocation of the electrical connectors at the SIA/probe interface shall be as described on LMMS drawing 1C34103. The interface also conforms to the requirements listed in the following subsections.	I	Lower Level Compliance per: SIA/ Probe Integration VRCM 7/6/99; PA-05-SIA-25771-101-SM-1
3.7.2.2.1.3	Support of Stanford Jumper Wires	The probe structure shall have provisions to support the Stanford coaxial jumper wires at the edge of the birdcage per LMMS drawing 1C34103.	I	Lower Level Compliance per: Probe C AR, GPB-100269 v3, 15 May 98
3.7.2.2.3.1	Ground Connectors for the SIA	There shall be threaded holes in the extrusions for the attachment of ground wires as shown on LMMS drawing 1C34103.	I	Lower Level Compliance per: Probe C AR, GPB-100269 v3, 15 May 98
3.7.2.2.3.2	Quartz Block Support Resistance	The resistance between the z* Station 200* ring and the ground attachment points of 3.7.2.2.3.1 shall be <= 0.1 ohms.	T	Lower Level Compliance per: Probe C AR, GPB-100269 v3, 15 May 98
3.7.2.2.3.3	Composite Neck Tube Resistance	The primary ground path between the top hat and the z* Station 200* ring shall be the titanium foil lining of the composite neck tube. The resistance of the primary ground path between the top hat and the z* Station 200* ring shall be <= 0.5 ohms.	T	Lower Level Compliance per: Probe C AR, GPB-100269 v3, 15 May 98 (use as is)
3.7.2.2.3.4	Probe Conducting Parts	(1) All conducting parts forward of Station 159.13 in the probe with projected surface area >929 square centimeters (144 sq. in.) shall have a resistance to top hat ground < 10 Mohms. (2) Conducting loops in the region between the top hat and the Station 200 ring shall have a resistance > 20 ohms.	I,T	Lower Level Compliance: Final Probe C VRCM Vol. 1 Rev A
3.7.2.2.3.5	Top Hat	The resistance between any two points on the top hat shall be <= 0.1 ohms.	T	Lower Level Compliance per: Probe C AR, GPB-100269 v3, 15 May 98
3.7.2.2.3.6.1	Ground Bond Resistance	The resistance across any ground bond within the probe shall be <= 10 mohms. This does not apply for bonds within the probe conducting parts of 3.7.2.2.3.4	T	Lower Level Compliance: Final Probe C VRCM Vol. 1 Rev A

Table 4: Lower Level Verifications

PLSE-12 #	Title	Requirement	Method	Compliance Data
3.7.2.2.3.7	100% Shielded Enclosure	The probe shall provide a complete and continuous ground electrostatic shielding surface surrounding the Quartz Block assembly during normal operation. The sheet resistance shall be <= 20 mohms per square except for the coating of the warm window, which is governed by an RFI attenuation specification.	T	Lower Level Compliance per: Probe C AR, GPB-100269 v3, 15 May 98
3.7.2.2.3.7.1	Grounding of the Warm Window	The conductive coating on the window 4 substrate shall be electrically connected to the support ring around its circumference. The resistance from the center of the coating to the top hat shall be consistent with the RFI attenuation specification for the window.	A	Lower Level Compliance per: Probe C AR, GPB-100269 v3, 15 May 98
3.7.2.2.3.8	Grounding of Spin-up Filters	The resistance between ground and any gas filter in the spin-up lines shall be <= 2 ohms.	T	Lower Level Compliance per: Probe C AR, GPB-100269 v3, 15 May 98
3.7.2.2.4	Support of Stanford SQUID-to-Gyroscope Wires	The probe structure shall have provisions to attach a Stanford-supplied support to the spider for the Stanford SQUID-to-gyroscope wires per LMMS drawing 1C34103.	I	Lower Level Compliance per: Probe C AR, GPB-100269 v3, 15 May 98
3.7.2.3.6	Exhaust Line Pressure Drop	The pressure drop of the exhaust line from the probe/SIA interface to free space shall be <= 60 Pa (0.45 torr) at a flow rate per 3.7.2.3.3 for a gas temperature range of 5 - 7 K.	A	Lower Level verification per: Probe C AR, GPB-100269 v3, 15 May 98. (this requirement applies only to the Probe).
3.7.2.4.1	Number of Caging Circuits	There shall be three (3) separate circuits for the caging of the science gyroscopes. The circuits are configured such that gyros 1 & 2 are caged independently and gyros 3 & 4 are caged together.	I	Lower Level Compliance per: Caging VRCM 4/19/99; Probe C compliant
3.7.2.4.4	Volume of Displaced Gas	When the caging system is at its nominal operating pressure of 170 psi, the volume of liquid helium in each caging mechanism including the lines on the SIA side of the SIA/probe interface shall be <= 0.5 cm^3 (0.03 in^3). Each of the three independent caging circuits shall have a volume of liquid helium <= 1.0 cm^3 (0.06 in^3) on the SIA side of the SIA/probe interface when pressurized at the operating pressure.	I,A	Lower Level Compliance per: Caging VRCM 4/19/99; Probe C compliant
3.7.2.6.3	Location of Gyroscopes Within the Probe	The location of science gyroscope #1 shall be z* Station 153.29* +/- 0.10 inches. The location of science gyroscope #4 shall be z* Station 143.54* +/- 0.10 inches.	I	Lower Level Compliance per: SIA/ Probe Integration VRCM 7/6/99; PA-05-SIA-25771-101-SM-1
3.7.3	Probe Specification	The probe shall be designed to perform as specified in the following subsections while exposed to the orbital environments of 3.2.5.6. The probe shall survive exposure to the environments of 3.2.5.1 through 3.2.5.5 without degradation of its subsequent performance. The probe shall comply with the requirements of section 3.3.	I,A,T	Lower level compliance per Probe VRCD , Probe C ADP, GPB-100269 v3, 15 May 98

Table 4: Lower Level Verifications

PLSE-12 #	Title	Requirement	Method	Compliance Data
3.7.3.2.1	Probe Weight	The weight allocated to the probe assembly, including sunshade assembly, and excluding the SIA, is 180 kg, as specified in P024612.	A,T	Lower Level Compliance per: Probe C AR, GPB-100269 v3, 15 May 98
3.7.3.2.2.1	External Dimensions	The probe shall conform to the envelope dimensions, mechanical and electrical interface locations, fluid interface locations and vent locations given in 3.7.2, 3.7.4, and 3.7.6.	T	Lower Level Compliance per: Probe C AR, GPB-100269 v3, 15 May 98 (use as is)
3.7.3.2.2.2	Internal Compartment for SIA	The probe shall provide an internal location for the Science Instrument Assembly (SIA) that meets the interface requirements of section 3.7.2.	I	Lower Level Compliance per: Probe C AR, GPB-100269 v3, 15 May 98 (use as is)
3.7.3.2.3	Structural Characteristics	The probe shall be designed to accommodate the launch loads of section 3.2.5.5 and meet the structural resonance requirements of 3.2.2.4.	A,T	Lower Level Compliance per: Probe C AR, GPB-100269 v3, 15 May 98 EM SMS 304 Evaluation of Coupled Loads Analysis Results, EM SMS 349 Evaluation of PreMECO & MECO Loads Analysis Results, EM326/P065918 Updated Structural Analysis of the GP-B CNTs, GPB-100431 Stress Analysis of the Probe-C Electrical Cables, GPB-100432 Deflection Analysis of the Probe-C Cables, GPB-100433 Analysis of the UV Fiber Optic Cables in the Probe-B Tophat, EM222 (F428532) Structural Analysis of the Quartz Black Support, GPB- 100434 Structural Analysis and Weight Optimization of the Probe-C Cross Flange, GPB-100435 Stress Analysis of the probe-C Tophat, GPB-100436 Structural Analysis of the Probe-C Window 4 Assy, EM SMS 358A, Probe C Redesign Stress Analysis, EM SMS 355 Probe C Caging Lines Stress Analysis, EM SMS 288 Parametric Analysis of Probe C Thermal Gradients and Forces, EM SMS 339B Modification to the Axial Lock Restraint System (Belleville Preload System, BPS), EM SMS 396 GP-B Sunshade Stress Analysis Update, EM SMS 261 Probe C CNT Static Load Test
3.7.3.2.6	Handling Attachments	The probe shall provide a means of attaching GSE for the purpose of lifting and rotating the probe as stated in the following subsections.	I	Lower Level compliance per Probe C VRCD, Probe C ADP, GPB-100269 v3, 15 May 98

Table 4: Lower Level Verifications

PLSE-12 #	Title	Requirement	Method	Compliance Data
3.7.3.2.6.1	Lifting Support	The probe shall provide a lifting support to allow the probe to be raised by an overhead hoist with the z* axis vertical.	I	Lower Level Compliance per: Probe C AR, GPB-100269 v3, 15 May 98
3.7.3.2.6.2	Orientation Capability	The probe shall provide GSE attachment points at z* Station 200*. The attachment points shall be designed to enable the probe to be tilted from horizontal to vertical and rotated about the z* axis.	I	Lower Level Compliance per: Probe C AR, GPB-100269 v3, 15 May 98
3.7.3.2.9	Preload System	A preload system shall be capable of clamping the probe to the dewar at Station 200 as specified in drawing 5833117. The system shall provide a minimum of 8896N (2000 lb) load force across the Station 200 interface for the worst case on-orbit temperatures.	A	Lower Level Compliance per: Probe C AR, GPB-100269 v3, 15 May 98 Probe level Verification also addressed by Modification to the Axial Lock Restraint System (Belleville Preload System, BPS), SMS 339B; Belleville PreLoad System Tolerance Analysis, SMS 258
3.7.3.3	Magnetic Environment	The probe occupies portions of magnetic zones 2A through 5 and SP described in section 3.3.1.1.14.1. The materials used in the probe shall conform to the requirements of 3.3.1.1.14.	I,T	Lower Level Compliance per: Probe C AR, GPB-100269 v3, 15 May 98
3.7.3.3.1	Probe Residual Steady State Field	The residual field of the probe assembly shall be consistent with 3.2.1.3.1.	T	Lower Level Compliance per: Probe C AR, GPB-100269 v3, 15 May 98 (use as is)
3.7.3.4.2	Thermal Connections	The probe to dewar interface shall be designed to meet the thermal interface requirements of 3.7.2.5.	I	Lower Level Compliance per: Probe C AR, GPB-100269 v3, 15 May 98
3.7.3.4.6	Spin-up Gas Heating	The probe shall provide the capability to warm the spin-up inlet filter to meet the requirement of 3.7.2.3.5.	T	Lower Level Compliance per: Probe C AR, GPB-100269 v3, 15 May 98
3.7.3.5.3	Vacuum During Operational Life	After completion of spin-up and the low-temperature bakeout, the probe shall be capable of reducing and maintaining the internal pressure to meet the vacuum requirements of 3.2.1.2.2.	A	Lower Level Compliance per: Probe C AR, GPB-100269 v3, 15 May 98
3.7.3.5.4	External Pressure	The probe shall withstand a one atmosphere [101 kPa (760 torr)] external pressure under all ground operating conditions.	T	Lower Level Compliance per: Probe C AR, GPB-100269 v3, 15 May 98
3.7.3.5.5.1	Helium Permeation and Leak Rate through Top Hat and Cross Flange Region	The helium permeability rate and leak rate through the top hat section of the probe, not including the permeation through the elastomers of the vatterfly valves, with one atmosphere of helium outside the probe Top Hat and Cross-flange shall be <= 1 x 10-7 scc/s He (goal <= 10-8 scc/s He)	S	Lower Level Compliance per: Probe C AR, GPB-100269 v3, 15 May 98
3.7.3.5.5.2	Helium Permeation and Leak Rate through Probe Walls	The helium permeability rate and leak rate through the probe walls with one atmosphere of helium outside the probe composite neck tube and vacuum shell shall be <= 1 x 10-6 scc/s He (goal <= 10-7 scc/s He)	S	Lower Level Compliance per: Probe C AR, GPB-100269 v3, 15 May 98

Table 4: Lower Level Verifications

PLSE-12 #	Title	Requirement	Method	Compliance Data
3.7.3.5.5.3	Probe Outgassing Rate for All Gases	The probe shall achieve a room temperature outgassing rate of less than 1 x 10-4 scc/s (goal less than 10-5 scc/s) within 100 hours of pumping at room temperature.	T	Lower Level Compliance per: Probe C AR, GPB-100269 v3, 15 May 98
3.7.3.5.5.4	Probe Outgassing Rate of Helium	The probe shall have a helium outgassing rate of <= 5 x 10-8 scc/s He (goal <= 10-9 scc/s He) after filling the interior of the probe with 1 torr of helium and immersing the exterior of the probe with 1 atmosphere of helium for 1 day and then pumping for 1 day.	S	Lower Level Compliance per: Probe C AR, GPB-100269 v3, 15 May 98
3.7.3.5.5.5	Internal Pressure Measurement	The probe shall provide capability for measuring internal pressure with pressure gauges sensitive to probe pressure. One gauge is to be located at the top of the pressure sensing line (P-1 line) and two are located on the cross flange, as shown in ICD 1C34355.	I	Lower Level Compliance per: Probe C AR, GPB-100269 v3, 15 May 98
3.7.3.5.5.5.1	Provision for "T" in P1 line	The probe shall be designed with a "T" in the P1 line between the top hat and the P1 valve. This branch shall have a 2 +/-m filter, a Nupro valve and Gamah fitting for mating with the gas feed line coming up from the GMA.	I	Lower Level Compliance per: Probe C AR, GPB-100269 v3, 15 May 98
3.7.3.5.5.6	Trapped Volumes	Designs shall not create trapped volumes that are difficult to pump out or other construction that may become virtual leaks.	I	Lower Level Compliance per: Probe C AR, GPB-100269 v3, 15 May 98
3.7.3.6	Cleanliness and Contamination	The probe shall meet the requirements of the cleanliness and contamination zones as defined in section 3.3.1.2.6. The materials used in the probe shall conform to the requirements of 3.3.1.2.6.	I	Lower Level Compliance per: Probe C AR, GPB-100269 v3, 15 May 98
3.7.3.7.1.1	Sunshade-Induced Residual Position Error	The sunshade shall induce a residual position error over the linear range of <= 0.048 milliarcseconds after bias & scale factor corrections are applied.	A	Lower Level Compliance per: Final Probe-C VRCD; compliance via GPB-10061. Probe Window (1-3) Thermal Gradients, EM146, F314431, Updated Thermal Analyses of GPB Window, GPB-10061 includes Sunshade induced error.
3.7.3.7.1.2	Window-Induced Residual Position Error	The total set of probe windows shall induce a residual position error over the linear range of <= 0.048 milliarcseconds after bias & scale factor corrections are applied.	A	Lower Level Compliance per: Final Probe-C VRCD; compliance via 102546/EM462. Probe Window (1-3) Thermal Gradients, EM146, F314431, Updated Thermal Analyses of GPB Window, GPB-10061. Above analyses are for the combination of sunshade and window 4 .Linear Thermal Gradients in Windows 3 & 4 GPB 102546/EM 462;Evaluating the Effect of Flight Temperatures on Window 4 EMI Coating Transmission GPB 102617/EM 466

Table 4: Lower Level Verifications

PLSE-12 #	Title	Requirement	Method	Compliance Data
3.7.3.7.1.3	Ghost Image-Induced Residual Position Error	The ghost image induced residual position error shall be <= 0.048 milliarcseconds over the linear range after bias & scale factor corrections are applied.	A	Lower Level Compliance per: Probe C AR, GPB-100269 v3, 15 May 98
3.7.3.7.1.4	Scattered Light-Induced Residual Position Error	The scattered light induced residual position error shall be <= 0.048 milliarcseconds over the linear range after bias & scale factor corrections are applied.	A	Lower Level Compliance per: Probe C AR, GPB-100269 v3, 15 May 98
3.7.3.7.2	SIA View of Space	The probe shall provide the SIA with a straight optical path to space to meet the requirements of 3.2.1.5.2.2 and 3.2.1.5.2.3.	I	Lower Level Compliance per: Probe C AR, GPB-100269 v3, 15 May 98
3.7.3.7.3.1	Transmissibility to the Telescope	The transmissibility through the probe windows combined shall average greater than 65% over the transmission band of 3.2.1.5.3.1.	T	Lower Level Compliance per: Final Probe C VRCD: Window transmissibility tested at component level. Gravity Probe-B Window system Transmissibility EM 476/GPB-102632
3.7.3.7.4.1.1	Sunshade/Window #4 EMI Filtration with Shutter Open	The EMI attenuation capability of the sunshade/window #4 combination with the shutter open shall be as follows: 80 dB from 10 kHz to 250 MHz 80 dB at 250 MHz decreasing to 65 dB at 1 GHz	A	Lower Level Compliance per: Final Probe-C VRCD; compliance via analysis EM SYS 230. SYS 230 EMI Attenuation of the Probe Sunshade from 10kHz to 1 GHz
3.7.3.7.4.1.2	Sunshade/Window #4 EMI Filtration with Shutter Closed	The Sunshade/Window #4 combination, with the sunshade shutter closed, shall attenuate EMI to an amplitude <= 0.1 V/m behind Window #4 for the following EMI sources at the entrance to the sunshade: Frequency Amplitude 1.40 GHz 10.0 V/m 2.15 GHz 30.0 V/m 2.80 GHz 9.0 V/m 5.70 GHz 40.0 V/m 7.00 GHz 170.0 V/m 10.00 GHz 100.0 V/m In addition, the EMI attenuation capability of the sunshade/window #4 combination with the shutter closed shall be as follows: 80 dB from 10 kHz to 250 MHz; 80 dB at 250 MHz decreasing to 65 dB at 1 GHz	A	Lower Level Compliance per: Probe C AR, GPB-100269 v3, 15 May 98

Table 4: Lower Level Verifications

PLSE-12 #	Title	Requirement	Method	Compliance Data
3.7.3.7.4.2	Window #4 EMI Filtration	The EMI attenuation capability of the window 4 coating shall be as follows: >= 40 dB at frequencies between 1 GHz and 100 GHz	A,T	Lower Level Compliance per: Final Probe-C VRCD; compliance via PRC 0636 (LL 801) 3/9/98 Window 4 EMI Coating, Environmental Testing Results, Presentation to Stanford, 12 Jan 98, P480018. Window EMI tested at component level EMI Testing of the Engineering Model Sapphire Window 4 PRC0636, and flight unit Assembly of flight window 4 PRC0590.
3.7.3.8	Electrical Cables	The probe shall provide the quantity and type of electrical cables called out in table 3.7.3-1 and the following subsections. (See OLE tab.)	I	Lower Level Compliance per: Probe C AR, GPB-100269 v3, 15 May 98
3.7.3.8.1	Coaxial Cables	Coaxial connectors and cables, shall meet or exceed the requirements specified in tables 3.7.3-2. (See OLE tab.)	I,A,T	Lower Level Compliance per: Probe C AR, GPB-100269 v3, 15 May 98
3.7.3.8.1.1	Ground and UV Bias Cables	The ground and UV bias cables, shall have the pin-to-pin locations specified in Table 3.7.3-3. (See OLE tab.)	I	Lower Level Compliance per: Probe C AR, GPB-100269 v3, 15 May 98
3.7.3.8.2	SQUID Cables	The SQUID cables shall meet the performance requirements of tables 3.7.3-4 and 3.7.3-5. (See OLE tab.)	I,A,T	Lower Level Compliance per: Probe C AR, GPB-100269 v3, 15 May 98 (some areas use as is)
3.7.3.8.3.1.1	SQUID GRTs Wiring	The SQUID Package GRT's identified as T-8Q, T-9Q, T-10Q and T-11Q shall have their drive and sense wires routed in separate shields. The GRT sense wires shall also be routed separately from any heater wires, with the exception that the SQUID loop and mounting bracket heater wires may be run with the GRT sense lines. The GRT drive wires may be routed in a shield with remaining heater wires.	I	Lower Level Compliance per: Probe C AR, GPB-100269 v3, 15 May 98
3.7.3.8.3.1.2	Wiring for Other SIA GRTs	The GRT drive and sense wires for SIA instrumentation, other than what is identified in 3.7.3.8.3.1, may run together in the same shield.	I	Lower Level Compliance per: Probe C AR, GPB-100269 v3, 15 May 98
3.7.3.8.3.1.3	Probe Instrumentation	The wires running from the probe sensors to the terminal blocks located at the end of the instrumentation cables may be unshielded. Probe is identified with a suffix designation of "P" (e.g. T-6P)	I	Lower Level Compliance per: Probe C AR, GPB-100269 v3, 15 May 98
3.7.3.8.3.2	Twisted Pair Conductor Separation	The separation of the two conductors in any instrumentation circuit shall not exceed 5 mm (0.2 in) at any point in magnetic zone 1 or 10 mm (0.4 in) in any other magnetic zone.	I	Lower Level Compliance per: Probe C AR, GPB-100269 v3, 15 May 98
3.7.3.8.3.3	Instrumentation to Suspension Cable Separation	The separation of instrumentation lines from suspension lines shall be >= 3 cm.	I	Lower Level Compliance per: Probe C AR, GPB-100269 v3, 15 May 98

Table 4: Lower Level Verifications

PLSE-12 #	Title	Requirement	Method	Compliance Data
3.7.3.8.3.4	Flux Density Induced by Instrumentation	The flux density measured at a distance of 2 cm (0.8 in) from any instrumentation circuit while conducting its maximum current during normal operation shall be: In magnetic zone 1: <= 1 x 10-11 tesla (10-7 gauss) for frequencies from DC to 0.001 Hz <= 1 x 10-13 tesla (10-9 gauss) for frequencies from 0.001 to 0.1 Hz <= 1 x 10-11 tesla (10-7 gauss) for frequencies from 0.1 Hz to 1 GHz In other regions within dewar: <= 1 x 10-8 tesla (10-4 gauss) for frequencies from DC to 1 GHz	A	Lower Level Compliance per: Probe C AR, GPB-100269 v3, 15 May 98
3.7.3.8.4.1.1	Connectors and Cables	Materials used in the connectors and cables shall have been tested to ASTM-E-595 or JSC-SSP-R-0022.	I	Lower Level Compliance per: Probe C AR, GPB-100269 v3, 15 May 98
3.7.3.8.4.1.2	Center Conductor Material	Center conductors for all cables shall be UNS-C-510 phosphor bronze A, UNS-C-507 phosphor bronze E, or OFHC copper in accordance with QQ-B-750.	I	Lower Level Compliance per: Probe C AR, GPB-100269 v3, 15 May 98
3.7.3.8.4.1.3	Conductor Material for UV Bias and Low Voltage Ground Wires	The wire material and size for the UV bias and low voltage ground wires shall be the same as the gyroscope suspension wires.	N/A	Lower Level Compliance per: Probe C AR, GPB-100269 v3, 15 May 98
3.7.3.8.4.2	Cycle Life	The cables shall have a failure-free mechanical cycle life of 30 cycles. A cycle consists of one thermally-induced contraction and subsequent expansion.	A	Lower Level Compliance per: Probe C AR, GPB-100269 v3, 15 May 98
3.7.3.9	Science Gyroscope Ultraviolet Charge Control	Probe-C shall provide a minimum of 2 fiber optic cables to each gyroscope, 2 cables to the proof mass and 2 spare cables for the gyroscopes. The cables shall meet the following requirements: frequency of light 254 nm; input energy 5 +/-W; duration of exposure 3 years; attenuation from output of cable at tophat to output of probe cable at SIA interface: <= 9 dB (end of life); <= 2 dB after 200 hrs at 5 +/- 3 +/-W; degradation profile: asymptotic (no degradation greater than measurement error in last 100 hours)	I,T	Lower Level Compliance per: Final Probe C VRCD; compliance via PRC 0780 (LL869) 11/02/98. Test results in Probe-C Acceptance Test Procedure Summary Report, 1C34932, Vol.1.

Table 4: Lower Level Verifications

PLSE-12 #	Title	Requirement	Method	Compliance Data
3.7.3.10.1	Gyroscope Spin-up	The probe shall provide the piping, gas flow components, and fittings which connect the spin-up gas assembly to the SIA to meet the gyroscope spin-up requirements of 3.7.2.3 and the following requirements.	I	Lower Level Compliance per: Probe C AR, GPB-100269 v3, 15 May 98
3.7.3.10.1.1.1	Spin-up Inlet Warm Filter	There shall be a 2 +/-micron filter in each spin-up inlet line external to the top hat.	A	Lower Level Compliance per: Probe C AR, GPB-100269 v3, 15 May 98
3.7.3.10.1.1.2	Spin-up Inlet Cold Filter	The spin-up inlet line cold filter shall have a surface area five times the surface area of the spin-up inlet line from the filter to the point it reaches 20 K.	A	Lower Level Compliance per: Probe C AR, GPB-100269 v3, 15 May 98
3.7.3.10.1.2	Cleanliness of Spin-up Gas Components	Cleanliness of the spin-up gas assembly components shall be per the cleanliness requirements of Zone II and VII per section 3.3.1.2.6.	I,T	Lower Level Compliance per: Probe C AR, GPB-100269 v3, 15 May 98
3.7.3.10.2	Gyroscope Caging	The probe shall provide fluid lines from the top hat to the SIA caging interface to meet the caging requirements of section 3.2.1.6 and the following requirements.	I	Lower Level Compliance per: Probe C AR, GPB-100269 v3, 15 May 98
3.7.3.10.2.1	Redundancy	Each independent circuit shall meet the redundancy requirement of section 3.2.1.6.3.	I	Lower Level Compliance per: Probe C AR, GPB-100269 v3, 15 May 98
3.7.3.10.2.2	Cleanliness of Caging Assembly Components	The caging assembly components shall be designed to meet the cleanliness and contamination requirements of Zones I, III, IV, V, and VII as stated in 3.3.1.2.6.	I	Lower Level Compliance per: Probe C AR, GPB-100269 v3, 15 May 98
3.7.3.10.2.3	Volume of Caging Lines	The portion of the caging lines below HEX2 on the probe side of the SIA/probe interface shall have a volume of <= 4.0cubic centimeters (0.24 cubic inches) per caging circuit.	A	Lower Level Compliance per: Probe C AR, GPB-100269 v3, 15 May 98
3.7.3.10.3	Pressure Sense Line	The probe shall provide a pressure sense line from a fitting at the top hat to a point near the SIA.	I	Lower Level Compliance per: Probe C AR, GPB-100269 v3, 15 May 98
3.7.3.11	Handling	At the completion of all cleaning procedures, all items shall be capped with Level 100 caps and bagged to control to a Class 100 environment. Items must be removed from their bags and then the caps must be removed in a Class 100 or better clean room.	I	Lower Level Compliance per: Probe C AR, GPB-100269 v3, 15 May 98
3.7.3.12.1	Storage Life	The probe shall be designed to meet the requirements of 3.2.1.8.	A	Lower Level Compliance per: Probe C AR, GPB-100269 v3, 15 May 98
3.7.3.12.2	Orbital Life	The probe shall perform as specified herein for the orbital life of 3.2.1.10.	A	S0599 covers this verification (this is not a uniquely verifiable requirement).

Table 4: Lower Level Verifications

PLSE-12 #	Title	Requirement	Method	Compliance Data
3.7.4.1	Mechanical Interface	The dimensional interface between the probe and dewar is described by LMMS drawing 5833117.	I	Lower Level compliance per: Dewar AR, GPB-100155A, 26 Feb 97; Probe C AR, GPB-100269 v3, 15 May 98 SMD Acceptance Test Procedure, Vol.2, ICD Verification, 5835036.
3.7.4.1.1	Probe Structural Support	The probe shall be structurally supported by the dewar at the top plate to top hat interface, and preloaded against Station 200, as shown in drawing 1C34111.	T	Lower Level compliance per: Dewar AR, GPB-100155A, 26 Feb 97; Probe C AR, GPB-100269 v3, 15 May 98 SMD Acceptance Test Procedure, Vol.2, ICD Verification, 5835036.
3.7.4.1.2	Lead Bag Retainer Interface	The probe shall structurally interface with the dewar well via the lead bag retainer, as specified in drawing 5833117.	I,A,S	Lower Level compliance per: Dewar AR, GPB-100155A, 26 Feb 97; Probe C AR, GPB-100269 v3, 15 May 98 Retainer used in EDD for GTU-1.
3.7.4.2.2	Conductive Loops	There shall be no conductive loops through the integrated probe and dewar assembly that cross a temperature differential of >= 5 K. Conductive loops through the integrated probe and dewar assembly in isothermal (<= 5 K differential) regions are permitted.	I	Lower Level Compliance per: Dewar AR, GPB-100155A, 26 Feb 97; Probe C AR, GPB-100269 v3, 15 May 98. Note: No Place in the SIA has >5K differential.
3.7.4.3	External Alignment Reference	A reference surface that is on the top exterior of the dewar shall be aligned to +/- 0.25 degrees, to the QBA mounting flange. This surface shall be controlled by LMMS ICD drawing 1C34102.	A,T	Lower Level Compliance per: Dewar AR, GPB-100155A, 26 Feb 97; N/A for Probe C SMD Acceptance Test Procedure, Vol.2, ICD Verification, 5835036.Internal Alignment of the SMD, GPB-100647
3.7.4.4.1	Thermal Interface at Station 200	The thermal interface between the probe and dewar at Station 200 shall be designed such that the probe will meet all its thermal requirements as specified in Section 3.7.3.4.	I,A	Lower Level Compliance per: Dewar AR, GPB-100155A, 26 Feb 97; Probe C AR, GPB-100269 v3, 15 May 98
3.7.4.4.2	Probe Thermal Grounding to Dewar	The probe shall be thermally grounded to the dewar via thermal conductance through 24 thermal shoes, 6 on each heat station ring, which contact the dewar thermal stop rings.	I	Lower Level compliance per: Dewar AR, GPB-100155A, 26 Feb 97; Probe C AR, GPB-100269 v3, 15 May 98 SMD Acceptance Test Procedure, Vol.2, ICD Verification, 5835036
3.7.5	Dewar Specification	The Science Mission Dewar (SMD) shall be designed to perform as specified in the following subsections while exposed to the orbital environments of Stanford document P0149. The SMD shall survive exposure to the ground and launch environments of 3.2.5.1 through 3.2.5.5 without degradation of its subsequent performance. The SMD shall comply with the design requirements of section 3.3.	I,A,T,D	Lower Level Compliance per: Dewar VRCD (Dewar AR, GPB-100155A, 26 Feb 97 & GPB-100168 Analysis of Science Mission Dewar Top Plate)

Table 4: Lower Level Verifications

PLSE-12 #	Title	Requirement	Method	Compliance Data
3.7.5.2.1.1	Dry Weight	The dry weight allocated to the SMD in P024612-6 is 862 kg.	A,T	Lower Level Compliance per: Dewar AR, GPB-100155A, 26 Feb 97: The actual dry dewar weight is 786 kg. See SMD Acceptance Test Procedure, Vol.1, 5835036.
3.7.5.2.2	Axial Short Term Shift in Center of Gravity	The allowable short term shift in the center of gravity of the superfluid helium in the main tank shall be as shown in figure 3.7.5-1, for axial motion. Short term is defined as motion occurring over a time span of <= 1 week. (See OLE tab.)	A,T	Lower Level Compliance per: Dewar compliance, PLIT-03, GPB 100155A, 26Feb 97. Analyses listed in SMD VRCD, GPB-100155A, Feb 97. Scale model tests at Purdue U. verified axisymmetric bubble around well when vehicle rolled initially to 1 rpm, then slowed to 0.3 rpm.
3.7.5.2.4	Main Tank Volume	The main tank shall provide a reservoir for storing superfluid helium of sufficient volume to satisfy the orbital lifetime requirement of 3.2.1.10.	I,A	Lower Level Compliance per: Dewar AR, GPB-100155A, 26 Feb 97 Volume of liquid helium is 2319 liters at 95% full, by design. Steady state thermal model predicts volume meets lifetime requirement.
3.7.5.2.5	Vacuum Shell	The SMD Vacuum Shell shall provide the external shell for surviving the ground and launch environments of 3.2.5.1 through 3.2.5.5 and the orbital environments of Stanford document P0149, and provide thermal isolation of the main tank with respect to these environments.	I,A,T	Lower Level Compliance per: Dewar VRCD; DR R13235 closed 5/7/97. Vacuum shell proof-pressure tested to 37 psid. Vacuum Shell will withstand two-fault tolerance of any postulated event, including Main Tank burst disc venting plus Emergency Vent Line failure. See GPB-10051A, 11/94.
3.7.5.2.5.1	Support Ring	A support ring shall provide the structural support interface between payload and spacecraft, as specified in drawing 5833115.	I,T	Lower Level Compliance per: Dewar AR, GPB-100155A, 26 Feb 97 See SMD Acceptance Test, Vol.2, ICD Verification, 5835036, for Interface verification.
3.7.5.2.5.4	Forward Cone Rings	Three rings shall be provided on the forward cone of the SMD vacuum shell at approximate locations Stations 193, 202, 210 to support cables, plumbing lines, and magnetometers. Regularly spaced mounting holes of approximately 0.5 cm (0.2 in) diameter shall be provided in the rings for flexibility in routing.	I,T	Lower Level Compliance per: Dewar AR, GPB-100155A, 26 Feb 97 See SMD Acceptance Test, Vol.2, ICD Verification, 5835036, for Interface verification.

Table 4: Lower Level Verifications

PLSE-12 #	Title	Requirement	Method	Compliance Data
3.7.5.2.6.1	Well	The main tank shall include a well for housing the probe assembly that meets the interface requirements of section 3.7.4 and drawing 5833117.	I,T	Lower Level Compliance per: Dewar AR, GPB-100155A, 26 Feb 97 See SMD Acceptance Test, Vol.2, ICD Verification, 5835036, for Interface verification.
3.7.5.2.6.3	Top Plate Assembly	The SMD top plate/bellows assembly shall provide the structural interface for the probe top hat as specified in drawing 5833117.	I,A,T	Lower Level Compliance per: Dewar AR, GPB-100155A, 26 Feb 97 & GPB-100168 Analysis of Science Mission Dewar Top Plate See SMD Acceptance Test, Vol. 3 Critical Component Tests, 5835036, for lateral load tests on Top Plate Bellows.
3.7.5.2.6.4	Lead Bag Retainer	The SMD lead bag retainer shall provide structural support for the lead bag, and the structural interface for the probe with the dewar well as specified in drawing 5833117, while meeting the magnetic requirements specified in section 3.3.1.1.14.1 and P0057A.	I,A,T	Lower Level Compliance per: Dewar AR, GPB-100155A, 26 Feb 97
3.7.5.2.7	Guard Tank Volume	The guard tank shall provide a volume which satisfies the launch pad ground hold requirement of section 3.2.1.9.	I,A,T	Lower Level Compliance per: Dewar AR, GPB-100155A, 26 Feb 97 See SMD Acceptance Test, Vol. 1 System Level Tests, 5835036, for ground hold test.
3.7.5.2.8.1	Structural Strength	The SMD shall be capable of accommodating the loads resulting from any dewar attitude which will occur during ground handling, or during launch, as specified in Sections 3.2.5.1 through 3.2.5.5.	A	Lower Level Compliance per: Dewar AR, GPB-100155A, 26 Feb 97
3.7.5.2.8.2.1	First Resonance During Launch	The SMD shall conform to the space vehicle lowest resonance of >= 9 Hz in the lateral direction and >= 28 Hz in the axial direction when in its launch configuration.	A,T	Lower Level Compliance per: Dewar AR, GPB-100155A, 26 Feb 97
3.7.5.2.8.2.2	First Resonance In Orbit	The SMD shall conform to the primary payload resonance on orbit of >= 10 Hz.	A	Lower Level Compliance per: Dewar AR, GPB-100155A, 26 Feb 97
3.7.5.2.8.3.1	Initial On-orbit Uncertainty	The initial on-orbit uncertainty in the roll position sensor mounting surface relative to the Quartz Block Support structure interface plane shall not exceed 1 degree.	I,A,T	Lower Level compliance per: Dewar compliance, PLIT-03, GPB 100155A, 26Feb 97. Mid cylinder tilt relative to Station 200 was <= .004 deg. See Internal Alignment of the SMD, GPB-100647.
3.7.5.2.8.3.2	Long Term Drift	The roll position sensor mounting surface, relative to the Quartz Block/support structure position, shall drift in a "random walk" fashion <= 5 arcseconds (+/- 2.5 arc-sec) per year about the space vehicle roll axis.	A	Lower Level Compliance per: Dewar AR, GPB-100155A, 26 Feb 97

Table 4: Lower Level Verifications

PLSE-12 #	Title	Requirement	Method	Compliance Data
3.7.5.2.8.3.3	Roll Period Stability	The roll position sensor mounting surface, relative to the Quartz Block/support structure position, shall shift <= 0.5 arcseconds during a roll period, about the roll axis (assuming 10 +/-C vacuum shell variation during a roll cycle).	A	Lower Level Compliance per: Dewar AR, GPB-100155A, 26 Feb 97
3.7.5.3.1.1	Cryoperm Steady State Shielding	The dc shielding of the cryoperm shield shall yield a flux density <= 3 x 10-6 tesla (.03 Gauss) at the science gyro locations, and <= 1 x 10-5 tesla (.1 Gauss) at the mouth of the lead bag (Station 191).	T	Lower Level Compliance per: Dewar AR, GPB-100155A, 26 Feb 97 See SMD Acceptance Test Report, Vol.3, Critical Components Tests, 5835036. Measured <= .012 Gauss in zone 2, <= .053 Gauss at Station 191.
3.7.5.3.2.1	Cryoperm Longitudinal Shielding Factor	The cryoperm shield shall provide an attenuation factor of the external magnetic field <= 0.2 in the longitudinal direction, throughout the interior of the shield up to the mouth of the lead bag (Sta. 191), when the cryoperm is at a temperature <= 4 K.	T	Lower Level Compliance per: Dewar AR, GPB-100155A, 26 Feb 97 See SMD Acceptance Test Report, Vol.3, Critical Components Tests, 5835036. Measured <= .18 in zone 3 at 4 K, <= .0186 in zone 2 at 4 K. Reference PCB #362
3.7.5.3.2.2	Cryoperm Transverse Shielding Factor	The cryoperm shield shall provide an attenuation factor of the external magnetic field <= 0.015 in the transverse direction, throughout the interior of the shield up to the mouth of the lead bag (Sta. 191), when the cryoperm is at a temperature <= 4 K.	T	Lower Level Compliance per: Dewar AR, GPB-100155A, 26 Feb 97 See SMD Acceptance Test Report, Vol.3, Critical Components Tests, 5835036. Measured <= .0122 in zone 3 at 4K, <= .007 in zone 2 at 4K. Reference PCB #362
3.7.5.4	Proton Shielding	The SMD shall incorporate a separate proton shield around the well to provide additional proton shielding in addition to the intrinsic shielding provided by the SIA, probe and dewar. The proton shield shall provide aluminum in the areas shown in figure 3.7.5-2. (See OLE tab.)	I	Lower Level Compliance per: Dewar AR, GPB-100155A, 26 Feb 97
3.7.5.5.2	Vapor Cooled Shields	Vapor cooled shields shall provide thermal grounding of the incoming parasitic heat load to the SMD heat exchangers.	I,A	Lower Level Compliance per: Dewar AR, GPB-100155A, 26 Feb 97
3.7.5.5.4	Heat Exchangers	Heat exchangers shall provide heat exchange between the outgoing helium vent gas and the incoming parasitic heat load.	I,A,T	Lower Level Compliance per: Dewar AR, GPB-100155A, 26 Feb 97
3.7.5.5.5	Passive Orbital Disconnect Struts	Passive Orbital Disconnect Struts (PODS) shall provide structural support for the main tank relative to the vacuum shell, and thermally isolate the main tank from the ambient environment in orbit.	I,A,T	Lower Level Compliance per: Dewar VRCD; DR R13061 closed 5/7/97.
3.7.5.5.6	Composite Neck Tube and Thermal Stop Rings	Thermal Stop Rings on the SMD Composite Neck Tube shall provide the physical interface for thermally grounding the probe neck tube to the heat exchangers of the SMD.	I,A,T	Lower Level Compliance per: Dewar AR, GPB-100155A, 26 Feb 97

Table 4: Lower Level Verifications

PLSE-12 #	Title	Requirement	Method	Compliance Data
3.7.5.5.6.1	Neck Tube Liner	A titanium foil liner shall be provided on the interior surface of the CNT to act as a vacuum permeation barrier in the neck tube region.	I,A	Lower Level Compliance per: Dewar AR, GPB-100155A, 26 Feb 97
3.7.5.5.8	Well Fill Temperature Control	The SMD shall be capable of maintaining the helium that is being introduced into the well at a temperature less than or equal to the lead bag temperature of 6.5 K.	A,T	Lower Level Compliance per: Dewar AR, GPB-100155A, 26 Feb 97
3.7.5.6.1	Venting to the Spacecraft Thrusters	Helium boiloff gas from the main tank shall be provided to the spacecraft thrusters as the propellant for the Spacecraft Force and Torque System.	I,A	Lower Level Compliance per: Dewar AR, GPB-100155A, 26 Feb 97
3.7.5.6.1.1	Venting through the Porous Plug	Venting of the superfluid helium in orbit shall be through a Porous Plug, capable of a flow rate range encompassing 4 - 16 mg/s, at a bath temperature of 1.8 K.	A,T	Lower Level Compliance per: Dewar AR, GPB-100155A, 26 Feb 97
3.7.5.6.2	Helium Vent Locations	The regions in which helium boiloff gas is vented during normal or emergency ground and orbital operations shall be as shown in drawing 5833115.	I	Lower Level Compliance per: Dewar AR, GPB-100155A, 26 Feb 97
3.7.5.6.3	Venting During Ground Operations	For ground operations, the SMD shall provide a main tank vent path which bypasses the spacecraft thrusters, and vents the main tank either to the ambient atmosphere, or to a vacuum pump.	I,A,T	Lower Level Compliance per: Dewar VRCD; DR R13234 closed 5/7/97.
3.7.5.6.3.1	Porous Plug Bypass Vent Path	For ground operations, a Porous Plug bypass valve shall be provided as an alternate vent path for the helium boil-off gas.	I	Lower Level Compliance per: Dewar AR, GPB-100155A, 26 Feb 97
3.7.5.6.3.2	Venting of Guard Tank	A vent path independent of the main tank vent path shall be provided for venting the guard tank either to the ambient atmosphere or to a vacuum pump.	I,A	Lower Level Compliance per: Dewar AR, GPB-100155A, 26 Feb 97
3.7.5.6.4	Venting of the Well When SFHe is Present	The SMD shall provide for venting of the well in the event SFHe is introduced in the well for launch.	I,A	Lower Level Compliance per: Dewar AR, GPB-100155A, 26 Feb 97
3.7.5.7.1	Filling of the Main Tank	It shall be possible to fill the main tank up to 95% full from an external liquid helium supply dewar with the SMD vertical (+z* up).	T	Lower Level Compliance per: Dewar AR, GPB-100155A, 26 Feb 97 SMD Acceptance Test Procedure, Vol.1, System Level Tests, 5835036.
3.7.5.7.2	Filling of the Guard Tank	It shall be possible to fill the guard tank up to 95% full of NBPHe with the SMD vertical.	T	Lower Level Compliance per: Dewar AR, GPB-100155A, 26 Feb 97 SMD Acceptance Test Procedure, Vol.1, System Level Tests, 5835036.

Table 4: Lower Level Verifications

PLSE-12 #	Title	Requirement	Method	Compliance Data
3.7.5.7.3	Fill Line Filter	There shall be a 10 +/-m filter in the dewar fill line just downstream of bayonet B3 and upstream of all RAVs. The pressure drop of this filter shall allow transfer of LHe at a temp <= 4.5K at a rate >= 200 liters/hour, with <= 207 torr (4 psid) overpressure in the supply dewar. For GHe over a temp range of 4.5 - 293 K, a 70 torr differential pressure across this filter shall produce a flow rate of 4 g/min or greater.	A,T	Lower Level Compliance per: Dewar AR, GPB-100155A, 26 Feb 97 SMD Acceptance Test Procedure, Vol.1, System Level Tests, 5835036.
3.7.5.7.4.1	External Well Fill Capability	It shall be possible to fill the well with NBPHe from an external liquid helium supply dewar with the SMD vertical.	I,A,T	Lower Level Compliance per: Dewar AR, GPB-100155A, 26 Feb 97 SMD Acceptance Test Procedure, Vol.1, System Level Tests, 5835036.
3.7.5.7.4.2	Internal Well Fill Capability	It shall be possible to transfer liquid helium, including both normal helium and superfluid helium, from the main tank to the well without the use of external plumbing. The SMD shall be vertical during well fill operations.	I,A,T	Lower Level Compliance per: Dewar AR, GPB-100155A, 26 Feb 97 SMD Acceptance Test Procedure, Vol.1, System Level Tests, 5835036.
3.7.5.7.4.2.1	Fountain Effect Pump	The Fountain Effect Pump (FEP) shall provide sufficient flow of SFHe to fill the dewar well up to Station 200 in <= 3 hrs with the probe inserted and the bath temperature <= 1.8 K.	I,A,T	Lower Level Compliance per: Dewar AR, GPB-100155A, 26 Feb 97 SMD Acceptance Test Procedure, Vol.1, System Level Tests, 5835036.
3.7.5.7.4.3	Well Fill Line Filter	There shall be a 2 +/-m filter in the well fill line downstream of all valves. The pressure drop of this filter shall be <= 10 torr at 60 liters/hour of liquid helium at a temperature <= 4.5 K.	I,A,T	Lower Level Compliance per: Dewar AR, GPB-100155A, 26 Feb 97
3.7.5.9	Plumbing Requirements	The SMD shall provide all plumbing lines and valves required to perform the filling, venting, and vacuum operations described in Section 3.7.5.	I	Lower Level Compliance per: Dewar AR, GPB-100155A, 26 Feb 97
3.7.5.9.1	Pressure Vessel Relief Devices	Pressure relief devices shall be provided as necessary to comply with 3.3.6.2.2.2 and its subsections.	I,A	Lower Level Compliance per: Dewar AR, GPB-100155A, 26 Feb 97
3.7.5.9.1.1	Main Tank Burst Discs	Redundant burst discs on the main tank shall be provided to protect the main tank from damage due to over pressurization.	I,T	Lower Level Compliance per: Dewar AR, GPB-100155A, 26 Feb 97
3.7.5.9.1.2	Emergency Vent Lines	An Emergency Vent Line (EVL) shall be provided on each burst disc of the main tank to exit the gas and/or liquid emanating from these burst discs through the vacuum space to burst discs on the Vacuum Shell.	I,A,T	Lower Level Compliance per: Dewar AR, GPB-100155A, 26 Feb 97
3.7.5.9.1.2.1	EVL Flow Conductance	A single Emergency Vent Line shall provide sufficient flow conductance to maintain the main tank internal pressure below 262 kPa (38 psid) (relative to guard vacuum) for any emergency vent situation with a back pressure <= 21 kPa (3 psi).	A	Lower Level Compliance per: Dewar AR, GPB-100155A, 26 Feb 97

Table 4: Lower Level Verifications

PLSE-12 #	Title	Requirement	Method	Compliance Data
3.7.5.9.1.2.2	EVL Leakage Rate	The leakage rate of a single EVL shall be <= 38,000 l/h at standard temperature and pressure at the maximum internal pressure of 262 kPa (38 psid) (relative to guard vacuum).	T	Lower Level Compliance per: Dewar AR, GPB-100155A, 26 Feb 97 SMD Acceptance Test Procedure, Vol.3, Critical Components Tests, 5835036.
3.7.5.9.1.3	Vacuum Shell Burst Discs	Redundant burst discs on the vacuum shell shall be provided to protect the vacuum shell from damage due to over pressurization of the vacuum space.	I,T	Lower Level Compliance per: Dewar AR, GPB-100155A, 26 Feb 97
3.7.5.9.1.6	Guard Tank Burst Disc	A burst disc on the guard tank shall be provided to protect the guard tank from damage due to over pressurization.	I,A,T	Lower Level Compliance per: Dewar AR, GPB-100155A, 26 Feb 97
3.7.5.9.2	Pumpout Port	A pumpout port shall be provided for connecting a vacuum pump to evacuate the SMD vacuum space.	I	Lower Level Compliance per: Dewar AR, GPB-100155A, 26 Feb 97
3.7.5.9.3	Ion Pump	An ion pump shall be provided for monitoring the pressure in the SMD vacuum space on the ground.	I	Lower Level Compliance per: Dewar AR, GPB-100155A, 26 Feb 97
3.7.5.9.4	Remotely Actuated Valves	Remotely Actuated Valves (RAVs) shall be provided as required, to perform the venting and filling requirements of Section 3.7.5.	I,A,T	Lower Level Compliance per: Dewar AR, GPB-100155A, 26 Feb 97
3.7.5.9.4.1	Vent to Thrusters	Redundant RAVs shall be provided for venting the helium boiloff gas of the main tank to the spacecraft thrusters.	I,T	Lower Level Compliance per: Dewar AR, GPB-100155A, 26 Feb 97
3.7.5.9.4.2	Shut off of Well Fill Path	Redundant RAVs shall be provided for closure of the lines for internal well fill.	I	Lower Level Compliance per: Dewar AR, GPB-100155A, 26 Feb 97
3.7.5.10.1	Vacuum Shell to Main Tank Resistance	The composite of all resistance paths between the SMD vacuum shell and the SMD main tank, with the exception of the path from the main tank to the top plate via the titanium foil of the neck tube, shall be >= 10 ohms. The resistance of each path shall be >= 20 ohms.	T	Lower Level Compliance per: Dewar AR, GPB-100155A, 26 Feb 97
3.7.5.10.2	Component Grounding	All SMD components with a surface area greater than 0.09 m^2 (1 ft^2), except the conductive surfaces on both sides of the aluminized Mylar in the MLI, shall be grounded to the SMD top plate with a resistance between 20ohms and 10Mohms.	T	Lower Level Compliance per: Dewar AR, GPB-100155A, 26 Feb 97
3.7.5.10.3	Conductive Loops	There shall be no conductive loops through the integrated probe and dewar assembly that cross a temperature differential of >= 5 K. Conductive loops in isothermal (<= 5 K differential) regions are permitted.	I	Lower Level Compliance per: Dewar AR, GPB-100155A, 26 Feb 97
3.7.5.10.4	Ground Bond Resistance	Where two components are to be grounded together, the resistance of the connection between the two components shall comply with the requirement of 3.7.2.2.3.6.	T	Lower Level Compliance per: Dewar AR, GPB-100155A, 26 Feb 97

Table 4: Lower Level Verifications

PLSE-12 #	Title	Requirement	Method	Compliance Data
3.7.5.10.5	Instrumentation Isolation	All SMD internal instrumentation shall be isolated from ungrounded conductive surfaces (i.e., the aluminized surfaces of the internal MLI) with insulation which has a breakdown voltage which exceeds 1500 Vdc.	I	Lower Level Compliance per: Dewar AR, GPB-100155A, 26 Feb 97
3.7.5.10.6	EMI Shielding	The SMD shall be designed to provide a continuous Faraday shield, when combined with the probe top hat and dewar instrumentation EMI filters. Exceptions for openings are allowed for pyrovalves, and plumbing, upon approval of the EMI committee.	I	Lower Level Compliance per: Dewar AR, GPB-100155A, 26 Feb 97
3.7.5.12.1	Redundant Heaters	Redundant heaters shall be provided for the following functions: Heat Pulse Meter operation ; Flow Meter operation; Depleting the guard tank (ground); Internal transfer of NBPHe to the well (ground); Internal transfer of SFHe to the well (ground); Increasing helium boiloff rate for thruster flow control ; Correct choking of Porous Plug; Correct breakthrough of Porous Plug;	I,A	Lower Level Compliance per: Dewar AR, GPB-100155A, 26 Feb 97
3.7.5.12.2	Other Heaters	Non- redundant heaters shall be provided for the following functions: Prevent ice formation on guard tank vent line (ground)	I,A	Lower Level Compliance per: Dewar AR, GPB-100155A, 26 Feb 97
3.7.5.12.3	Redundant Temperature Sensors	Redundant temperature sensors shall be provided for the following functions: Measure helium bath temperature in main tank; Measure the downstream temperature of the Porous Plug; Measure the vent line flowmeter temperature; Measure the temperature on the exterior of the guard tank; Measure the temperature at Heat Exchanger 0 (near Station 200)	I,A	Lower Level Compliance per: Dewar AR, GPB-100155A, 26 Feb 97
3.7.5.12.4	Other Temperature Sensors	Non- redundant temperature sensors shall be provided for the following functions: Measure temperature at HEX-1, HEX-2, HEX-3, HEX-4 ; Measure temperature gradients of Vapor Cooled Shield-1; Measure the temperature on the exterior of the main tank ; Measure the temperature at the support ring; Measure the temperature on the exterior of the vacuum shell; Measure the temperature at various locations of the lead bag; Measure the temperature at the top plate; Measure the temperature on the guard tank vent line (ground); Measure the temperature on the manual internal fill valve V13 (ground)	I,A	Lower Level Compliance per: Dewar AR, GPB-100155A, 26 Feb 97

Table 4: Lower Level Verifications

PLSE-12 #	Title	Requirement	Method	Compliance Data
3.7.5.12.5	Liquid Level Sensors	Redundant liquid level sensors shall be provided for the following functions: Measure liquid level in main tank (ground); Measure liquid level in guard tank (ground); Measure liquid level in upper portion of well (ground)	I	Lower Level Compliance per: Dewar AR, GPB-100155A, 26 Feb 97. DR R13061 closed 5/7/97.
3.7.5.12.6	Liquid Point Detector	A Liquid Point Detector shall be provided on the downstream side of the Porous Plug to detect liquid breakthrough through the plug in orbit.	I	Lower Level Compliance per: Dewar AR, GPB-100155A, 26 Feb 97
3.7.5.12.7	PODS Resistance Sensors	Resistance sensors on each PODS shall be provided to verify disconnect for thermal isolation in orbit.	I	Lower Level Compliance per: Dewar AR, GPB-100155A, 26 Feb 97
3.7.5.12.8	Accelerometers	Accelerometers shall be provided as required at critical locations for structural ground testing evaluation.	I	Lower Level Compliance per: Dewar AR, GPB-100155A, 26 Feb 97
3.7.5.12.9	Connector Pins	Dewar connector locations and pin assignments shall be as specified in the SMD Instrumentation Installation drawing 5833394.	I	Lower Level Compliance per: Dewar AR, GPB-100155A, 26 Feb 97
3.7.5.13.1	Storage Life	The SMD shall be designed to meet the requirements of 3.2.1.8.	I,A	Lower Level Compliance per: Dewar AR, GPB-100155A, 26 Feb 97
3.7.5.13.2	Launch-ready Life	The SMD shall include a normal liquid helium guard tank to absorb the heat flowing into the probe/dewar assembly during ground operations. This tank shall be sized such that it will meet the requirements of 3.2.1.9 with a design margin of 0%.	A,T	Lower Level Compliance per: Dewar AR, GPB-100155A, 26 Feb 97
3.7.5.13.3	Orbital Life	The SMD shall operate as specified herein for the orbital life of 3.2.1.10.	A,T	Lower Level Compliance per: Dewar AR, GPB-100155A, 26 Feb 97
3.7.5.14	Magnetics	The SMD shall meet the requirements of the magnetic zones as defined in Section 3.3.1.1.14.	I	Lower Level Compliance per: Dewar AR, GPB-100155A, 26 Feb 97
3.7.5.15	Cleanliness	The SMD shall meet the requirements of the cleanliness and contamination zones as defined in Section 3.3.1.2.6.	I	Lower Level Compliance per: Dewar AR, GPB-100155A, 26 Feb 97
3.7.5.16	Reliability	The SMD shall meet the reliability requirements of section 3.2.3.	I,A	Lower Level Compliance per: Dewar AR, GPB-100155A, 26 Feb 97
3.7.5.17	Maintainability	The SMD shall meet the maintainability requirements of section 3.2.4.	I	Lower Level Compliance per: Dewar AR, GPB-100155A, 26 Feb 97
3.7.6.1.1	Top Hat Ground Attachment Points	There shall be attachment points on the top hat for external ground straps located as shown on LMMS drawing 1C34355.	I	Lower Level Compliance per: Probe C AR, GPB-100269 v3, 15 May 98, N/A for Dewar.
3.7.6.1.2	Top Hat Spinup Gas Attachment Points	The physical location to the spin-up gas interface shall be as described on LMMS drawing 1C34355.	I	Lower Level Compliance per: Probe C AR, GPB-100269 v3, 15 May 98, N/A for Dewar.

Table 4: Lower Level Verifications

PLSE-12 #	Title	Requirement	Method	Compliance Data
3.7.6.2.4	Dewar Instrumentation Interface Data	SMD instrumentation interface data shall be as shown in Table 3.7.6-5 for dewar sensors, heaters, PODS resistors, liquid level sensors, liquid point sensor, accelerometers, and the Remotely Actuated Valves. This interface data covers SMD instrumentation to ground and spacecraft electronics, as well as to payload electronics. (see attached doc. file)	I	Lower Level Compliance per: Dewar AR, GPB-100155A, 26 Feb 97; N/A for Probe C
3.7.8.13.1	Spinup Exhaust Valves	A 2.5 inch motorized Vatterfly exhaust valve shall be provided on each of the 4 spinup exhaust lines for exhausting spinup gas. They shall be installed on the probe Top Hat, as specified in the Probe-C to SU External Interface Drawing 1C34355.	I	Lower Level compliance per Vatterfly VRCM.
3.7.8.13.2	Leakage Exhaust Valves	Two 6 inch diameter exhaust valve shall be provided for exhausting the probe. They shall be installed on the probe Cross Flange, as specified in the Probe-C to SU External Interface Drawing 1C34355.	I	Lower Level compliance per Vatterfly VRCM.
3.7.8.13.3	Leak Rate, Permeation and Temperature	Leak rates shall meet the requirements listed in the tables below for the temperatures and durations specified. The test configuration shall be one (1) atmosphere of helium on one side and vacuum on the opposite side. See OLE tab for tables.	I,T	Lower Level compliance per Vatterfly VRCM.
3.7.8.13.4	Random Vibration Environment	The Vatterfly valves shall be tested to the protoqualification vibration environment as shown in Table 3.7.8-2. See OLE tab for table.	T	Lower Level compliance per Vatterfly VRCM.
3.7.8.13.5	Valve Motors	Each Vatterfly valve shall have redundant motor windings on a common drive shaft for opening and closing the valve. Each shall be driven independently by the Valve Control Unit (VCU).	I	Lower Level compliance per Vatterfly VRCM.
3.7.8.13.5.1	Input Voltage	The valve shall meet its performance requirements within an input voltage range of 22 to 35 Vdc.	T	Lower Level compliance per Vatterfly VRCM.
3.7.8.13.6	Redundant Valve Sensors	Each Vatterfly valve shall have redundant sensors for determining whether the valve is open or closed.	I	Lower Level compliance per Vatterfly VRCM.
3.7.8.13.7	Response Time	The time to open or close the valves shall be <= 60 seconds.	T	Lower Level compliance per Vatterfly VRCM.
3.7.8.13.8.1	Mechanical Design Life	The mechanical elements of the valves shall be designed for >= 5000 cycles.	S	Lower Level compliance per Vatterfly VRCM.
3.7.8.13.8.2	Elastomer Seal Life	The valve shall meet the leak requirements listed in Table 3.7.8-1 for >= 250 cycles.	T	Lower Level compliance per Vatterfly VRCM.

Table 5: Requirements Deferred from a lower level

The collection of lower-level verification and acceptance data listed on page 4 contained many requirements which were to be "verified at a higher level". Since this verification document looks at all PLSE –12 requirements, all requirements deferred from a lower level package are addressed herein.

Table 6: Deferred Requirements

These requirements are verified at a higher level. Sections 3.2 and 3.3 of PLSE-12 must be revisited after the GMA and Payload Electronics are integrated with the Payload.

Table 6: Deferred Requirements

PLSE-12 #	Title	Requirement	Method	Comment
3.2.1.2.4	Allowable Permeation	The maximum amount of air allowed to enter any one of the spin-up inlet lines after the probe has been cooled to liquid helium temperatures, but while the spin-up gas is not flowing, shall be less than 540 Pa-L (5.3 ATM-cc).	A,T	Muhlfelder S0581, Verification of Spin Up Air Intrusion Requirements, verifies this requirement at the PL level, but full verification will be achieved after GMA integration at the Space Vehicle level.
3.2.1.7.4	Spin-up Attempts	The Science Payload shall be capable of providing at least two complete spin-up attempts on orbit for each of the four gyroscopes.	I,A	Verified at GMA level integration and Testing. C. Gray to perform analysis. Inspection to be done by D. Ross.
3.2.1.7.5	Pressurized Helium Supply	The Science Payload shall provide a reservoir of pressurized helium and the piping and gas flow conditioning components and fittings necessary to meet the requirements of 3.2.1.7.	I,A	Verified at GMA level integration and Testing. C. Gray to perform analysis. Inspection to be done by D. Ross.
3.2.1.13	Gyro Charge Control System	The Science Payload shall provide an UV photo emission based charge control system capable of maintaining the potential of each gyroscope at or below 15 mV (15pC charge). The average heating power into each gyroscope, caused by the charge control system, shall be less than 0.3 nW. No single point failure in the UV lamps and switches, or in the fiber optic system shall cause the failure of charge control to any gyroscope.	I,A,T	This must be run at Space Vehicle level with flight cables. Need Charge Control Algorithm to complete first analysis; 2nd analysis (heating) uses test data; 3rd requirement is verified by looking at the redundancy provided in the design. P0565 UV Gyroscope Charge Control Check-out was run in PL Phase B.
3.2.1.14.1	Initial On-orbit Uncertainty	The initial on-orbit uncertainty in the roll position sensor boresight relative to the Quartz Block/support structure interface plane shall not exceed one degree.	I,T	Requires SV roll position sensor to be integrated with the payload.

Table 6: Deferred Requirements

PLSE-12 #	Title	Requirement	Method	Comment
3.2.2.4	Structural Dynamics	The Science Payload shall be designed such that the lowest structural resonances of the Space Vehicle are >= 9 Hz in the lateral direction and >= 28 Hz in the axial direction when in its launch configuration.	A,T	The current analysis (LM EM SMS 349) shows positive margins against Pre-MECO input. The Lateral resonance frequency is 10 Hz (bending Modes), but the axial response of the Truss + Payload + Solar Arrays is 26.1 Hz. The S/C alone has a frequency of ~50 Hz, and the payload attachment is nearly rigid (relating to axial response). Therefore, the contribution to natural response from the payload is driven by payload mass. Space Vehicle Modal test (and subsequent analysis) will result in a more accurate assessment of SV structural resonance frequency.
3.2.5.1	Assembly and Test Environments	1) The Science Payload shall perform as specified after exposure to the assembly and test thermal environments of 203K to 310K	A	To be verified at SV level .
3.2.5.2	Transportation Environments	1) The Science Payload shall perform as specified after exposure to the external thermal transportation environment of 278K to 310K. 2) The Science Payload shall perform as specified after exposure to loads of 2g axial and 3g lateral simultaneously applied.	A	Skinner, EM 304/349 provides partial verification by at the PL level. Full Verification at SV level.
3.2.5.4	Launch Vehicle Integration Environments	The Payload shall perform as specified after exposure to the Launch Vehicle integration environmental requirements at Vandenberg Air Force Base (AFB) as defined in the Delta II Gravity Probe B Mission Specification.	A	Partial Ver. At PL level. Full Ver. At SV; Lower level ver. Complete per: Dewar AR, GPB-100155A, 26 Feb 97
3.2.5.6.1	Thermal Environment	The Science Payload shall perform as specified while exposed to the on-orbit thermal environment specified in Stanford document P0149, "Natural Orbital Environment Specification" section 5.0 titled "Thermal Environment".	A	Partial Ver. At PL level. Full Ver. at SV This can be expected 6 mo. after PL Acceptance (Need GSS and SRE data).

Table 6: Deferred Requirements

PLSE-12 #	Title	Requirement	Method	Comment
3.2.5.6.6	EMI Environment	The on-orbit EMI environment is specified in Stanford document P0149, "Natural Orbital Environment Specification"	A,T	Partial Ver. At PL level. The on-orbit EMI environment is specified in Stanford document P0149, "Natural Orbital Environment Specification." To be verified at SV level. Partial verification at PL level during GTU-1 testing including external EMI tests (S-262 pages 14-15, and pages 68) for SQUID electronics in SIA. ECU box tested by procedure ECU-073 (passed with DR R339-5, which was closed "use-as-is". GSS passed box level EMI tests. Proton-monitor passed EMI testing and is documented in appendix of S0462. GPS receiver EMI verified by similarity. Closure pending ongoing SRE box EMI testing results (SRE-172).
3.2.5.6.7	Atmospheric (Neutral) Particles	The Science Payload shall perform as specified while exposed to on-orbit atmospheric particles environment in accordance with Stanford document P0149, "Natural Orbital Environment Specification" section 4 titled “Atmospheric (Neutral) particles”.	A	To be verified at SV level .
3.2.5.6.8	Plasma Environment	The Science Payload shall perform as specified while exposed to on-orbit plasma environment in accordance with Stanford document P0149, "Natural Orbital Environment Specification" section 6 titled “Plasma Environment”.	A	To be verified at SV level .
3.3.2	Electromagnetic Compatibility (EMC)	The payload shall comply with the EMC requirements specified in T003, Section 15.	T	To be verified at SV level. As risk reduction, ran EMC test procedure P0574 during payload verification II. An EMC test is scheduled during payload test at the SV level. P0833 Payload EMC Test Procedure was run in PL Phase B. (partial verification at PL level; full verification at SV level) Lower Level Compliance per: Dewar AR, GPB-100155A, 26 Feb 97; Probe C AR, GPB-100269 v3, 15 May 98

Table 6: Deferred Requirements

PLSE-12 #	Title	Requirement	Method	Comment
3.7.3.2.8	Shutter	The probe shall provide the capability to block the optical path at a location outside of the probe vacuum enclosure. The shutter shall be capable of being opened and closed once per orbit for the entire mission lifetime.	I,T	Requires sunshade integration to the Payload. To be verified at SV Level.
3.7.5.2.5.2	Dewar Solar Absorptivity	The average absorptivity of the external surfaces of the SMD at the time of delivery shall be < 0.09 and < 0.12 at the end of operational life as specified in section 3.2.1.10.	A,T,S	FOSR properties; installed at PL integration to S/C. Analysis is complete when FOSR properties are measured.
3.7.5.2.5.3	Dewar Emissivity	The average infrared emissivity of the external surfaces of the SMD at the time of delivery shall be > 0.80. The average infrared emissivity shall not degrade below this value in orbit.	A,T,S	Burns test, Dewar surface emissivity. Additional testing and analysis at the SV Level are planned. Requires spacecraft integration for best results.
3.7.5.2.5.5	Magnetometer Locations	Four magnetometers shall be mounted on the forward cone between Stations 202 and 205. They shall be bolted to existing holes in the middle forward cone ring, clocked approximately 90 deg apart with arbitrary global clocking. Each magnetometer enclosure shall have approximate dimensions 38.1 mm wide by 63.5 mm long by 38.1 mm high (1.5" wide by 2.5" long and 1.5" high), and each magnetometer plus bracket shall weigh less than 1 lb.	I	Deferred to PL Mag installation.
3.7.5.9.1.4.1	Pyrovalve Shock	The SMD well pyrovalve shall be shock isolated as required to prevent shockwaves from being transmitted to the forward electronics.	I,T	Open until installation of Pyrovalve PV3.
3.7.5.9.1.5	Guard Tank Relief Valve	A relief valve capable of opening the guard tank vent line under zero gravity shall be provided for preventing backflow of atmosphere into the guard tank vent line.	I,T	Open until installation of Relief Valve RV13.
3.7.5.9.1.8	Well Relief Valve	A relief valve near the top of the well shall provide a well vent path during ground operations when helium is in the well.	I	Open until installation of well vent relief valve.
3.7.6.1.4	FEE Modules Mechanical Interface	The mechanical interface between the forward equipment section modules and the probe/dewar assembly shall be as shown in 1C34102.	I	Compliance documented at Dewar level per Dewar VRCD, GPB-100155A, 26 Feb 97. Open until installation of FEE onto Payload.
3.7.6.1.5	GMA Plumbing Lines Mechanical Interface	GMA plumbing lines shall be routed as defined in Spacecraft to Payload ICD, F277233.	I	Verified at GMA Level integration and testing.

Table 6: Deferred Requirements

PLSE-12 #	Title	Requirement	Method	Comment
3.7.6.1.6	Cables Mechanical Interface	Payload cables shall be mounted to the PL/ SC in accordance with 8A02049, Cable Clamp Wire Harness Installation. Final Cable routing will be documented by photograph.	I	To be verified at the Space Vehicle Level.
3.7.8.2	Location and Envelope	The GMA pallet, with mounted components, shall be located on the spacecraft frame within the triangular truss area located at a rotation angle about +Z* of 60 degrees from the +X* axis toward +Y*. The envelope dimensions are as specified in the GMA Interface Control Drawing 8A00188.	I	Open until GMA is mounted on to Space Vehicle.
3.7.8.3	Temperature During GMA Operation	The GMA shall provide thermal control to maintain average baseplate temperature during GMA operation to 293 K +/- 10 K (20 deg C +/- 10 deg C). The temperature variation across the GMA Baseplate shall be <= 10 K (10 deg C).	A,T	Verified at GMA Level integration and testing.
3.7.8.4	Spinup Function	The GMA shall provide the capability of delivering 500 sccm +/- 10% and 700 sccm +/- 10% He to the spinup inlet of any individual gyro.	I,T	Verified at GMA Level integration and testing.
3.7.8.4.2	Low Speed Spin-up Function	The GMA shall provide gas flow for low speed gyro spinup. The gas flow shall be between 1 and 50 sccm.	T	Verified at GMA Level integration and testing.
3.7.8.4.3	Pressurized Helium Gas Supply	The GMA shall provide a reservoir of pressurized helium (He3 or He4) >= 1200 STP-l	I	Verified at GMA Level integration and testing.
3.7.8.4.3.1	Spin-up Gas Composition	The GMA shall be capable of delivering He of purity better than 99.999% when filled with He of purity at least 99.9995% pure.	I,T	Verified at GMA Level integration and testing.
3.7.8.4.4	Venting Function	The GMA shall be capable of being pumped down to <= 6.7 x 10^-2 Pascal (0.5 mtorr) to facilitate evacuation of an individual gyro spinup line.	T	Verified at GMA Level integration and testing.
3.7.8.6	Spin-down Function	The GMA shall provide helium gas into the probe through the P1 pressure sense line. This gas shall be provided at a flow rate of 1.0 +/- 0.5 sccm. This gas flow is usable for both gyro spindown and exchange gas.	T	Verified at GMA Level integration and testing.
3.7.8.7.1	Allowable Permeation	The maximum amount of air allowed to enter any one of the spin-up inlet lines after the probe has been cooled to liquid helium temperatures, but while the spin-up gas is not flowing, shall be less than 54.0 Pa-L (.53 ATM-cc). For a 90 day hold, this corresponds to	A,T	Verified at GMA Level integration and testing.

Table 6: Deferred Requirements

PLSE-12 #	Title	Requirement	Method	Comment
		a steady state leak rate of 6.8x10^-8 scc/s.		
3.7.8.7.2	Allowable Leakage	The amount of air allowed to enter the spin-up inlet line with the helium gas shall be less than 100 Pa-L (1.0 ATM-cc).	A,T	Verified at GMA Level integration and testing.
3.7.8.8	Cleanliness and Contamination Control	The interior of the spin-up lines and valves which are in contact with the flowing gas shall be cleaned to level 100. Assembly and handling of the GMA hardware shall be in a Class 100 or better facility when the internal gas flow elements are exposed.	I	Verified at GMA Level integration and testing.
3.7.8.8.1	Particle Control	Gas flow lines shall be filtered with 2 micrometer filters to prevent particles from entering the SIA.	I	Verified at GMA Level integration and testing.
3.7.8.9	GMA Instrumentation	The GMA shall provide instrumentation for evaluating performance and controlling temperature.	D	Verified at GMA Level integration and testing.
3.7.8.10	Redundancy	Redundancy of GMA valve or regulator failures shall be provided for all mission critical functions.	I	Verified at GMA Level integration and testing.
3.7.8.11.1	Survival Temperature Range	The GMA shall be designed to survive a temperature range of -49 degrees C to +51 degrees C.	I,T	Verified at GMA Level integration and testing.
3.7.8.11.2	Random Vibration Environment	The GMA shall be tested to the following protoqualification vibration environment in all 3 axes: 20 Hz: .00265 g^2/Hz 20-150 Hz: +3dB/octave 150-600 Hz: .02g^2/Hz 600-2000 Hz: -6dB/octave 2000 Hz: .0018 g^2/Hz 4.3 GRMS overall	T	Verified at GMA Level integration and testing.

Table 6: Deferred Requirements

PLSE-12 #	Title	Requirement	Method	Comment
3.7.8.12.1	Structural Safety Factors	The inertial safety factors for the GMA shall be 1.25 for yield and 1.5 for ultimate for all structure except the base plate; the safety factor for the base plate shall be 2.0 for ultimate.	A	Verified at GMA Level integration and testing.
3.7.8.12.2	Pressure Safety Factors	All pressure systems shall be designed to the requirements of MIL-STD-1522A: Lines and fittings design with burst pressure factor =2.5 Pressure bottles designed and tested per section 5.2.1 of MIL-STD-1522. Components designed and tested to a burst pressure factor = 2.5	I	Verified at GMA Level integration and testing.

Table 6.1: GSE Requirements

Additional GSE Requirements (not verified here)
A GSE Review will be required to complete the Requirements of Section 3.3.6

Table 6.1: GSE Requirements

PLSE-12 #	Title	Requirement	Method
3.3.6.7.1	GSE Pressure Systems	Ground support pressure vessels services up to 3000 psi shall be designed to safety factors of no less than those identified in Table 3.3.6-2. Ground support pressure vessels may have a safety factor of 3:1 providing the requirements of ASME Boiler Code Division 2 are satisfied. Pressure system plumbing used at launch pads or missile facilities must be identified in accordance with MIL-STD-1247.	I
3.3.6.7.1.1	GSE Pressure Relief	Relief devices shall be provided on flight hardware or GSE to protect flight hardware against over pressurization. Launch vehicles using GSE relief devices when pressure systems are active shall have these relief devices connected as long as possible prior to launch.	I
3.3.6.7.1.2	Pressure System Certification	Each complete system shall be pressure tested and leak-checked at its maximum operating pressure at least once and pressure relief valves operationally tested at ten percent (10%) above the maximum operating pressure prior to use in normal operations at WR. The same requirements apply for modified or repaired components. New, modified, or repaired systems and subsystems shall be functionally validated prior to acceptance for normal operational use. The user shall certify that validation tests were successfully completed and the system and subsystem are certified for use. Functional tests up to maximum operating pressure are required each time a component, such as a valve or regulator, is disassembled for repair, modification, or replacement of soft goods (valve seats) and reassembled for use.	I
3.3.6.7.2	Electrical GSE	Electrical and electronic systems shall meet design requirements of AFSC DH 1-6, section 4E. Electrical fuse and switch boxes shall be stenciled on the outside to show the voltage present and the functions controlled by the circuits. The discharge time for high voltage circuits and capacitors accessible to personnel shall comply with MIL-STD-454.	I
3.3.6.7.2.1	GSE Power Switches	All GSE shall provide a main power switch on the equipment. Power switches shall be located and guarded to prevent accidental contact by personnel from activating equipment.	I
3.3.6.7.2.2	Critical Switches	Critical switches that can produce or induce hazardous conditions (i.e. switches that: override safety inhibits; power High Voltage Power Supplies; etc.) shall have a protective cover over them.	I
3.3.6.7.2.3	GSE Ground Potential	All external surfaces of GSE shall be at GSE ground potential at all times.	I

Table 6.1: GSE Requirements

PLSE-12 #	Title	Requirement	Method
3.3.6.7.2.4	Explosion-Proofing of Electrical Equipment	Electrical and electronic equipment used in areas classified as hazardous locations (e.g. flight hardware and GSE taken up in the launch tower) shall be "explosion-proof" per article 500 of the National Electrical Code (NEC, NFPA 70), or "hazard-proof" (by potting, hermetically sealing, or by positive pressurization with inert gas). Flight hardware need not be explosion-proof if it is intrinsically safe per NFPA 493. Intrinsically safe equipment which is not "labeled, identified, or listed" shall have a national testing laboratory (e.g. UL) approval statement. The use of manual kill switches, interlocks or automatic shutdown devices in lieu of hazard proofing shall be in accordance with NFPA 496 and coordinated with the 30th Space Wing Safety Engineering Directorate (30 SPW/SE).	I
3.3.6.7.2.5	Batteries	Batteries shall comply with the requirements of sections 3.14.1.6, 3.14.3.3, 3.14.4 through 3.14.4.3 of EWRR 127-1.	I
3.3.6.7.3.1	Design Criteria	Design and certification of accessory hoisting equipment shall be per Standard 6.3 of LMMS C-12, and standards identified in EWRR 127-1, sections 3.6.2.2, 3.6.2.3, 3.6.2.5, and 3.6.2.6. Critical hardware slings which have components that are normally disassembled shall be marked, coded, or tethered to assure proper reassembly. Disassembly or removal of any part for the purpose of lifting other items is prohibited. Components not properly identified shall invalidate certification of the entire assembly.	I
3.3.6.7.3.2	Nondestructive Inspections	Dye penetrant or other suitable nondestructive inspections (NDI) which can reduce the risk to high value hardware shall be performed on all accessory hoisting equipment used to lift these items. Hooks, shackles, links, eyebolts, hoist rings, and single failure point welds used for handling critical hardware at the Western Range shall receive a suitable nondestructive test annually.	I
3.3.6.7.3.3	Proof Test	All slings, riggers, and lifting fixtures shall be proof-tested to 200% of the rated load prior to initial use and 200% of the rated load within a year of use at the Western Range.	I
3.3.6.7.4	Mobile Equipment	Equipment that is mounted on casters or wheels shall have provisions for locking these casters or wheels.	I
3.3.6.7.5	Seismic Load Capability	When hardware is designed for use on the launch tower, for 24 hours or more, then the hardware or restraints shall react to accelerations equivalent to horizontal forces of two times the equipment weight applied through its center of gravity in the direction in which movement is to be restricted. As an option, calculations of force may be made in accordance with AFM 88-3, Chapter 13.	A
3.8	SMD GROUND SERVICING EQUIPMENT	.	N/A
3.8.1	Facilities Compatibility	The applicable SMD GSE shall be compatible with the facility requirements at the following facilities: Western Range B1610 and SLC-2W Launch Tower, Lockheed buildings B205 high bay, B181 vibration facility, B156 (Spin Balance, T-V), B159 (Acoustic Chamber), and Stanford HEPL FIST Area	I
3.8.1.1	Explosion Proofing	GSE electrical equipment to be placed on the launch tower shall be "explosion proof" per article 500 of NEC article 500, or hazard proof by positive pressurization of dry air.	I
3.8.1.2	Electrical Interface	GSE electrical equipment shall be compatible with 208 V, 3 phase, or 120 VAC, single phase, voltage source. Current requirements shall be coordinated with facilities, as required.	I

Table 6.1: GSE Requirements

PLSE-12 #	Title	Requirement	Method
3.8.3.1	Vacuum Space Evacuation	The GSE shall include a Vacuum Module, with a turbo pump speed >= 400 l/s, capable of achieving a blank-off pressure <= 10-7 torr, for the function of evacuating the SMD vacuum space.	I,T
3.8.3.2	Well Evacuation	The GSE shall be capable of evacuating the dewar well.	I,T
3.8.3.3	Guard Tank Evacuation	The GSE shall be capable of evacuating the guard tank to a pressure of 10 millitorr.	I,T
3.8.3.5	Conditioning LHe in LHSD to Subatmospheric Helium	The GSE shall include a Pump Module, based on a Roots pump with a nominal displacement of >= 700 cfm (330 l/s) (which can be started at one atmosphere) and a vane forepump with a displacement >= 200 cfm (94 l/s), for the function of conditioning the liquid helium in the liquid helium supply dewar from He I to subatmospheric helium.	I,T
3.8.3.7	Plumbing Connectors Guard Manifolds	All GSE plumbing connectors shall have a guard manifold with vacuum or 1 atm He during transport.	I
3.8.4	Gaseous Helium Purge	The GSE shall be capable of purging the lines and vessels with gaseous helium prior to transfer and backfill operations.	I,T
3.8.5.1	Venting of Helium Gas	The GSE shall be capable of venting 70,000 l/hr STP, with backpressure < 50 torr.	I,T
3.8.5.2	Warming of Exhaust Gas	The GSE shall be capable of warming 70,000 l/hr STP of vent gas from 20 K to 300 K prior to its reaching the facility vent lines.	I,T
3.8.6	Leak Detection	The GSE shall be capable of providing leak detection to a level of <= 10-10 scc/s He.	I,T
3.8.7.1	Remotely Actuated Valves Electronics	The GSE shall provide power supplies and electronics for all Remotely Actuated Valves (ground and flight).	I,T
3.8.7.2	Dewar Instrumentation	The GSE shall provide power supplies and signal conditioning for all SMD instrumentation (ground and flight).	I,T
3.8.7.3	Pressure Sensor Readouts	The GSE shall provide power supplies and electronics for all dewar and GSE pressure sensor readouts.	I,T
3.8.8	Data Acquisition and Processing	The GSE shall provide the capability to condition, collect, reduce, and store all SMD (except accelerometers) and GSE generated data, and display desired data.	I
3.8.10.1	Modularity	The GSE shall be of modular construction for ease of handling, servicing, transporting, and floor configuration flexibility.	I
3.8.10.2	Dimensions	The dimensions of the modules shall be compatible with the space allocated on the launch tower.	I
3.8.10.3	Weight	The weight of the modules shall be within the floor loading capability of the launch tower.	T
3.8.10.4	Lifting and Handling Structures Factors of Safety	Lifting and handling structures shall be proof tested to 2 times the maximum expected operating load, and designed with an ultimate safety factor of 5.	T
3.8.10.5	Pressure System Structures Factors of Safety	GSE pressure systems structures shall be proof tested to 1.5 times the maximum expected operating pressure, and designed with an ultimate safety factor of 4.	T
3.8.11	Cleanliness Requirements	The GSE interior lines shall be cleaned to Zone VI of Section 3.3.1.2.6.	I

Table 6.1: GSE Requirements

PLSE-12 #	Title	Requirement	Method
3.8.12	Grounding Requirements	All external surfaces of GSE shall be at common ground potential at all times.	I
3.8.13.1	Electrical Switches	All external switches shall have protective covers.	I
3.8.13.2	Alarms for Purge Pressure	An alarm audible to 200 ft shall be provided when the purge-gas pressure drops below its minimum allowable pressure. A visual alarm shall be visible to 50 ft when viewing within 60 deg of normal to the front panel.	I
3.8.13.3	Anchors	The modules shall be anchored to be seismically safe while on the launch tower.	I
3.8.13.4.1	Plumbing Connectors	GSE Plumbing Connectors shall be clearly labeled with regard to mating with dewar plumbing.	I
3.8.13.4.2	Electrical Connectors	GSE Electrical Connectors shall be clearly labeled and color coded.	I

Attachment 1 Complete list of PLSE-12

(Note: Strike throughs and underlines are remnant of PCB activity.)

Complete list of PLSE-12

PLSE-12 #	Title	Requirement	Method	Verification Status
3.1.	SCIENCE PAYLOAD DEFINITION	The Science Payload consists of the Science Instrument Assembly (SIA), Probe-C, Science Mission Dewar (SMD), Gas Management Assembly (GMA), Forward Equipment Enclosure (FEE), and the support electronics boxes, regardless of where this equipment is physically located. Definitions of these terms are contained in section 1.4.	N/A	.
3.2.	CHARACTERISTICS	.	N/A	.
3.2.1	Performance	The Science Payload is designed to perform as specified in the following subsections while exposed to the orbital environments of Stanford document P0149. The Science Payload is exposed to the ground and launch environments of 3.2.5.1 through 3.2.5.5.	N/A	.
3.2.1.1	SIA Reference Measurements	.	N/A	.
3.2.1.1.1	Inertial Reference (Gyroscope)	The Science Payload provides a measurement of the angle between the line defined by the optical axis of the telescope and the spin-axis direction of a spherical gyroscope with a classical drift rate in the freely-falling inertial frame of <= 0.3 milliarcseconds/year.	N/A	.
3.2.1.1.2	Satellite Position (Drag-Free Sensor)	The drag-free sensor provides a measurement of the satellite position (sensor housing) relative to the sensor mass. The sensor mass will be in free fall about the Earth (drag free).	N/A	.
3.2.1.1.3	Satellite Attitude (Telescope)	The telescope provides a measurement of the angle between the line-of-sight from the satellite to the guide star and the line defined by the optical axis of the telescope.	N/A	.
3.2.1.2	Vacuum Requirements	The Science Payload shall provide a vacuum enclosure capable of meeting the following requirements.	N/A	.
3.2.1.2.1	Vacuum During Spin-up	The Science Payload shall be capable of maintaining a pressure of <= 7.1 x 10-2 Pa (5.3 x 10-4 torr) at the SIA during spin-up with a helium leakage mass flow rate <=110 micrograms/second through the probe.	T	Verified at PL level
3.2.1.2.2	Vacuum After Spin-up	The Science Payload shall be capable of maintaining a pressure <= 2.6 x 10-8 Pa (2 x 10-10 torr) at the SIA over the lifetime specified in section 3.2.1.10 after spin-up of the science gyroscopes, low temperature bake-out and subsequent evacuation.	A,T	Verified at PL level
3.2.1.2.3	Trapped Volumes	Designs shall not create trapped volumes that are difficult to pump out or other construction (such as large surfaces that are tightly compressed together) that may become virtual leaks.	A	Verified at PL level
3.2.1.2.4	Allowable Permeation	The maximum amount of air allowed to enter any one of the spin-up inlet lines after the probe has been cooled to liquid helium temperatures, but while the spin-up gas is not flowing, shall be less than 540 Pa-L (5.3 Atm-cc).	A,T	Deferred

Complete list of PLSE-12

PLSE-12 #	Title	Requirement	Method	Verification Status
3.2.1.3	Magnetic Shielding Requirements	The Science Payload shall provide the following magnetic shielding at the science gyroscope locations from the time the SIA and its associated cryogenic electronics have been cooled below their superconducting transition temperature through all ground handling and testing, through the launch environment specified in section 3.2.5, and over the operational lifetime specified in section 3.2.1.10. The assumed disturbance field is equal to the Earth's magnetic field such that the maximum orbital external flux density is equal to 5.0 x 10-5 tesla (0.5 gauss) and the magnetic flux density produced by the entire space vehicle at the mouth of the cryoperm shield shall be <= 1.5 x 10-5 tesla (0.15 gauss).	A,T	Verified at PL level
3.2.1.3.1	Steady State Field	The Science Payload shall provide a steady state flux density of <= 9 x 10^-10 Tesla (9 x 10^-6 Gauss) at the science gyroscope. The steady state field below the mouth of the lead bag (Station 191) shall be <= 1 x 10-5 tesla (0.1 gauss).	T	Verified at PL level
3.2.1.3.2	Attenuation Factor	The Science Payload shall provide attenuation of external magnetic fields at the science gyroscopes (flux density at gyros' external flux density) of <= 2 x 10-12 over the frequency band from 0.00167 Hz (10 minute period) to 0.0167 Hz (1 minute period). This attenuation factor refers to an equivalent field referred to the area of each gyro pickup loop regardless of actual coupling mechanism. Compliance with this requirement may be verified by an attenuation measurement at any frequency in the specified range.	A,T	Verified at PL level
3.2.1.4	Thermal Requirements	The Science Payload shall be capable of meeting the SIA thermal requirements specified in 3.4, 11.1, and 12.8 of T003.	I,A,T	Verified at PL level
3.2.1.4.1	Helium Bath Temperature	The helium bath operating temperature during the science data taking phase shall be no greater than 1.85 K, maintained with an accuracy of +/- 30 mK about the chosen operating temperature.	A	Verified at PL level
3.2.1.5	Optical Requirements	The Science Payload provides the optical system interfaces for the SIA as specified in the following subsections. The optical system consists of all components located in the path from the entrance aperture of the sunshade to detectors.	N/A	.
3.2.1.5.1	Optical System Linearity	The linear range and linearity shall meet the requirements of 7.2.3 Linear Range in T003.	A	Verified at PL level
3.2.1.5.2	Optical System Range	The optical system has the following range capability:	N/A	.
3.2.1.5.2.2	Field of View	The optical system shall have a field of view meeting the requirements of 7.2.1.3 Minimum Field of View with Usable Signal and 7.2.2 Saturation Range of T003.	T	Verified at PL level
3.2.1.5.2.3	Primary Mirror Aperture	The optical system shall provide an aperture at the primary mirror of the telescope of at least 0.1422 meters (5.6 inches)	I	Verified at PL level
3.2.1.5.3	Optical System Transmissibility	The optical system shall provide the following overall system transmissibility.	N/A	.
3.2.1.5.3.1	Transmission Band	The transmission band of the optical system is defined as a band from 400 to 1000 nanometers (4000-10000 angstroms).	N/A	.

Complete list of PLSE-12

PLSE-12 #	Title	Requirement	Method	Verification Status
3.2.1.5.3.2	Efficiency of Light Input to Current Output	The efficiency of light input (at Window #4 over the clear aperture of the telescope) to photodetector current output shall be measured with an accuracy of 10% within a wavelength of 100 nm of mid-band (700 nm) for each of the eight (8) detectors. This measurement is made at telescope null and at <= 200 marcsec intervals over a 10 arcsec range centered on null in the two readout axes. The units are A/W.	T	Verified at PL level
3.2.1.5.3.2.1	Minimum Efficiency	The minimum efficiency of light input to photodetector current output of the sum of the current of all eight detectors shall be >= 0.038 A/W within a wavelength of 100 nm of mid-band (700 nm).	A, T	Verified at PL level
3.2.1.5.3.3	Derivative of Normalized Pointing Signal with respect to Angle, System	With the telescope/window system in the Payload configuration, the derivative of the normalized Pointing signal with respect to angle at a nominal wavelength of 668 nm +/- 10 nm shall be >= 0.45 /arcsec within 100 marcsec of null. The normalized pointing signal is the current difference between a photodetector pair divided by the sum of their currents.	A, T	Verified at PL level
3.2.1.5.4	Telescope Detectors	The telescope detectors are solid-state devices mounted at the telescope.	N/A	.
3.2.1.5.5	Guide Star	The guide star shall be chosen from the list of candidate stars given in section 25.1 of T003.	I	Verified at PL level
3.2.1.7	Gyroscope Spin-up	The science gyroscopes are spun up in accordance with the requirements in the following subsections.	N/A	.
3.2.1.7.1	Final Gyroscope Angular Velocity	The science gyroscopes shall be capable of being spun up to 80-180 Hz using pressurized helium gas at a mass flow rate <= 2.8 mg/s of He4 or <= 2.1 mg/s of He3 (both equivalent to 950 scc/m) supplied to the input of each gyroscope spin-up channel. Further, the above required spin speed shall be achieved with a total helium mass per gyro of < 26.5 g for He4 or < 19.9 g for He3. (equivalent to 950 scc/m for 158 min)	A,T,S	Verified at PL level
3.2.1.7.2	Gyroscope Alignment	The science gyroscopes shall be capable of being aligned towards the target star to within 10 arcseconds. The spin alignment system shall be capable of functioning simultaneously for any number of gyroscopes. The total time required for spin alignment of all gyroscopes shall be less than 10 days.	A	Verified at PL level
3.2.1.7.3	Spin-up Configuration	The Science Payload shall provide the capability to individually spin-up each of the gyroscopes.	I	Verified at PL level
3.2.1.7.4	Spin-up Attempts	The Science Payload shall be capable of providing at least two complete spin-up attempts on orbit for each of the four gyroscopes.	I,A	Deferred
3.2.1.7.5	Pressurized Helium Supply	The Science Payload shall provide a reservoir of pressurized helium and the piping and gas flow conditioning components and fittings necessary to meet the requirements of 3.2.1.7.	I,A	Deferred
3.2.1.7.6	Post Spin-up Helium Venting	The Science Payload shall be capable of venting the remaining pressurized helium after the spin-up is complete to prevent leakage into the probe.	I	Verified at PL level
3.2.1.8	Storage Life	The Science Payload shall be capable of meeting the following storage requirements.	N/A	.
3.2.1.8.2	Storage After Space Vehicle Integration	After integration into the space vehicle, the Science Payload shall be capable of being stored and transported while filled with cryogen for a period of five years when stored in a controlled environment per sections 3.2.5.1-3.2.5.4.	A	Verified at PL level
3.2.1.9	Launch-ready Life	The Science Payload provides the capability to maintain a launch-ready superfluid state during ground operations while meeting the requirements in the following subsections. These service intervals assume that the external ground environment will be less than 32 deg C (90 deg F).	N/A	.

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PLSE-12 #	Title	Requirement	Method	Verification Status
3.2.1.9.1	Guard Tank	The guard tank shall have adequate liquid helium capability so that it does not have to be refilled for a period of >= 5 days.	A,T	Verified at PL level
3.2.1.9.2	Main Helium Tank	After the main tank is filled with SFHe, with the guard tank maintained with NBPHe, a period of >= 90 days shall elapse before the temperature of the SFHe rises above 1.85 K. This period may include up to 2 launch aborts at intervals >= 24 hours and a subsequent successful launch.	A,T	Verified at PL level
3.2.1.10	Orbital Life	The Science Payload shall have an orbital operating lifetime of >= 16.5 months after initiation of launch. The lifetime includes operations such as spinup, flux flushing, and low temperature bakeout. The 16.5 mo. requirement is reduced on a pro-rata basis for any increased helium flow rate required by the spacecraft helium thrusters for attitude control, translation control, or orbit trim.	A,T	Verified at PL level
3.2.1.10.1	Orbital Design Life	The on-orbit design life of the Payload, excluding helium, shall be >= 3 yr.	A	Verified at PL level
3.2.1.11	Proton Shielding	The Science Payload shall provide an average of 20 g/cm2 aluminum equivalent shielding for gyroscopes 1 through 3. Gyroscope 4 may have lower shielding.	I,A	Verified at PL level
3.2.1.12	Electromagnetic Shielding	The Science Payload shall provide EMI shielding within the probe vacuum shell with the following attenuation of electromagnetic fields from external sources: 80 dB from 10 kHz to 250 MHz; 80 dB at 250 MHz decreasing to 65 dB at 1 GHz; 40 dB from 1 GHz to 100 GHz	A,T	Verified at PL level
3.2.1.13	Gyro Charge Control System	The Science Payload shall provide an UV photo emission based charge control system capable of maintaining the potential of each gyroscope at or below 15 mV (15pC charge). The average heating power into each gyroscope, caused by the charge control system, shall be less than 0.3 nW. No single point failure in the UV lamps and switches, or in the fiber optic system shall cause the failure of charge control to any gyroscope.	I,A,T	Deferred
3.2.1.14	Stability of Roll Phase Sensor Location	The stability of the roll phase sensor location shall be as described in the following subsections.	N/A	.
3.2.1.14.1	Initial On-orbit Uncertainty	The initial on-orbit uncertainty in the roll position sensor boresight relative to the Quartz Block/support structure interface plane shall not exceed one degree.	I,T	Deferred
3.2.1.14.2	Long Term Drift	The roll position sensor boresight, relative to the QB position, shall drift in a "random walk" fashion less than ten arcseconds per year. The relative drift shall not correlate with any periodic behavior of the satellite.	A	Verified at PL level
3.2.1.14.3	Roll Period Stability	The roll position sensor mounting plane, relative to the QB position, shall not shift more than 0.5 arcsecond during a roll period. (assuming 10 deg C dewar vacuum shell variation).	A	Verified at PL level
3.2.2	Physical Characteristics	.	N/A	.
3.2.2.1	Physical Interface	The Science Payload shall meet the physical interface requirements of the Spacecraft to Science Payload ICD, F277233.	I	Verified at PL level
3.2.2.2	Mass Properties	.	N/A	.
3.2.2.2.1	Payload Weight	The total weight of the wet payload includes the probe with SIA, dewar with 95% full main tank, electronics, GMA and associated plumbing, cables and forward equipment enclosure.	N/A	.

Complete list of PLSE-12

PLSE-12 #	Title	Requirement	Method	Verification Status
3.2.2.3	Coordinate System	Interface coordinates for the Science Payload are specified in the assembly coordinate system specified in the Spacecraft to Science Payload ICD, F277233.	N/A	.
3.2.2.4	Structural Dynamics	The Science Payload shall be designed such that the lowest structural resonances of the Space Vehicle are >= 9 Hz in the lateral direction and >= 28 Hz in the axial direction when in its launch configuration.	A,T	Deferred
3.2.2.5	Proton Monitor	The Science Payload shall provide a proton detector capable of monitoring the flux of protons in a minimum range from 30 35 MeV to 500 MeV. The proton detection shall be along two directions, 90 and 180 deg from the guide star direction, with a nominal cone angle of 45 deg.	I,A	Verified at PL level
3.2.2.5.1	Proton Monitor Power Consumption	All power for the Proton Monitor shall be drawn from the Spacecraft primary power bus (28 Vdc nominal)	I	Verified at PL level
3.2.2.5.1.2	Load Shed Science Mission Operation	During periods of low power availability, the Proton Monitor may be turned off to save power. The Proton Monitor shall survive being turned off for up to one year.	I	Verified at PL level
3.2.2.6	Science Magnetometers	The Science Payload shall provide 4 three-axis fluxgate magnetometers on the forward cone of the dewar, located axially near the top of the lead bag, and radially approximately 90+/- apart, to measure the local external field. The alignment of each magnetometer relative to the spacecraft truss shall have maximum error in knowledge <= 0.5 degree, rotation and <= 1.75 mm, translation, for X, Y, and Z axes.	I	Verified at lower level
3.2.2.6.1	Science Magnetometers Power Consumption	The electronics for the Science Magnetometers are located in the ECU. The power for these electronics is counted in the ECU power budget.	N/A	.
3.2.3	Reliability	The probability of the Science Payload operating as specified shall be optimized within the cost, schedule, weight, power and performance requirements and limitations of the Relativity Mission program. The reliability evaluation shall include the entire life cycle of the Science Payload and its components and spares in the analyses performed, as well as system safety, maintenance, human interaction, inspection, storage, transportation and test.	I	Verified at PL level
3.2.3.1	Mechanism Reliability	No single mechanism failure shall cause major system damage, resulting in loss of mission.	A	Verified at PL level
3.2.3.2	Electrical Reliability	No single electrical failure shall cause major system damage, resulting in loss of mission.	A	Verified at PL level
3.2.4	Maintainability	The design of the Science Payload shall meet the maintainability requirements of the following subsections.	N/A	.
3.2.4.1	Repair, Replacement, and Calibration	The design shall allow for repair, replacement, or calibration of any item that is subject to wear-out or drift, has limited-life that may be exceeded prior to launch, or may reasonably be expected to fail during pre-integration operation, test, storage, or transportation (such as a fuse).	I	Verified at PL level
3.2.4.2	Damage-Free Maintenance	Repair, replacement, or calibration of any serviceable item shall be performed without damage to neighboring or interacting hardware and with the introduction of a minimum amount of contaminants to the hardware.	I	Verified at PL level
3.2.4.3	Testability	Subassemblies shall incorporate sufficient self-test or in-place testability through test connectors to isolate system malfunctions to a specific item.	I	Verified at PL level

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PLSE-12 #	Title	Requirement	Method	Verification Status
3.2.5	Environmental Conditions	This section describes the environments that the Science Payload will be exposed to during its lifetime.	N/A	.
3.2.5.1	Assembly and Test Environments	1) The Science Payload shall perform as specified after exposure to the assembly and test thermal environments of 203K to 310K	A	Deferred
3.2.5.2	Transportation Environments	1) The Science Payload shall perform as specified after exposure to the external thermal transportation environment of 278K to 310K. 2) The Science Payload shall perform as specified after exposure to loads of 2g axial and 3g lateral simultaneously applied.	A	Deferred
3.2.5.4	Launch Vehicle Integration Environments	The Payload shall perform as specified after exposure to the Launch Vehicle integration environmental requirements at Vandenberg Air Force Base (AFB) as defined in the Delta II Gravity Probe B Mission Specification.	A	Deferred
3.2.5.5	Launch Environments	The Payload shall survive the launch and pre-launch environments as described in the Delta II Payload Planners Guide, MDC H3224C, Section 4. These environments include radiation and electromagnetic environments, contamination and cleanliness, fairing internal pressure, thermal, loads, acoustic, vibration, and shock.	N/A	.
3.2.5.5.1	Launch Loads	The load factors for the primary structure are given below: All Except Sunshade (Lateral) ± 2.5g Sunshade (Lateral) ± 20.0g All (Axial) 6.2 ± 0.6 Secondary structures design load factors are given by the SSD secondary structure loads curve below, taken from EM 310A/P030739A. Secondary structures include all hardware not in the primary load path, such as plumbing, valves, electronics boxes, connectors, burst discs, etc.	A	Verified at PL level
3.2.5.6	Orbital Environments	.	N/A	.
3.2.5.6.1	Thermal Environment	The Science Payload shall perform as specified while exposed to the on-orbit thermal environment specified in Stanford document P0149, "Natural Orbital Environment Specification" section 5.0 titled "Thermal Environment".	A	Deferred
3.2.5.6.2	Vacuum Environment	The total pressure at orbital altitude is approximately 5 x10-8 Pa (4 x 10-10 torr).	N/A	.
3.2.5.6.3	Magnetic Environment	The Science Payload shall perform as specified while exposed to the earth's magnetic field peak magnitude of 5.0 x 10-5 tesla (0.5 gauss).	A, T	Verified at PL level
3.2.5.6.4	Radiation Environment	The Science Payload shall perform as specified while exposed to on-orbit radiation environment in accordance with Stanford document P0149, "Natural Orbital Environment Specification" section 2.0 titled "Ionizing radiation".	A	Verified at PL level
3.2.5.6.5	Micrometeorite Environment	The Science Payload shall perform as specified while exposed to on-orbit radiation environment in accordance with Stanford document P0149, "Natural Orbital Environment Specification" section 1 titled "Meteoroid and debris strike resistance".	A	Verified at PL level
3.2.5.6.6	EMI Environment	The on-orbit EMI environment is specified in Stanford document P0149, "Natural Orbital Environment Specification"	A,T	Deferred

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PLSE-12 #	Title	Requirement	Method	Verification Status
3.2.5.6.7	Atmospheric (Neutral) Particles	The Science Payload shall perform as specified while exposed to on-orbit atmospheric particles environment in accordance with Stanford document P0149, "Natural Orbital Environment Specification" section 4 titled “Atmospheric (Neutral) particles”.	A	Deferred
3.2.5.6.8	Plasma Environment	The Science Payload shall perform as specified while exposed to on-orbit plasma environment in accordance with Stanford document P0149, "Natural Orbital Environment Specification" section 6 titled “Plasma Environment”.	A	Deferred
3.3.	DESIGN AND CONSTRUCTION	.	N/A	.
3.3.1	Materials, Processes and Parts	.	N/A	.
3.3.1.1	Material Requirements	The material selected for design shall be selected per GPB-100275 and the requirements in the following subsections.	I	Verified at PL level
3.3.1.1.1	Thermal Vacuum Stability	Materials in the payload hardware that are exposed to a thermal-vacuum environment shall be selected to minimize contamination of optical or functionally critical surfaces by deposition of volatilized materials.	I	Verified at PL level
3.3.1.1.1.1	Total Mass Loss	Materials shall have a total mass loss (TML) <=1.0 percent.	I	Verified at PL level
3.3.1.1.1.2	Volatile Condensable Material	Materials shall have a volatile condensable material (VCM) content <= 0.1 percent.	I	Verified at PL level
3.3.1.1.2	Materials Flammability	The use of combustible materials shall be minimized.	I	Verified at PL level
3.3.1.1.3	Corrosion Control	The Science Payload shall use materials that are corrosion-resistant.	I	Verified at PL level
3.3.1.1.5	Dissimilar Metals	Dissimilar metal combinations shall not be used unless protected against electrolytic corrosion. Metals are considered compatible if they are in the same grouping as specified in MIL-STD-889.	I	Verified at PL level
3.3.1.1.6	Electrical Bonding	Materials and finishing systems shall be consistent with requirements for electrical grounding in accordance with MIL-B-5087.	I	Verified at PL level
3.3.1.1.7	Fungus Resistance	Materials that absorb or retain moisture to the extent performance characteristics are degraded or are nutrients for fungus shall be avoided in the design.	I	Verified at PL level
3.3.1.1.8	Sensitive Materials	Materials with unlimited shelf and assembly life shall be used. Where limited shelf or assembly life materials are required, appropriate storage controls shall be specified in the applicable specification.	I	Verified at PL level
3.3.1.1.9	Prohibited Materials	The following materials are prohibited: 1) Cadmium, zinc, or selenium except internal to hermetically sealed devices. 2) Pure, unalloyed tin (greater than 99.1% Sn). 3) Corrosive solder fluxes, except where approved by Quality Assurance. 4) Mercury and compounds of mercury, except internal to hermetically sealed devices. 5) Silicones which evolve a corrosive acetic acid.	I	Verified at PL level

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PLSE-12 #	Title	Requirement	Method	Verification Status
3.3.1.1.10	Material Strength Properties	The material properties used in the design and analysis of all structural and pressure system components are to be the values such that the vendor guarantees that 99% of material will have a 95% confidence level. Materials selection shall consider the effects of fabrication processing, cleaning materials and procedures, and the effect of dye penetrant & proof test fluids.	I	Verified at PL level
3.3.1.1.11	Material Fracture Toughness	Fracture properties shall be considered in selection of all pressure vessel components, with the materials' fracture toughness to be as high as practical. Materials with a threshold stress intensity factor KTH of <= 60% of the critical stress intensity factor KIc for the expected service environment shall require a "worst case" fracture mechanics analysis.	I	Verified at PL level
3.3.1.1.12	Temperature Effect on Material Properties	Thermal effects which result in changes in the physical and mechanical properties of the materials of construction shall be considered in the design of all pressure vessels, and all other structures. These effects shall be based on temperature extremes which simulate those predicted for the operating environment plus a design margin. Materials shall be selected on the basis of proven environmental compatibility, material strengths, fracture properties, and service life consistent with the specific program thermal requirements.	I	Verified at PL level
3.3.1.1.13	Material Characterization	Mechanical properties, strength and fracture properties of all materials selected for pressure vessels shall be characterized in sufficient detail to permit reliable and high confidence predictions of their structural performance in the expected operating environments unless these properties are available from reliable sources such as MIL-HDBK-5, MIL-HDBK-17, ASTM Standards, Military Specifications, Aerospace Structural Metals Handbook, or other sources approved by the procuring agency.	I	Verified at PL level
3.3.1.1.14	Magnetic Properties of Materials	Selection of materials for use in the Science Payload shall meet the requirements of P0057-A. An approved materials and process list is contained in GPB-100275. The standards for magnetic acceptability for materials to be used in the various zones are given in Table 2 of P0057-A.	I	Verified at PL level
3.3.1.1.14.1	Magnetic Control Zones	The following zones are defined to assist in controlling the magnetic fields produced at the science gyroscopes. The zones are shown in figure 3.3.1-1 and 3.3.1-2. (See OLE tab.) Zone 1 Four separate cylindrical volumes defined within the outer surfaces of each local science gyroscope magnetic shield. Zone 2A The volume within 9 cm of the center of any science gyroscope. Zone 2B The volume inside the lead bag within 25 cm of any gyro center and bounded above by Station 163, excluding zones 1 and 2A. Zone 3 The remainder of the lead bag volume not included in zones 1, 2A, and 2B. Bounded above by Station 191. Zone 4 The volume outside the lead bag and inside the cryoperm shield. Bounded above by Station 199. Zone SP This special zone contains the remainder of the probe interior not included in zones 1-4, plus parts outside the probe that may contain particles which could migrate into the lead bag. Zone 5 This zone includes that area outside the probe and cryoperm volume, that is no	N/A	.
3.3.1.1.14.2	Remanent Magnetization	The remanent magnetization for finished parts according to zone shall meet the requirements of Table 4 of P0057-A.	I,A,T	Verified at PL level

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PLSE-12 #	Title	Requirement	Method	Verification Status
3.3.1.1.14.3	Payload Produced Magnetic Field	The instantaneous magnetic field produced by the payload shall not exceed 0.1 gauss at the location of the lead bag mouth at any time or under any operating conditions, excluding the shielding effects of the lead bag and the cryoperm shield.	A,T	Verified at PL level
3.3.1.1.15	External Surface Protective Coatings	External surfaces visible by the science telescope (i.e., window 4), shall be protected as required, such that they do not cause signal degradation at the detectors due to the impingement of atomic oxygen, as defined in Stanford document P0149.	A	Verified at PL level
3.3.1.2	Process Requirements	The requirements in the following subsections form the basis for the process selection criteria.	N/A	.
3.3.1.2.1	Process Quality	Processes shall conform to recognized industry practices of sufficient proven quality to allow the part, assembly, or equipment on which it is applied to meet spacecraft system performance life cycle and all ground plus space environmental requirements.	I	Verified at PL level
3.3.1.2.2	Process History	Processes shall have a satisfactory history in the production of parts, assemblies, or equipment of sufficient proven quality to meet the performance life cycle and environmental requirements.	I	Verified at PL level
3.3.1.2.3	Space Qualification	Processes shall be developed to satisfy a specific set of performance and environmental criteria established for spacecraft application.	I	Verified at PL level
3.3.1.2.4	Process Consistency	Processes shall have adequate controls and verification requirements to assure consistent results.	I	Verified at PL level
3.3.1.2.5	Prohibited Processes	The following processes shall be prohibited for use: 1) Electrodeposited tin plating unless subsequently fused or reflowed. 2) Structural adhesive bonding unless materials evaluation and design verification testing has been conducted for hardware using adhesive bonded joints.	I	Verified at PL level
3.3.1.2.6	Contamination Control	Contamination control of the Science Payload shall satisfy the requirements and approach delineated in the Science Payload Contamination Control Plans, LMMS 5835083 for Lockheed supplied probe and dewar hardware, and P0059 for Stanford supplied hardware.	I,T	Verified at PL level

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PLSE-12 #	Title	Requirement	Method	Verification Status
3.3.1.2.6.1	Contamination Control Zones	The following zones are defined to assist in defining the cleanliness requirements. The zones are also shown in figures 3.3.1-3 and 3.3.1-4. (See OLE tab.) Zone I Interior of the science gyroscope housings Zone II Spin-up gas inlet line downstream of the filter and the spin-up exhaust line Zone III Bore of the Quartz Block Zone IV Interior of the probe below the Quartz Block mounting flange Zone V Interior of the probe above the Quartz Block mounting flange and below window 4 Zone VI Ground Support Equipment (GSE) vacuum system Zone VII Exterior surface of the probe below the top hat Zone VIII Interior of all liquid fill lines and cold valves Zone IX Interior of well, main tank, guard tank, vent lines, and axial lock tubing Zone X Interior of GSE fill lines downstream of external filter Zone XI Interior and exterior of dewar vacuum shell Zone XII Interior of cross flange, window #4, shutter Zone XIII Interior of sunshade Zone XIV Exterior surface of probe above top ha	N/A	.
3.3.1.2.6.2	Cleanliness Requirements	Components in each zone shall meet the cleanliness requirements stated in Lockheed document 583503 and Stanford document P0059.	I,T	Verified at PL level
3.3.1.2.7	Electrostatic Discharge (ESD)	The payload shall comply with the Electrostatic Discharge Control procedures described in Section 1.17 of the LMMS Safety, Reliability, Maintainability and Product Assurance Plan (SRMPA), F428533E.	I	Verified at PL level
3.3.2	Electromagnetic Compatibility (EMC)	The payload shall comply with the EMC requirements specified in T003, Section 15.	T	Deferred
3.3.4	Workmanship	All hardware shall be built and maintained to workmanship standards suitable for a precision spacecraft component.	I,T	Verified at PL level
3.3.5	Interchangeability	Within the Science Payload, items with identical part numbers (including rev numbers) shall be interchangeable without modification. Such items shall have similar interface definition, within tolerance and state-of-the-art limitations, including form, fit, and function. Such interchange shall be possible without damage to neighboring or interfacing hardware and with a minimum of contamination introduced into the hardware.	I	Verified at PL level
3.3.6	Safety	.	N/A	.
3.3.6.1	Hazard Management	.	N/A	.
3.3.6.1.1	Hazard Category Definitions	1) Major Mishaps are those that could result in: a) Loss of life. b) Loss of major systems such as a launch vehicle, payload, launch facility, or support facility. 2) Serious Mishaps are those that could result in: a) Personnel injuries. b) Damage to launch vehicle, payload, or launch site equipment or facilities.	N/A	.

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PLSE-12 #	Title	Requirement	Method	Verification Status
3.3.6.1.2	Failure Tolerance Design Criteria	The system must be designed to tolerate a number of credible failures and/or operator errors, determined by the degree of hazard involved in the operation. The required failure tolerance is given in table 3.3.6-1 (see OLE tab).	I	Verified at PL level
3.3.6.1.4	Hazard Control	Hazards that present unacceptable levels of risk will be eliminated or controlled using an order of precedence as follows: 1) Design for Minimum Risk Design to eliminate hazards. If an identified hazard can't be eliminated, attempt to control the unacceptable risks that it presents through design tradeoffs. 2) Safety Devices Hazards that cannot be eliminated or controlled through design selection should be controlled to an acceptable level through the use of fixed, automatic, or other safety design features or devices. Where possible, make provisions for periodic functional checks of safety devices. 3) Warning Devices When design selection or safety devices can't eliminate or effectively control identified hazards, warning devices should be incorporated in the design to detect hazardous conditions and generate warning signals to alert personnel to danger. 4) Procedures, and Training Where it is impractical to eliminate hazards through design selection or adequately reduce the associated risk with safety and warning devices, procedures and training shall be used. However, without a specific waiver, no warning, caution, or other form of written advisory shall be used as the only risk reduction method for Category I or II hazards (defined in section 1B.1.1.5.d of EWRR 127-1). Procedures may include the use of personal protective equipment. Tasks and activities judged critical require certification of personnel proficiency.	I	Verified at PL level
3.3.6.1.5	Definition of Load Terminology	The following terms are defined for structural and pressure system stress and safety analyses. 1) Design Limit Load - The design limit load (or pressure) is the maximum expected working load (or pressure) acting on a structure during its service life. It includes static, dynamic, and impulse loads (or pressures) as well as loads (or pressures) induced by the environment, operating pressure or vacuum, or assembly tolerances. 2) Design Yield Load - The design yield load (or pressure) is the design limit load (or pressure) multiplied by the yield safety factor. 3) Design Ultimate Load - The design ultimate load (or pressure) is the design limit load (or pressure) multiplied by the ultimate safety factor. 4) Margins of Safety - The yield and ultimate margins of safety are calculated by the following equations: yield margin of safety = (load capability at yield / design yield load) - 1 ultimate margin of safety = (load capability at failure / design ultimate load) - 1	N/A	.
3.3.6.1.6	Structural and Pressure Load Capability	Science payload components and systems shall meet the load requirements in the following subsections.	N/A	.

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PLSE-12 #	Title	Requirement	Method	Verification Status
3.3.6.1.6.1	Design Yield Load Capability	All systems shall be capable of withstanding the design yield loads and pressures without experiencing detrimental deformation.	A	Verified at PL level
3.3.6.1.6.2	Design Ultimate Load Capability	All systems shall be capable of withstanding design ultimate loads and pressures without rupture or collapse. Pressurized structures subject to destabilizing external loads shall be designed for buckling using ultimate loads and pressures, except that any load or internal pressure that tends to alleviate buckling shall not be increased by any safety factor for this buckling calculation.	A	Verified at PL level
3.3.6.1.6.3	Safety Factors	The safety factors listed in the following subsections are used for all science payload components. Safety factors are not applied to temperatures or temperature gradients. Design temperatures may be specified to include margins above/below the maximum/minimum expected operating temperatures.	N/A	.
3.3.6.1.6.3.1	Pressure System Safety Factors	Pressure or vacuum systems shall be designed using the safety factors in Table 3.3.6-2a and 3.3.6-2b. (See OLE tab.)	A	Verified at PL level
3.3.6.1.6.3.2	Structural Safety Factors	The Science Payload will be protoflight hardware. As such, it must be designed with higher margins of safety than an item which has had a qualification unit tested to its ultimate strength limit. All structural components of the science payload shall be designed using the safety factors listed in table 3.3.6-3. (See OLE tab.)	A	Verified at PL level
3.3.6.1.6.4	Margin of Safety	All margins of safety shall be positive and shall be determined by analysis or test at design yield and design ultimate levels, when appropriate, at the temperatures expected for all critical conditions.	A	Verified at PL level
3.3.6.2	Pressurized Systems	.	N/A	.
3.3.6.2.1	Pressure Vessels	.	N/A	.
3.3.6.2.1.1	Stresses in Pressure Vessels	The entire anticipated service life stress history shall be determined in accordance with specified mission requirements. As a minimum, the following factors and their statistical variations shall be considered: 1) Design loads and pressures. 2) Environmental stresses which act simultaneously with design loads and pressures, such as thermal effects, including heating rates, temperatures, and thermal stresses. 3) The frequency of application of stresses mentioned in 1 and 2 and their levels and duration. These data shall be used to define the design spectra which shall be used for design analysis and testing. The design spectra shall be revised as the structural design develops and the stress analysis matures.	A	Verified at PL level
3.3.6.2.1.2	Strength of Pressure Vessels	.	N/A	.
3.3.6.2.1.2.1	Internal Loads	Pressure vessels shall possess sufficient strength and stiffness to withstand limit loads and internal pressures in the expected operating environments throughout their respective service lives without experiencing detrimental deformation. Pressure vessels shall be capable of withstanding ultimate internal loads and internal pressures in the expected operating environments without collapse or rupture.	A	Verified at PL level
3.3.6.2.1.2.2	External Loads	Pressure vessels shall be capable of withstanding ultimate external loads and ultimate external pressures (destabilizing) without collapse or rupture when internally pressurized to the minimum anticipated operating pressure.	A	Verified at PL level

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PLSE-12 #	Title	Requirement	Method	Verification Status
3.3.6.2.1.2.3	Proof Pressure	Pressure vessels and plumbing shall sustain proof pressure without incurring gross yielding or detrimental deformation. When proof tests are conducted at temperatures other than design temperatures, the change in material properties at the proof temperature shall be accounted for in determining proof pressure.	T	Verified at PL level
3.3.6.2.1.3	Stiffness of Pressure Vessels	Pressure vessels shall possess adequate stiffness to prevent all detrimental instabilities of coupled vibration modes, minimize detrimental effects of the loads and dynamics response which are associated with structural flexibility, and minimize adverse interaction with other vehicle systems.	A	Verified at PL level
3.3.6.2.1.4	Manufacture and Refurbishment	The structural design for all pressure vessels shall employ proven processes and procedures for fabrication and repair to preclude damage or material degradation. The design shall emphasize the need for access, inspection, service, replacement, repair and refurbishment. For all reusable pressure vessels, the structural design shall permit these structures to be maintained in and refurbished to a flightworthy condition. Repaired and refurbished structures shall meet all stipulated conditions of flight worthiness.	I	Verified at PL level
3.3.6.2.1.4.1	Fracture Toughness	The fracture toughness, mechanical and physical properties of the parent materials, weldments and heat-affected zones shall be within established design limits after exposure to the intended fabrication processes.	A	Verified at PL level
3.3.6.2.1.4.2	Fracture Control	Fracture control requirements and precautions shall be defined in applicable drawings and process specifications. Detailed fabrication instructions and controls shall be provided to insure proper implementation of the fracture control requirements. Special precautions shall be exercised throughout the manufacturing operations to guard against processing damage or other structural degradation. In addition, procurement requirements and controls shall be implemented to insure that suppliers and subcontractors employ fracture control procedures and precautions consistent with the fabrication and inspection processes intended for use during actual hardware fabrication.	A	Verified at PL level
3.3.6.2.2	Pressure Relief Systems	.	N/A	.
3.3.6.2.2.1	Pressure Relief Capability	There shall be no tanks, components or sections of plumbing in any GSE or flight cryogenic system that can be isolated without pressure relief capability in any configuration of the system or valves. Sufficient pressure relief devices shall be incorporated to meet the failure tolerance requirements of section 3.3.6.1.2.	I	Verified at PL level
3.3.6.2.2.2	Relief Devices	The pressure relief systems shall be designed to handle a sudden loss of the vacuum in the dewar or probe with full main and guard tanks.	I	Verified at PL level
3.3.6.2.2.2.1	Location	Rupture disks shall be located so that the debris fragments from the disks, if used, do not impinge upon or obstruct plumbing, lines, tanks, cables, or primary structure. Relief devices shall be located such that they do not ice up prior to or during activation sufficient to become ineffective. The external locations of the exhaust ports for the pressure relief system shall be as shown in drawing 5833115.	I	Verified at PL level
3.3.6.2.2.2.2	Relief Pressure Setting	Rupture disks shall burst, at the nominal working temperatures, at a pressure <= the maximum expected operating pressure (design limit load) of the applicable assembly. The lower limit shall be high enough so that normal operations of the associated pressure vessel are not impaired.	I	Verified at PL level

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PLSE-12 #	Title	Requirement	Method	Verification Status
3.3.6.2.2.2.3	Plumbing Line Size	Pressure relief discharge lines shall be of sufficient size that they do not restrict the relieving capability of the safety device.	A	Verified at PL level
3.3.6.2.2.2.4	Redundancy	Redundant pressure relief devices shall have independent pressure escape routes.	I	Verified at PL level
3.3.6.2.2.2.5	Cleanliness	Relief discharge lines shall be provided with protective devices to prevent the entrance of contaminants prior to and after activation of the pressure relief function.	I	Verified at PL level
3.3.6.2.3	Pressure Monitoring	All pressurized systems shall be designed so that supply and operating pressures can be monitored by gauges or other suitable indicators (i.e. remote monitors at a control station). During prelaunch pressurization, pressure monitoring must be provided by means of a hard-line umbilical cable or telemetry.	I	Verified at PL level
3.3.6.2.3.2	Remote Monitors	The payload electronics shall provide monitor signals for each separate line or vessel that can be statically pressurized. These signals shall be available on externally accessible test connectors.	I	Verified at PL level
3.3.6.2.4	Safety Verification and Certification	All flight and GSE components shall be evaluated by a safety engineer for potential risk to personnel in the event of a failure. Items identified as safety-critical shall be inspected per LMMS C-12 to ensure safe operation. All proof tests shall be witnessed by the safety engineer.	N/A	.
3.3.6.3	Electrical Systems	.	N/A	.
3.3.6.3.1	Redundant Systems	Elements of safety-critical redundant systems shall not pass through the same connector as the primary system elements.	I	Verified at PL level
3.3.6.3.2	Marking of Connectors	Connectors shall be keyed, clearly marked, or color coded to minimize the possibility of incorrectly connecting systems.	I,A	Verified at PL level
3.3.6.4	Electroexplosive Subsystem	Electroexplosive Subsystem (EES) shall be designed, tested and certified according to MIL-STD-1576. EES includes all components, from the power source through the electroexplosive device (EED). EES will be designed so the sensitive or initiating elements can be installed in the system just prior to electrical hookup and as late in the countdown as possible. Sufficient inhibits shall be incorporated to meet the failure tolerance requirements and shall comply with sections 3.13.3 through 3.13.3.4 of EWRR 127-1.	I,T,S	Verified at PL level
3.3.6.4.1	Prohibited Pyrotechnic Device	Exploding Bridgewire system initiators shall not be used.	I	Verified at PL level
3.3.6.5	Mechanical/Electromechanical Devices	Mechanical or electromechanical devices used for structure deployment or actuating release mechanisms shall be evaluated to establish if damage to equipment or injury to personnel could occur in the event of inadvertent initiation. Sufficient inhibits shall be incorporated to meet the failure tolerance requirements.	I,A	Verified at PL level
3.3.6.6	Software and User-System Interface	Software shall comply with the requirements of section 3.16 of EWRR 127-1.	I	Verified at PL level
3.3.6.7	Ground Support Equipment (GSE)	.	N/A	.

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PLSE-12 #	Title	Requirement	Method	Verification Status
3.3.6.7.1	GSE Pressure Systems	Ground support pressure vessels services up to 3000 psi shall be designed to safety factors of no less than those identified in Table 3.3.6-2. Ground support pressure vessels may have a safety factor of 3:1 providing the requirements of ASME Boiler Code Division 2 are satisfied. Pressure system plumbing used at launch pads or missile facilities must be identified in accordance with MIL-STD-1247.	I	GSE review
3.3.6.7.1.1	GSE Pressure Relief	Relief devices shall be provided on flight hardware or GSE to protect flight hardware against over pressurization. Launch vehicles using GSE relief devices when pressure systems are active shall have these relief devices connected as long as possible prior to launch.	I	GSE review
3.3.6.7.1.2	Pressure System Certification	Each complete system shall be pressure tested and leak-checked at its maximum operating pressure at least once and pressure relief valves operationally tested at ten percent (10%) above the maximum operating pressure prior to use in normal operations at WR. The same requirements apply for modified or repaired components. New, modified, or repaired systems and subsystems shall be functionally validated prior to acceptance for normal operational use. The user shall certify that validation tests were successfully completed and the system and subsystem are certified for use. Functional tests up to maximum operating pressure are required each time a component, such as a valve or regulator, is disassembled for repair, modification, or replacement of soft goods (valve seats) and reassembled for use.	I	GSE review
3.3.6.7.2	Electrical GSE	Electrical and electronic systems shall meet design requirements of AFSC DH 1-6, section 4E. Electrical fuse and switch boxes shall be stenciled on the outside to show the voltage present and the functions controlled by the circuits. The discharge time for high voltage circuits and capacitors accessible to personnel shall comply with MIL-STD-454.	I	GSE review
3.3.6.7.2.1	GSE Power Switches	All GSE shall provide a main power switch on the equipment. Power switches shall be located and guarded to prevent accidental contact by personnel from activating equipment.	I	GSE review
3.3.6.7.2.2	Critical Switches	Critical switches that can produce or induce hazardous conditions (i.e. switches that: override safety inhibits; power High Voltage Power Supplies; etc.) shall have a protective cover over them.	I	GSE review
3.3.6.7.2.3	GSE Ground Potential	All external surfaces of GSE shall be at GSE ground potential at all times.	I	GSE review
3.3.6.7.2.4	Explosion-Proofing of Electrical Equipment	Electrical and electronic equipment used in areas classified as hazardous locations (e.g. flight hardware and GSE taken up in the launch tower) shall be "explosion-proof" per article 500 of the National Electrical Code (NEC, NFPA 70), or "hazard-proof" (by potting, hermetically sealing, or by positive pressurization with inert gas). Flight hardware need not be explosion-proof if it is intrinsically safe per NFPA 493. Intrinsically safe equipment which is not "labeled, identified, or listed" shall have a national testing laboratory (e.g. UL) approval statement. The use of manual kill switches, interlocks or automatic shutdown devices in lieu of hazard proofing shall be in accordance with NFPA 496 and coordinated with the 30th Space Wing Safety Engineering Directorate (30 SPW/SE).	I	GSE review

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PLSE-12 #	Title	Requirement	Method	Verification Status
3.3.6.7.2.5	Batteries	Batteries shall comply with the requirements of sections 3.14.1.6, 3.14.3.3, 3.14.4 through 3.14.4.3 of EWRR 127-1.	I	GSE review
3.3.6.7.3	Accessory Hoisting Equipment	Accessory hoisting equipment is designed to meet the requirements in the following subsections.	N/A	.
3.3.6.7.3.1	Design Criteria	Design and certification of accessory hoisting equipment shall be per Standard 6.3 of LMMS C-12, and standards identified in EWRR 127-1, sections 3.6.2.2, 3.6.2.3, 3.6.2.5, and 3.6.2.6. Critical hardware slings which have components that are normally disassembled shall be marked, coded, or tethered to assure proper reassembly. Disassembly or removal of any part for the purpose of lifting other items is prohibited. Components not properly identified shall invalidate certification of the entire assembly.	I	GSE review
3.3.6.7.3.2	Nondestructive Inspections	Dye penetrant or other suitable nondestructive inspections (NDI) which can reduce the risk to high value hardware shall be performed on all accessory hoisting equipment used to lift these items. Hooks, shackles, links, eyebolts, hoist rings, and single failure point welds used for handling critical hardware at the Western Range shall receive a suitable nondestructive test annually.	I	GSE review
3.3.6.7.3.3	Proof Test	All slings, riggers, and lifting fixtures shall be proof-tested to 200% of the rated load prior to initial use and 200% of the rated load within a year of use at the Western Range.	I	GSE review
3.3.6.7.4	Mobile Equipment	Equipment that is mounted on casters or wheels shall have provisions for locking these casters or wheels.	I	GSE review
3.3.6.7.5	Seismic Load Capability	When hardware is designed for use on the launch tower, for 24 hours or more, then the hardware or restraints shall react to accelerations equivalent to horizontal forces of two times the equipment weight applied through its center of gravity in the direction in which movement is to be restricted. As an option, calculations of force may be made in accordance with AFM 88-3, Chapter 13.	A	GSE review
3.3.6.8	Operations Safety	.	N/A	.
3.3.6.8.1	Hazardous Operations	The system safety engineer shall identify all hazardous operations (e.g. operations involving liquid cryogens) which will require formally documented operating procedures. Hazardous operating procedures shall comply with section 6.2.2.3 of EWRR 127-1.	A	Verified at PL level
3.3.6.8.2	Computer Controlled Operations	All sequences, processes, and functions which operate under computer control shall be designed in such a manner that a critical failure mode or error condition will result in the system reverting to a known and safe state.	I	Verified at PL level
3.3.6.8.3	Personal Protective Equipment	Where appropriate, protective equipment or clothing is used on LM and SU premises.	N/A	.
3.3.7	Human Engineering	The design of the Science Payload shall allow for necessary personnel operation, inspection and maintenance of the hardware with a minimum of risk of injury to personnel or damage/contamination of the flight hardware. Written procedures shall be developed to minimize the risk to personnel or hardware during all operations. Tethers shall be used when there is a potential for injury or program critical hardware damage due to a dropped tool or GSE.	I	Verified at PL level

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PLSE-12 #	Title	Requirement	Method	Verification Status
3.4.	DOCUMENTATION	.	N/A	.
3.5.	LOGISTICS	.	N/A	.
3.6.	PRECEDENCE	.	N/A	.
3.7.	SUBASSEMBLY REQUIREMENTS	.	N/A	.
3.7.1	Science Instrument Assembly Specification	Each Science Gyroscope Assembly shall have the following electrical inputs and outputs. 1) Six Electrodes - for electrostatic suspension and capacitive position readout of the rotor 2) Charge Control Bias electrode - for photoelectric control of the rotor charge 3) Readout Hardware - for pickup and detection of the London moment signal associated with the Gyro rotor spin axis 4) Input deflux heater current for a heater on the superconducting readout cable 5) Housing Ground 6) Heater 7) Thermometer	N/A	.
3.7.1.1	SIA Definition	The Science Instrument Assembly (SIA) refers to the science instruments and support structure. The SIA consists of the following components: 1) Four gyroscope assemblies with needed features for electrostatic suspension, helium gas spin up, gyroscope readout, and gyroscope rotor charge management 2) Four SQUID packages (design to accommodate eight, but only four may be installed) for gyroscope readout mounted on two SQUID brackets with temperature control 3) One fused quartz telescope, pitch and yaw readout sensors, and cryogenic preamplifiers 4) One Quartz Block and hardware to mount the gyroscopes and telescope 5) Four local superconducting magnetic shields 6) Four assemblies to connect the probe spin-up lines to the gyroscopes 7) Four gyroscope rotor caging assemblies (not required to function) 8) Thermometers	N/A	.
3.7.1.2	Physical Characteristics	.	N/A	.
3.7.1.2.1	Mass Properties	.	N/A	.
3.7.1.2.1.1	Mass Allocation	The total mass of the SIA shall not exceed 41.0 kilograms (90.4 pounds).	A	Verified at lower level
3.7.1.2.1.2	Mass Measurement	The total mass of the as-built SIA shall be measured and reported to within 0.2 kg.	A	Verified at lower level
3.7.1.2.1.3	Center of Mass Position	The SIA center of mass shall be located at a point on the z-axis located at Station 157.01 (3988.1 mm from reference plane) within a 20.32 mm (0.8 inch) radius sphere. The SIA center of mass position shall be verified by a combination of measurement and analysis to an accuracy of less than or equal to 1.27 mm (0.05 inch).	A	Verified at lower level

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PLSE-12 #	Title	Requirement	Method	Verification Status
3.7.1.2.1.4	Moments and Products of Inertia	The moments and products of inertia of the SIA are analytically calculated based on as-built information.	N/A	.
3.7.1.2.2	Dimensions	The principal external dimensions are as shown in figure 3.7.1-1 (click "OLE" tab to view).	N/A	.
3.7.1.2.3	Structural Characteristics	The SIA shall be designed to withstand the launch loads as described in Section 3.2.5.5. More detailed requirements on the allowable limit stress for fused quartz can be found in Section 3.7.1.2.3.1.	A,S	Verified at lower level
3.7.1.2.3.1	Maximum Allowable Limit Stress for Fused Quartz	The maximum allowable limit stress in the fused quartz structure shall be 5.00 MPa (725 psi) in tension and shear and 1100 MPa (160 kpsi) in compression. The maximum allowable limit stress in tension and shear shall include a safety factor of 10.	A	Verified at lower level
3.7.1.2.4	SIA Installation and Interfaces	.	N/A	.
3.7.1.2.4.1	SIA Interfaces with Probe	The SIA design shall be in accord with Section 3.7.2, which includes the SIA/Probe ICD, LMMS 1C34103, by reference.	I	Verified at lower level
3.7.1.2.4.2	Gyroscope Caging Assembly	The SIA design allows installation and removal of the gyroscope caging assembly after installation of the QBA into the Probe. Note that the caging assembly is not required to function in the science payload.	N/A	.
3.7.1.2.4.3	Electrical Cable, Caging Line, and UV Fiber Optic	The SIA design provides the means to route the electrical cables in accord with all other mechanical, magnetic, and electrical requirements.	N/A	.
3.7.1.3	SIA Environmental Requirements	.	N/A	.
3.7.1.3.1	Thermal Requirements	.	N/A	.
3.7.1.3.1.1	Science Operations	.	N/A	.
3.7.1.3.1.1.1	Thermal Bending Stability of ST/QBA Assembly	The ST/QBA Assembly shall undergo thermal bending in inertial space of <= 0.1 marcsec while Science Data is collected (SV rolling at roll frequency about the line-of-sight to the Guide Star).	A	Verified at lower level
3.7.1.3.1.1.2	SIA Subassembly Temperature Requirements	The SIA thermal design shall meet the subassembly temperature requirements of Section 3.2.1.4.	A,T	Verified at PL level
3.7.1.3.1.1.3	Telescope JFET Preamplifiers	The SIA thermal design is compatible with the use of JFETs mounted to the front end of the telescope.	N/A	.
3.7.1.3.1.1.4	Power Dissipation of SIA Heat Power Sources	The power dissipation of SIA heat power sources is in accord with Section 3.7.2.5.7, while Science Data is collected.	N/A	.
3.7.1.3.1.2	Flux Flushing	During flux flushing the SIA is compatible with Section 3.7.2.5.9.	N/A	.
3.7.1.3.1.3	Spin Up	The SIA design is compatible with the thermal requirement of Section 3.7.2.3.5.	N/A	.
3.7.1.3.1.4	Room Temperature Bake-Out	The SIA is maintained at a temperature less than or equal to 60 C and shall be at 60 C for a period not to exceed one week during room temperature bake-out operations.	N/A	.

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PLSE-12 #	Title	Requirement	Method	Verification Status
3.7.1.3.2	Magnetic Requirements	.	N/A	.
3.7.1.3.2.1	Steady State Field	The residual field contributed by the SIA to the total residual magnetic field at the Science Gyroscopes is consistent with 3.2.1.3.1.	N/A	.
3.7.1.3.2.2	Attenuation Factor	The SIA shall provide an attenuation consistent with the requirement of 3.2.1.3.2.	A,T	Verified at PL level
3.7.1.3.2.3	Magnetic Noise from Conducting Loops	No metallic loop circuits having an enclosed area greater than or equal to 10 cm^2 shall be permitted in Magnetic Zones 1 or 2. Exceptions to this requirement are allowed if reviewed and approved by the Magnetics Committee.	A	Verified at PL level
3.7.1.3.2.4	Electrical Conductivity of Materials	Normal conductors and superconductors used in the SIA design shall be in accordance with the Magnetics Control Plan P0057.	I	Verified at lower level
3.7.1.3.2.5	Magnetic Control of Materials	All SIA parts shall be screened in accordance with the Magnetics Control Plan P0057.	I,T	Verified at lower level
3.7.1.3.3	Vacuum Requirements	.	N/A	.
3.7.1.3.3.1	Vacuum During Spin Up	The SIA is capable of spinning up the gyroscope assuming the limitations given in Section 3.2.1.2.1.	N/A	.
3.7.1.3.3.2	Vacuum After Spin Up and Bakeout	After spin up and low-temperature bakeout, the SIA shall be compatible with the vacuum required in Section 3.2.1.2.2.	T	Verified at PL level
3.7.1.3.4	Cleanliness Requirements	The SIA shall meet the cleanliness requirements in Section 3.3.1.2.6, but with the exceptions and verification approaches allowed as given in the Contamination Control Plan P0121 (formerly S0139).	I,T,S	Verified at lower level
3.7.1.4	QBA	The Quartz Block Assembly (QBA) consists of the following SIA components: 1) Four gyroscope assemblies with needed features for electrostatic suspension, helium gas spin up, gyroscope readout, and gyroscope rotor charge management 2) One fused quartz telescope, pitch and yaw readout sensors, and cryogenic preamplifiers 3) One Quartz Block and hardware to mount the gyroscopes and telescope 4) Four local superconducting magnetic shields 5) Four assemblies to connect the probe spin-up lines to the gyroscopes 6) Thermometers	N/A	.
3.7.1.4.1	Gyroscope Cavity Positioning and Alignment	.	N/A	.
3.7.1.4.1.1	Axial Position	The knowledge of the axial distance between the centers of adjacent gyroscopes shall meet the requirement given in section 1.7.2 of T003.	A	Verified at lower level
3.7.1.4.1.2	Positioning Transverse to Z-axis	The distance of the centers of all gyroscope cavities from the Roll Axis shall meet the requirement given in Section 1.7.1 of T003.	A	Verified at lower level

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PLSE-12 #	Title	Requirement	Method	Verification Status
3.7.1.4.2	Alignment of the Gyroscope Readout Loops	.	N/A	.
3.7.1.4.2.1	Alignment of Gyroscope Readout Loops Relative to Telescope Axis	.	N/A	.
3.7.1.4.2.1.1	Accuracy of Perpendicularity	The axes of all readout loops shall be perpendicular to the science telescope axis within the error given in Section 11.2.1 of T003.	A	Verified at lower level
3.7.1.4.2.1.2	Stability of Perpendicularity	The orientation of the Science Gyroscope readout loops with respect to the Telescope axis shall be stable as stated in Section 11.2.1 of T003.	A	Verified at lower level
3.7.1.4.2.1.3	Rotation	The Science Gyroscope and Science Telescope readout axes shall be aligned in rotation about the z-axis with the accuracy given in Section 11.3 of T003.	A	Verified at lower level
3.7.1.4.2.2	Gyroscope Readout Axes in Space Vehicle Frame	The gyroscope readout axes shall be oriented to measure pitch (rotation about y-axis) for gyroscopes #1 and #2, and to measure yaw (rotation about x-axis) for gyroscopes #3 and #4.	I	Verified at lower level
3.7.1.4.2.3	Parallelism between Pairs of Readout Loops	The axes of readout loops #1 and #2 shall be parallel to each other within the error given in Section 11.2.2 of T003. The same requirements apply to the axes of readout loops #3 and #4.	I,A,T	Verified at lower level
3.7.1.4.2.4	Perpendicularity between Readout Loops	The angles between the effective axes of each one of Readout Loops #1 and #2, including the effects of the mechanical misalignment and of electrical misalignment due to the out-of-plane stray area of the wire connecting the readout loops, and the effective axes of each one of Readout Loops #3 and #4 are nominally 90 degree. These angles shall be known to within the error given in section 11.2.3 of T003.	A	Verified at lower level
3.7.1.4.3	Reticle Plate	The reticle plate at the front of the telescope shall be in accord with the ICD drawing 25446, "Plate, Reticle"	I	Verified at lower level
3.7.1.4.3.1	X-Y Location of Reticle Pattern Center	The x-y position of the reticle pattern center with respect to a point determined by the intersection of the nominal Roll Axis with the reticle plate plane shall be known to 0.25 mm (0.010 inch).	A	Verified at lower level
3.7.1.4.3.2	Z Location of Reticle Reflecting Plane	The Z location of the Reticle Reflecting Plane relative to Gyroscope #1 shall be known to within 0.5 mm.	A	Verified at lower level
3.7.1.4.3.3	Rotation of Reticle Pattern	The reticle pattern rotation about the z-axis relative to the readout loop planes shall be known within 1.1 degree (see EM No. ATCS 215, 6/20/96).	A	Verified at lower level
3.7.1.4.3.4	Orientation of Reflecting Surface	The perpendicular to the reflecting surface of the reticle plate shall be parallel to the telescope optical axis within 10 arcsec and be known to within 5 arcsec.	T	Verified at lower level
3.7.1.4.3.5	Reflectivity	The reflecting surface of the reticle shall have a reflectivity of greater than or equal to 70% (intensity).	I	Verified at lower level
3.7.1.4.4	Installation and Replacement	.	N/A	.

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PLSE-12 #	Title	Requirement	Method	Verification Status
3.7.1.4.4.1	Telescope	.	N/A	.
3.7.1.4.4.1.1	Mechanical	The telescope is attached to the Quartz Block per the drawing 23521.	N/A	.
3.7.1.4.4.2	Gyroscopes	.	N/A	.
3.7.1.4.4.2.1	Modularity	The gyroscopes and gyroscope retention hardware is modular to the greatest extent possible.	N/A	.
3.7.1.4.4.2.2	Installation and Removal	The QBA design allows installation and removal of any gyroscope and its ancillary hardware both before and after installation of the QBA into the Probe.	N/A	.
3.7.1.4.4.2.3	Rotor Composition	The composition and location of each gyro rotor shall meet the requirement of Section 1.2 of T003.	I	Verified at lower level
3.7.1.4.4.2.4	Spin Direction	The QBA design allows the spin direction of any gyroscope to be in the + z or - z direction. The spin directions shall be those given in Section 1.1 of T003. The gyroscope shall be installed so the symmetry plane of the gyro spin-up channel is perpendicular to the z-axis within 0.005 rad (0.27 degree).	A	Verified at lower level
3.7.1.4.4.2.5	Orientation of Electrodes	The gyroscope shall be installed so the gyroscope electrode symmetry axis equidistant between two electrodes is parallel to the z-axis within 0.005 rad (0.27 degree).	A	Verified at lower level
3.7.1.4.7	Caging Assembly	.	N/A	.
3.7.1.4.7.1	Force Applied to Gyroscope by Caging Pin	The caging mechanism shall apply a force of 57.8 N +/- 4.4 N (13.0 lb +/- 1.0 lb).	T	Verified at lower level
3.7.1.4.7.2	Surface of Caging Pin	The surface of the caging pin in contact with the gyroscope shall have a surface finish and curvature compatible with applying the caging force to the gyroscope without affecting gyroscope performance requirements.	I,T	Verified at lower level
3.7.1.4.7.3	Actuation Pressure	The caging mechanism shall operate with a helium gas pressure in accordance with the requirement in section 3.7.2.4.3.	T	Verified at lower level
3.7.1.4.7.4	Volume of Caging Circuit	The volume of each caging circuit on the SIA side of the probe to SIA interface (up to two caging mechanisms per circuit) shall be in accord with the requirement in Section 3.7.2.4.4.	I,A	Verified at lower level
3.7.1.4.7.5	Interface of Helium Gas Actuation Line with Probe	The demountable connection of the helium gas line to the probe shall be in accord with the SIA to Probe ICD, LMMS 1C34103.	I	Verified at lower level
3.7.1.4.7.7	Position of Caging Pin with Zero Applied Pressure	The caging pin shall be withdrawn from the surface of the gyroscope housing (ID of spherical surface of uncoated housing) greater than or equal to 0.25 mm (0.010 inch) when a differential pressure of 0.00 MPa is applied to the mechanism.	T	Verified at lower level
3.7.1.4.7.8	Position of Caging Pin at 0.12 MegaPascal (17 PSID	The caging pin shall be withdrawn from the surface of the gyroscope housing (ID of spherical surface of uncoated housing) greater than or equal to 0.05 mm (0.002 inch) when a differential pressure is applied to the mechanism of 0.12 MPa (17 psid).	T	Verified at lower level
3.7.1.4.8	Spin-up Plumbing Assembly	.	N/A	.

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PLSE-12 #	Title	Requirement	Method	Verification Status
3.7.1.4.8.1	Probe Interface	The spin-up inlet and exhaust line fittings that interface with the gyroscopes meets the requirements in Section 3.7.2.1, which includes LMMS 1C34103 by reference.	N/A	.
3.7.1.4.8.2	Spin-Up Exhaust Line Gas Conduction	The pressure drop along the spin-up exhaust plumbing line assembly from its interface with the gyroscope to its interface with the probe shall be <= 40 Pa assuming the pressure of 60 Pa at the SIA/probe interface (Section 3.7.2.3.6), the flow rate given in Section 3.2.1.7.1 of He-4 or He-3, and a temperature of <= 7 K.	A	Verified at PL level
3.7.1.4.9	Local Superconducting Magnetic Shield	A local superconducting magnetic shield is provided around each gyroscope. This shield is to be a continuous right circular cylinder of niobium centered on the gyroscope with a length to internal diameter ratio greater than or equal to 2.7 and a wall thickness greater than or equal to 0.125 mm (0.005 inch).	N/A	.
3.7.1.4.9.1	Superconducting Transition Temperature	The local superconducting magnetic shield shall have a superconducting transition temperature greater than 8.5 K and less than 10.5 K.	I,S	Verified at lower level
3.7.1.4.9.2	Transverse Centering	The distance between the axis of the inside diameter of the local shield and the center of the gyroscope housing shall be less than or equal to 0.25 mm (0.010 inch).	I	Verified at lower level
3.7.1.4.9.3	Longitudinal Centering	The distance between the center of the shield in the longitudinal direction and the center of the gyroscope housing shall be less than or equal to 2.5 mm (0.10 inch).	I	Verified at lower level
3.7.1.4.9.4	Axial Symmetry	Small deviations from axial symmetry are allowed, but must be approved by the Magnetics Committee.	N/A	.
3.7.1.4.10	Thermal Instrumentation	The QBA has adequate instrumentation for monitoring the cooling rate during probe insertion, for verifying thermal performance, and for monitoring thermal behavior while on orbit.	N/A	.
3.7.1.4.10.1	Germanium Resistance Thermometer Characteristics	The GRTs shall have a nominal resistance of 1000 ohm to 2500 ohm at 4.2 K and be calibrated over the temperature range 1.4 K to 100 K with an accuracy of 5 mK over the temperature range from 1.4 K to 10 K.	I,T	Verified at lower level
3.7.1.4.10.2	Silicon Diode Thermometer Characteristics	The SDs shall have a nominal voltage of 0.5 V to .055 V at 300 K and be calibrated, at an excitation current of 10 microampere, over the temperature range of 1.4 K to 325 K with an accuracy of 0.1 K over the this temperature range.	I,T	Verified at lower level
3.7.1.5	Science Gyroscopes	.	N/A	.

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PLSE-12 #	Title	Requirement	Method	Verification Status
3.7.1.5.1	Prime Item Definition	Gyro Spherical Science Gyroscope (one of four) Housing Fused quartz Housing to support a single Gyro Support Hardware and Cabling: 1) Electrode hardware - for electrostatic suspension and capacitive position readout of the rotor. 2) UV Charge Control Hardware - for photoelectric control of the rotor charge. 3) Readout Hardware - for pickup and detection of the London moment signal associated with the Gyro rotor spin axis. 4) Thermal Control Hardware - for sensing and increasing (as needed) the Gyro Assembly temperature. Each Gyro assembly consists of an assembly including a Gyro and a fused quartz Housing. The Gyro is a fused quartz or monocrystalline Silicon sphere with a Niobium coating which becomes superconducting at the cryogenic operation temperature. The Housing contains support hardware necessary to sense the Gyro position within the cavity, levitate it, and spin it up and read out its axis of spin using the London moment of the spinning superconducting Gyro. Gyro systems including their SQUID readouts are used to provide a reference fixed to local inertial space. The Drag Free Gyro system is used to provide a translational reference fixed to local inertial space (a drag-free sensor). Gyro systems are compatible with serving as the drag-free sensor.	N/A	.
3.7.1.5.1.1	Prime Item Diagram	The Gyro Assembly is shown in Figure 3.7.1-2 (click on 'OLE' tab to view).	N/A	.
3.7.1.5.1.1.2	Signal Interfaces	Each Science Gyroscope Assembly shall have the following electrical inputs and outputs. 1) Six Electrodes - for electrostatic suspension and capacitive position readout of the rotor 2) Charge Control Bias electrode - for photoelectric control of the rotor charge 3) Readout Hardware - for pickup and detection of the London moment signal associated with the Gyro rotor spin axis 4) Input deflux heater current for a heater on the superconducting readout cable 5) Housing Ground 6) Heater 7) Thermometer	I	Verified at lower level
3.7.1.5.2	Characteristics	.	N/A	.
3.7.1.5.2.1	Operational Performance	.	N/A	.
3.7.1.5.2.1.1	Trapped Flux	The assembled gyroscopes shall be compatible with the trapped magnetic flux requirement of Section 1.5 of T003.	T	Verified at lower level

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PLSE-12 #	Title	Requirement	Method	Verification Status
3.7.1.5.2.1.2	Spin Speed	The set of Gyros as installed in the SIA shall be capable of achieving final spin speeds for all four Gyros in the range specified in Section 4.1 of T003 under the constraints of Sections 3.2.1.7 and 3.7.8.7.1.2. The maximum gyroscope temperature during spinup (measured at the housing) must be less than 8K. The spinup gas must exert a force of less than or equal to 0.05N on the Gyroscope Rotor.	A,T	Verified at lower level
3.7.1.5.2.1.3	Gyroscope Temperature	The Gyro Housings is compatible with the requirements of Section 3.2.1.4.	N/A	.
3.7.1.5.2.1.4	Spin-Down Rate	The one-g spin-down rate shall be less than or equal to (df/dt)/f = 2.0e-3 per hour in the spin speed range 0.3 Hz to 3 Hz.	T	Verified at lower level
3.7.1.5.2.1.5	Spin Alignment with Respect to Telescope Axis	.	N/A	.
3.7.1.5.2.1.5.1	Initial Alignment	The geometry of the gas spin-up system shall be compatible with the initial alignment required in Section 4.3 of T003 assuming a rolling spacecraft.	A	Verified at lower level
3.7.1.5.2.1.5.2	Final Alignment	The rotor shape for spin speeds in the range specified in Section 4.1 of T003 shall be compatible with final spin alignment given in Section 5.2 of T003 assuming a 10% modulation of the 0.1 g suspension preload at roll frequency in less than 50 hour. Lower levels of suspension preload may be used for the final fine adjustment.	A	Verified at lower level
3.7.1.5.2.1.6	Readout Loop/Readout Cable Assembly	.	N/A	.
3.7.1.5.2.1.6.1	Decay Time	The decay of the signal produced by magnetic flux injected into the superconducting input circuit shall be less than 1% in a 10 min period, under the condition that the R/O loop is connected to the input of a dc SQUID through the readout cable. The dc SQUID supporting this test shall have an input inductance and coupling equal to the requirements for the flight dc SQUID.	T	Verified at lower level
3.7.1.5.2.2	Physical Characteristics	.	N/A	.
3.7.1.5.2.2.1	Gyroscope Rotor		N/A	.
3.7.1.5.2.2.1.1	Substrate		N/A	.
3.7.1.5.2.2.1.1.1	Material	The rotor substrate material shall be as specified in Section 1.2 of T003.	I	Verified at lower level
3.7.1.5.2.2.1.1.2	Homogeneity	The density homogeneity d(rho)/(rho) across any diameter shall be less than or equal to 1.0e-5	I,A	Verified at lower level
3.7.1.5.2.2.1.1.3	Diameter	The diameter of the substrate shall be within +/- 750 nm (+/- 30 microinch) of the diameter of the reference sphere 93H57 at 22 degree C +/- 4 degree C.	T	Verified at lower level

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PLSE-12 #	Title	Requirement	Method	Verification Status
3.7.1.5.2.2.1.1.4	Asphericity of substrate	The substrate shall have a peak-to-valley asphericity less than or equal to the following: For the l=2 (oblateness) term, 30 nm (1.2 microinch) For odd harmonics l = 3 to 15, 23 nm (0.9 microinch) For even harmonics l = 4 to 16, 23 nm (0.9 microinch) The accuracy of the measurement of the roundness of any one of the great circles used to determine the asphericity shall be less than 17 nm (0.65 microinch).	T	Verified at lower level
3.7.1.5.2.2.1.2	Coating	.	N/A	.
3.7.1.5.2.2.1.2.1	Coating Material	The coating material shall be niobium.	I	Verified at lower level
3.7.1.5.2.2.1.2.2	Coating Uniformity	Coating uniformity shall be less than or equal to 50nm (p-v). The accuracy of the p-v coating uniformity measurement shall be less than 25 nm.	T	Verified at lower level
3.7.1.5.2.2.1.2.3	Superconducting Transition Temperature	The superconducting transition temperature shall be greater than or equal to 8 K.	S	Verified at lower level
3.7.1.5.2.2.1.2.4	Electron Field Emission	The electron field emission current shall be compatible with 1 g operation and testing.	T	Verified at lower level
3.7.1.5.2.2.1.2.5	Thermal Emissivity	The thermal emissivity shall be greater than or equal to 0.01.	S	Verified at lower level
3.7.1.5.2.2.1.2.6	UV 254 nanometer Photoemissivity of Rotor	The photo emission coefficient shall be greater than or equal to 1.0e-7 electrons/photon for 254 nm photons.	T	Verified at lower level
3.7.1.5.2.2.1.3	Mass Unbalance	Gyro: The coated rotor mass unbalance shall meet the requirement in Section 1.3.2 of T003.	A,T	Verified at lower level
3.7.1.5.2.2.1.4	Rotor Shape	The coated rotor shall meet the rotor shape requirements of T003 (System Design and Performance Requirements) Section 1.4.	A,T,S	Verified at lower level
3.7.1.5.2.2.2	Gyroscope Housing		N/A	.
3.7.1.5.2.2.2.1	Substrate		N/A	.
3.7.1.5.2.2.2.1.1	Material	The housing substrate shall be made from the material specified in Section 1a.1 of T003.	I	Verified at lower level
3.7.1.5.2.2.2.1.2	Cavity Diameter	The cavity diameter shall be 38.070 mm (1.4988 inch) with the accuracy given in Section 1a.2 of T003.	I	Verified at lower level
3.7.1.5.2.2.2.1.3	Cavity Asphericity	The internal spherical surface of the cavity shall meet the asphericity requirement of Section 1a.2 of T003.	I	Verified at lower level
3.7.1.5.2.2.2.1.4	Cavity Centering to Parting Plane	The center of the cavity shall coincide with the parting plane within 2.5 micrometer .	I	Verified at lower level

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PLSE-12 #	Title	Requirement	Method	Verification Status
3.7.1.5.2.2.2.1.5	Electrodes Position Accuracy	The positions of the six electrodes shall meet the requirement of Section 1a.3.3 of T003.	I	Verified at lower level
3.7.1.5.2.2.2.1.6	Electrodes Area Variation	The area variations of the six electrodes shall meet the requirement in Section 1a.3.2 of T003.	I	Verified at lower level
3.7.1.5.2.2.2.2	Electrode Coatings		N/A	.
3.7.1.5.2.2.2.2.1	Uniformity	The electrode coating uniformity shall meet the requirements of Section 1a.3.1 of T003.	S	Verified at lower level
3.7.1.5.2.2.2.2.2	Electron Field Emission	The electron field emission current shall be compatible with 1 g operation and testing.	T	Verified at lower level
3.7.1.5.2.2.2.2.3	Electrical Resistivity	The electrode coating resistivity shall be less than or equal to 25 micro-ohm-m at 2.5 K.	S	Verified at lower level
3.7.1.5.2.2.2.3	Support Land Coatings	The support land coatings shall insure that rotors and electrodes do not come in contact.	T	Verified at lower level
3.7.1.5.2.2.2.4	Caging Land Coatings	The caging land coatings shall insure rotor positioning while caged.	A	Verified at lower level
3.7.1.5.2.2.2.5	Spinup Land Coating	The spinup land coatings shall insure functional leakage rate of <=110 micrograms/second with flow rate of 725 scc/m during spinup.	I,T	Verified at lower level
3.7.1.5.2.2.2.6	Cavity Grounding Coating	A cavity grounding coating shall be provided for all surfaces less than 125 micrometer (5 milli-inch) from the rotor surface with the exception of: suspension and charge management electrodes, and the isolating areas around these electrodes. (Up to 50 missing areas not exceeding 5 mill are allowed in the grounding coating.)	I	Verified at lower level
3.7.1.5.2.2.2.7	Readout Loops	.	N/A	.
3.7.1.5.2.2.2.7.1	Geometry	The readout loop shall be located on the parting plane of the readout housing half and consist of 4 turns.	I	Verified at lower level
3.7.1.5.2.2.2.7.2	Materials and Composition	The readout loop shall be made from niobium.	I	Verified at lower level
3.7.1.5.2.2.2.7.3	Thickness	The readout loop thickness shall be 400 nm +200 /- 100 nm.	I	Verified at lower level
3.7.1.5.2.2.2.7.4	Superconducting Transition Temperature	The readout loop shall have a superconducting transition temperature greater than or equal to 4.2 K .	T	Verified at lower level
3.7.1.5.2.2.2.7.5	Centering to Cavity	The readout loop shall be centered on the gyro housing cavity within 10 micrometer.	T	Verified at lower level
3.7.1.5.2.2.2.7.6	In-Plane Asymmetry	The in-plane asymmetric loop area of the pickup loop shall be less than or equal to 0.6% of the total pickup loop area. This includes both geometric and diamagnetic contributions to the asymmetry.	I,A	Verified at lower level
3.7.1.5.2.2.2.7.7	Inductance	The readout loop inductance shall be less than or equal to 2 microhenry.	S	Verified at lower level

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PLSE-12 #	Title	Requirement	Method	Verification Status
3.7.1.5.2.2.2.7.8	Diameter	Inside diameter of inner turn >= 19.81 mm (0.780 inch). Outside diameter of outer turn <= 20.68 mm (0.814 inch).	I	Verified at lower level
3.7.1.5.2.2.2.8	Readout Cable	.	N/A	.
3.7.1.5.2.2.2.8.1	Inductance	The readout cable shall have an inductance of less than 0.1 microhenry, and the inductance shall be stable to 5 parts in 1.0e5 per year.	A	Verified at lower level
3.7.1.5.2.2.2.8.2	Out of Plane Asymmetry	Asymmetric loop area perpendicular to the plane of the pickup loop times the cosine of the angle between the spin axis and out of plane asymmetry shall be less than 6.0e-5 of the loop area.	I	Verified at lower level
3.7.1.5.2.2.2.8.3	Transition Temperature	The readout cable shall have a superconducting transition temperature of greater than 8.5 K.	S	Verified at lower level
3.7.1.5.2.2.2.8.4	Flux Coupling from Applied External Field	The flux coupling from an applied external field shall be less than or equal to 1.0e-7 flux-quanta/pT (flux is referred to flux in SQUID loop). The applied external field is the free magnetic field applied to the shield of the readout cable.	A	Verified at lower level
3.7.1.5.2.2.3	Gyroscope Assembly		N/A	.
3.7.1.5.2.2.3.1	Rotor Gap to Electrodes	When the rotor is centered, the gap between the rotor and electrodes shall be as required in Section 1.6.1 of T003.	I	Verified at lower level
3.7.1.5.2.2.3.2	Rotor Gap to Support Lands	When the rotor is centered, the gap between the rotor and the support lands shall be as required in Section 1.6.2 of T003 with a tolerance of +/- 3.7 micrometer.	I	Verified at lower level
3.7.1.5.2.2.3.3	Rotor Gap to Caging Lands	When the rotor is centered, the gap between the rotor and the caging lands shall be 21 micrometer +/- 3.7 micrometer.	I	Verified at lower level
3.7.1.5.2.2.4	Charge Control	.	N/A	.
3.7.1.5.2.2.4.1	Photo Emissivity from UV Electrode	The photoemission from the UV electrode shall be greater than or equal to 1.0e-7 electron/photon.	T	Verified at lower level
3.7.1.5.2.2.5	Gyro Instrumentation Characteristics	.	N/A	.
3.7.1.5.2.2.5.1	Germanium Resistance Thermometer Characteristics	The GRTs shall have a nominal resistance of 1000 ohm to 2500 ohm at 4.2 K and be calibrated over the temperature range 1.4 K to 100 K with an accuracy of 5 mK over the temperature range from 1.4 K to 10 K.	I	Verified at lower level
3.7.1.5.2.2.5.2	Heater Characteristics		N/A	.
3.7.1.5.2.2.5.2.1	Resistance	The resistance shall be 1320 ohm +/- 100 ohm at 4.2 K.	T	Verified at lower level
3.7.1.5.2.2.5.2.2	Dipole Moment due to Current	The current induced magnetic dipole moment shall be less than 2.0e-9 A-m^2/mA (2.0e-6 emu/mA).	S	Verified at lower level
3.7.1.6	Science Telescope	.	N/A	.

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PLSE-12 #	Title	Requirement	Method	Verification Status
3.7.1.6.1	Prime Item Definition	Definitions: ST Science Telescope QB Quartz Block ICD Interface Control Document or Interface Control Drawing The ST consists of a fused-quartz assembly including a primary, a secondary and a tertiary mirror, two roof prisms, and appropriate beam splitters and mirrors to convert a single plane wave beam of light from a distant star into 8 spots of light at the output ports. The intensities of the spots vary as the star is displaced from the telescope centerline in either axis in such a way that the Telescope Readout Electronics can use the variation to produce a signal corresponding to the magnitude and direction of the displacement.	N/A	.
3.7.1.6.1.1	Prime Item Diagram	The Science Telescope is shown in Figure 3.7.1-3 (click OLE tab to view).	N/A	.
3.7.1.6.1.2	Interface Definition	.	N/A	.
3.7.1.6.1.2.1	Functional Interfaces	The ST mechanically interfaces to the quartz block as described in section 3.7.1.6.1.2.4. It interfaces thermally by contact with the quartz block, radiatively with any radiation coming through the windows, and conductively through the detector cables, which mate with the probe connectors. It interfaces optically with the guide star wavefront coming through the windows and with the photodetectors of the Telescope Readout Electronics.	N/A	.
3.7.1.6.1.2.2	Signal Interfaces	The ST shall output to the Telescope Readout Electronics eight optical signals as listed below. Positive Pitch Axis Alternate Positive Pitch Axis Negative Pitch Axis Alternate Negative Pitch Axis Positive Yaw Axis Alternate Positive Yaw Axis Negative Yaw Axis Alternate Negative Yaw Axis The detailed electrical interface to the probe with identification of the electrical function is given in Section 3.7.6.2.2.	I	Verified at lower level
3.7.1.6.1.2.4	Mechanical Interfaces	The mechanical interface of the telescope to the quartz block meets the positioning and alignment requirements of Section 3.7.1.4.1 and mechanical attachment requirement of Section 3.7.1.4.4.1.1.	N/A	.
3.7.1.6.2	Characteristics	.	N/A	.
3.7.1.6.2.1	Performance	.	N/A	.
3.7.1.6.2.1.1	Perpendicularity of Readout Axes	The perpendicularity between the two readout axes shall meet the requirement of Section 7.3 of T003.	A	Verified at lower level
3.7.1.6.2.1.2	Field of View	.	N/A	.

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PLSE-12 #	Title	Requirement	Method	Verification Status
3.7.1.6.2.1.2.1	Misalignment of Optical Center from Center of Aperture Stop	The misalignment of the optical center of the telescope is defined to be the angle between the direction to a distant star which centers the image of the star on both of the image splitting roof prisms and the direction to a distant star which centers the image of the star on the center of the aperture stop. This misalignment shall be less than 10 arc sec.	A,T	Verified at lower level
3.7.1.6.2.1.2.2	Maximum Aperture Stop	The aperture stop has a radius so as to exclude at least 95% of the light from any star at an angle greater than 82 arc sec from the direction which centers the image of a distant star on the center of the aperture stop.	N/A	.
3.7.1.6.2.1.2.3	Minimum Aperture Stop for 95% of the Light	The aperture stop has a radius so as to include at least 95% of the light from any star at an angle less than 38 arc sec from the direction which centers the image of a distant star on the center of the aperture stop.	N/A	.
3.7.1.6.2.1.2.4	Minimum Aperture Stop for 10% of the Light	The aperture stop shall have a radius so as to include at least 10% of the light from any star at an angle less than 60 arc sec from the direction which centers the image of a distant star on the center of the aperture stop.	A,T	Verified at lower level
3.7.1.6.2.1.3	Unsaturated Range	The unsaturated range shall meet the requirements of Section 7.2.2.	A,T	Verified at lower level
3.7.1.6.2.1.4	Linear Range	The linear range and linearity shall meet the requirements of paragraph 7.2.3 in T003.	A	Verified at PL level
3.7.1.6.2.1.5	Strehl Ratio	The Strehl Ratio shall be >= 72%.	A	Verified at lower level
3.7.1.6.2.1.6	Optical Transmissibility	The power transmissibility collectively to all of the photodetectors shall be greater than or equal to 20% of the total light incident on the clear aperture of the telescope over an optical bandwidth from 400 nm to 1000 nm.	A	Verified at lower level
3.7.1.6.2.1.7	Reticle Plate	The reticle plate shall meet the requirements of Section 3.7.1.4.3.	I	Verified at lower level
3.7.1.7	SQUID Kit	.	N/A	.
3.7.1.7.1	Prime Item Definition	A SQUID kit consists of two SQUID Packages, each containing one SQUID Sensor, the cables connecting the above components to the cold end Probe connectors, and the SQUID bracket (providing the components for thermal control) and other mounting hardware required to hold the above components in place. There are two SQUID kits in the SIA.	N/A	.
3.7.1.7.1.1	Prime Item Diagrams	.	N/A	.
3.7.1.7.1.1.2	SQUID Package	The SQUID package is shown in Figure 3.7.1-4 (click 'OLE' tab to view diagram).	N/A	.
3.7.1.7.1.2	Interface Definition	.	N/A	.
3.7.1.7.1.2.1	Functional Interfaces	The SQUID kit shall interface through the probe cables to the SQUID forward Electronics for power and operational control (Section 3.7.1.7.1.2.2), for thermal control (Section 3.7.1.7.1.2.4), and to deliver Science Signals (Section 3.7.1.7.1.2.2). It shall interface to each Science Gyroscope through its Superconductive Cable. It shall interface to the structure of the Probe through the SQUID Mounting Bracket.	I	Verified at lower level

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PLSE-12 #	Title	Requirement	Method	Verification Status
3.7.1.7.1.2.2	Signal Interfaces	Each SQUID kit shall have the following electrical inputs and outputs. 1. Bracket instrumentation inputs and outputs a. Input drive currents to two GRTs. b. Output signal voltages from two GRTs. c. Two SQUID bracket heater current inputs (one prime & one spare). 2. The following inputs and output to/from each of the two SQUID packages contained in a SQUID kit for connection to the SQUID forward electronics. a. Bias current input. b. Modulation signal input. c. Feedback signal input. d. Voltage signal output. 3. The following input to each of the two SQUID packages contained in a SQUID kit for connection to the gyroscope pickup loop. a. Gyroscope pickup loop flux signal.	I	Verified at lower level
3.7.1.7.1.2.3	Electrical Interfaces	The SQUID hardware shall interface to the cold end connectors as shown in LMSC drawing 1C34103	I	Verified at lower level
3.7.1.7.1.2.4	Thermal Interfaces	The operating temperature of each SQUID Package is maintained as specified in Sections 3.7.1.7.2.1.6.4 and 3.7.1.7.2.1.6.5 by an active thermal control system that uses a GRT and a heater mounted on each SQUID Bracket. The Probe maintains a temperature at the mounting as specified in Section 3.7.2.5. The total power delivered to the SQUID Bracket does not exceed that specified in 3.7.2.5.7	N/A	**not in database**
3.7.1.7.1.2.5	Mechanical Interfaces	Each SQUID Bracket shall interface to the Probe Quartz Block Support structure as shown in LMMS drawing 1C34103 .	I	Verified at lower level
3.7.1.7.2	Characteristics	.	N/A	.
3.7.1.7.2.1	Performance	In the specifications below, the conversion from flux signal in the SQUID input loop to angle equivalent signal assumes a four turn pickup loop, a 130 Hz spin speed, and a 3 minute roll period.	N/A	.
3.7.1.7.2.1.1	Noise at 5.5 milliHertz	The SQUID sensor noise shall have a magnitude less than 140 marcsec/Hz^0.5 equivalent at 5.5 mHz (single-sided)with a measurement error of <=20 marcsec/Hz^0.5.	T	Verified at lower level
3.7.1.7.2.1.2	Noise at 130 Hertz	The SQUID sensor noise shall have a magnitude less than 60 marcsec/Hz^0.5 at 130 Hz, where the flux to angle scale factor assumes a rotating trapped dipole flux level equal to the London dipole moment at 130 Hz (this trapped flux level is an assumption only, and does not occur in fact).	T	Verified at PL level
3.7.1.7.2.1.3.1	Harmonic Distortion	The harmonic distortion of the SQUID operating with flux-locked-loop electronics having a disturbance rejection of 100-200 for a 1 kHz signal with an amplitude of 2 flux quanta shall be less than 10^-4.	T	Verified at PL level
3.7.1.7.2.1.4	SQUID Thermal Characteristics	.	N/A	.

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PLSE-12 #	Title	Requirement	Method	Verification Status
3.7.1.7.2.1.4.1	Operating Temperature Range	(a) The nominal operation temperature is defined in 3.4 of T003, and it is the range over which all other performance requirements must be met. (b) The functional operation temperature range is from 2.5 K to 4.2 K, and it is the range over which the only requirement is that the SQUID shall be able to flux locked.	T,S	Verified at lower level
3.7.1.7.2.1.4.2	SQUID Bias Temperature Coefficient	The SQUID shall have a bias temperature coefficient of less than 0.01 flux quanta/K over the temperature range 2.7 K - 3K	T	Verified at PL level
3.7.1.7.2.1.4.3	SQUID Scale Factor Temperature Coefficient	The SQUID shall have an input current-to-SQUID flux transfer coefficient whose temperature coefficient is less than 3.0x10^-4 in the range 2.7 - 3K	T	Verified at lower level
3.7.1.7.2.1.5	Flux Jumps	There shall be no more than 1 flux jump per 6 hours with an amplitude in the range of 1 to 20 arcsec. There shall be no flux jumps with an amplitude exceeding 20 arcsec.	T,S	Verified at lower level
3.7.1.7.2.1.6	Input Coil Impedance	The SQUID sensor input coil shall have an inductance less than 2.0 microhenry and shall be stable to 5 parts per million per year.	A,S	Verified at lower level
3.7.1.7.2.1.7	Damping of Cable to Package Joint	The decay time of the SQUID Package Input circuit and Cable to package joint shall be less than 1% in 10 min.	T	Verified at PL level
3.7.1.7.2.1.8	Feedback Transformer Coupling	The SQUID Feedback Transformer shall have mutual inductance of 0.35 microhenry to 0.45 microhenry and shall be stable to 5 parts per million per year.	A,S	Verified at lower level
3.7.1.7.2.1.9	Electrical Isolation	The resistance between any two of the following shall be greater than 20 megohms: bias, modulation, feedback, and signal.	T	Verified at lower level
3.7.1.7.2.1.10	Pickup Loop to SQUID Coupling	The Pickup Loop shall have a coupling to the SQUID better than 40 fA/marcsec.	A	Verified at lower level
3.7.1.7.2.1.11	Input Circuit Mutual Inductance Stability	The mutual inductance of input coil to SQUID loop shall be stable to better than 5 parts in 1.0e6 per year.	A	Verified at lower level
3.7.1.7.2.1.12	SQUID Bias Current	The SQUID sensor shall have a bias current between 20 microampere and 60 microampere.	T	Verified at PL level
3.7.1.7.2.1.13	Modulation Coil to SQUID Mutual Inductance	The mutual inductance shall be between 1.3 nH and 1.5 nH.	S	Verified at lower level
3.7.1.7.2.1.14	Input Filter Capacitance	The capacitance from each contact block to ground shall be between 8 nF and 13 nF.	T	Verified at PL level
3.7.1.7.2.1.15	SQUID Package AC Magnetic Shielding	The SQUID package shall provide ac shielding such that flux coupling from an applied external magnetic field shall be <= 4.0e-7 flux-quanta/pT (flux is referred to flux in SQUID loop). The applied external field is the free magnetic field applied to the exterior of the SQUID package.	T	Verified at lower level
3.7.1.7.2.1.16	SQUID Bracket Thermal Characteristics	The thermal design of the SQUID bracket (including GRTs & heaters), SQUID packages, and related electrical cables shall have the capability to meet the requirements in 3.4 of T003.	A	Verified at lower level

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PLSE-12 #	Title	Requirement	Method	Verification Status
3.7.1.7.2.1.16.1	Germanium Resistance Thermometer Characteristics	The GRTs shall have a nominal resistance of 1500 ohm to 2500 ohm at 4.2 K and be calibrated over the temperature range 2.5 K to 20 K with an accuracy of 5 mK over the temperature range from 2.5 K to 10 K	I	Verified at lower level
3.7.1.7.2.1.16.2	Heater Resistance	The heaters shall have a resistance of 1320 ohm +/- 100 ohm at 4.2 K.	T	Verified at lower level
3.7.1.7.2.1.16.3	Heater Dipole Moment due to Current	The heaters shall have a current induced magnetic dipole moment < 2.0e-9 A-m^2/mA (2.0e-6 emu/mA).	S	Verified at lower level
3.7.1.7.2.1.16.4	Thermal Delay Time	The time delay from heat applied to the SQUID bracket to the response at the GRT on the bracket shall be less than 1.0s. Will be tested in component-level tests for the Science Mission. Will be tested in GTU-2 integrated test.	A	Verified at lower level
3.7.1.7.2.1.17	Flux Slipping	It shall be possible to slip a flux quantum in the SQUID loop with a measurement error of less than 1 part in 10^5.	T	Verified at PL level
3.7.1.9	Detector Package Assembly	.	N/A	.
3.7.1.9.1	Vibration Environment	DPA shall perform as specified after exposure to the following vibration testing levels Frequency (Hz) Qual (g^2/Hz) 20 0.016 20-50 +8.3 dB/Octave 50-150 0.1 150-1000 -9.8 dB/Octave > 1000 0.0	S	Verified at lower level
3.7.1.9.3	Platform Temperature Variation at Roll Frequency	The DMA platform temperature variation shall be less than or equal to 50 mK (as defined in T003, 7.6.2)	A,T	Verified at PL level
3.7.1.9.5	Diameter of Photoactive Area	The diameter of DPA photoactive area shall be less than 0.8 +/-0.1 mm.	S	Verified at lower level
3.7.1.9.6	Base Temperature	.	N/A	.
3.7.1.9.6.1	Base Operational Temperature	The DMA will be fully operable with a base temperature between 2 and 6 K.	N/A	.
3.7.1.9.6.2	Base Test Temperature	The DMA will be testable with temperatures between 2 and 290 K.	N/A	.
3.7.1.9.7	Detector Thermal Output	.	N/A	.

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PLSE-12 #	Title	Requirement	Method	Verification Status
3.7.1.9.7.1	Total Telescope Detector Power (All Detectors)	The total detector power shall be less than or equal to 6 mW (1.5 mW/DMA).	T	Verified at lower level
3.7.1.9.8	Detector Base Operational Temperature Range	The base temperature operational range at the photo current levels 10 fA and 10 pA will be between 2 and 6 K. And the temperature operational range at the photo current levels 10 pA will between 2 and 300 K.	N/A	.
3.7.1.9.10	TRE Detector Performance Requirement	.	N/A	.
3.7.1.9.10.1	External Quantum Efficiency Over Operating Bandwidth	The photocell quantum efficiency shall be greater than 60%	T	Verified at lower level
3.7.1.9.10.2	Dark Current	The photocell dark current shall be less than 0.01 fA at 80 K.	T	Verified at lower level
3.7.1.9.10.3	Operating Temperature (Si JFETs)	The JFET operating temperature shall be 85K +/- 5K.	T	Verified at lower level
3.7.1.9.10.4	Random Noise	The DPA random noise shall be less than 100 electrons (rms)/(0.1 sec read) per photocell.	A	Verified at lower level
3.7.1.9.10.5	Temperature Stability	The DPA shall have a temperature coefficient of less than 440 electron/(read)/K	T	Verified at lower level
3.7.2	SIA to Probe ICD	.	N/A	.
3.7.2.1	Mechanical Interface Requirements	The dimensional interface between the probe and SIA shall be as described on LMMS drawing 1C34103.	I	Verified at lower level
3.7.2.1.1	SIA Removability	It is possible to remove the SIA from the probe, without having to remove the gyros.	N/A	.
3.7.2.1.2	Science Gyroscope Removability	Each of the individual science gyroscopes is removable from the probe without removing the SIA.	N/A	.
3.7.2.1.3	SQUID Removability	Each of the SQUIDs is capable of being removed individually from the probe without removing the SIA.	N/A	.
3.7.2.1.4	Stress in the SIA Flange	Tensile and shear stresses in the quartz flange at the finger interface shall be < 725 psi, under all expected conditions.	A	Verified at lower level
3.7.2.1.5	Contact Between the SIA Flange and the Birdcage Ring	During integration of the SIA into the probe, the four radial gaps between the Quartz Block mounting flanges and the birdcage ring shall be shimmed such that the gap is 0.10 - .18 mm (0.004 -0.007") when the assembly is at 4.2 K.	I	Verified at lower level
3.7.2.1.6	Telescope Keepout Zone	The probe shall have a telescope keepout zone as shown in interface control drawing 1C34103.	I	Verified at lower level

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PLSE-12 #	Title	Requirement	Method	Verification Status
3.7.2.1.7	Telescope Detector Access Ports	The probe QBS shall provide detector access ports, and approximately 6.5 mm (1/4 in) wide slots between these access ports and the corresponding connector ports, as shown in drawings 1C34135, 1C34375, and ICD 1C34103. Access shall be provided (and telescope detector mount made) such that access to and removal of the detector dual mounting block is facilitated.	I	Verified at PL level
3.7.2.2	Electrical Interface	The number, type, location, orientation, and pin allocation of the electrical connectors at the SIA/probe interface shall be as described on LMMS drawing 1C34103. The interface also conforms to the requirements listed in the following subsections.	I	Verified at lower level
3.7.2.2.1	Suspension Cable Interface	The suspension cable connectors have the following characteristics:	N/A	.
3.7.2.2.1.3	Support of Stanford Jumper Wires	The probe structure shall have provisions to support the Stanford coaxial jumper wires at the edge of the birdcage per LMMS drawing 1C34103.	I	Verified at lower level
3.7.2.2.1.4	Accessibility of Connectors	Installation and removal of a single science gyroscope's jumper wires from their coaxial connectors is possible without disturbing the jumper wires of any other gyroscope.	N/A	.
3.7.2.2.2	SQUID Cable Interface	The probe connectors for the SQUID cables shall be fixed in orientation and keyed. The key slots shall be oriented radially outward with respect to the probe z* axis.	I	Verified at PL level
3.7.2.2.3	Grounding Interface	The ground interface between the probe and SIA shall be as described in the following subsections and as shown in LMMS drawing 1C34571.	I	Verified at PL level
3.7.2.2.3.1	Ground Connectors for the SIA	There shall be threaded holes in the extrusions for the attachment of ground wires as shown on LMMS drawing 1C34103.	I	Verified at lower level
3.7.2.2.3.2	Quartz Block Support Resistance	The resistance between the z* Station 200* ring and the ground attachment points of 3.7.2.2.3.1 shall be <= 0.1 ohms.	T	Verified at lower level
3.7.2.2.3.3	Composite Neck Tube Resistance	The primary ground path between the top hat and the z* Station 200* ring shall be the titanium foil lining of the composite neck tube. The resistance of the primary ground path between the top hat and the z* Station 200* ring shall be <= 0.5 ohms.	T	Verified at lower level
3.7.2.2.3.4	Probe Conducting Parts	(1) All conducting parts forward of Station 159.13 in the probe with projected surface area >929 square centimeters (144 sq. in.) shall have a resistance to top hat ground < 10 Mohms. (2) Conducting loops in the region between the top hat and the Station 200 ring shall have a resistance > 20 ohms.	I,T	Verified at lower level
3.7.2.2.3.5	Top Hat	The resistance between any two points on the top hat shall be <= 0.1 ohms.	T	Verified at lower level
3.7.2.2.3.6	Definitions of Grounded and Isolated	.	N/A	.
3.7.2.2.3.6.1	Ground Bond Resistance	The resistance across any ground bond within the probe shall be <= 10 mohms. This does not apply for bonds within the probe conducting parts of 3.7.2.2.3.4	T	Verified at lower level
3.7.2.2.3.6.2	Isolation Resistance	Components which are required to be electrically isolated shall have a resistance >= 1 Mohms.	T	Verified at PL level

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PLSE-12 #	Title	Requirement	Method	Verification Status
3.7.2.2.3.7	100% Shielded Enclosure	The probe shall provide a complete and continuous ground electrostatic shielding surface surrounding the Quartz Block assembly during normal operation. The sheet resistance shall be <= 20 mohms per square except for the coating of the warm window, which is governed by an RFI attenuation specification.	T	Verified at lower level
3.7.2.2.3.7.1	Grounding of the Warm Window	The conductive coating on the window 4 substrate shall be electrically connected to the support ring around its circumference. The resistance from the center of the coating to the top hat shall be consistent with the RFI attenuation specification for the window.	A	Verified at lower level
3.7.2.2.3.7.2	Grounding of the Sunshade	The sunshade shall be grounded to the Cross Flange to provide EMI shielding, for frequencies up into the GHz range . See section 3.7.3.7.4.1 for EMI filtration requirement.	T	Verified at PL level
3.7.2.2.3.8	Grounding of Spin-up Filters	The resistance between ground and any gas filter in the spin-up lines shall be <= 2 ohms.	T	Verified at lower level
3.7.2.2.4	Support of Stanford SQUID-to-Gyroscope Wires	The probe structure shall have provisions to attach a Stanford-supplied support to the spider for the Stanford SQUID-to-gyroscope wires per LMMS drawing 1C34103.	I	Verified at lower level
3.7.2.3	Spin-up Gas Interface Requirements	.	N/A	.
3.7.2.3.1	Number of Spin-Up Circuits	There shall be 4 separate circuits for the spin-up of the science gyroscopes.	I	Verified at PL level
3.7.2.3.2	Location of Interface Connection	The physical location of the spin-up interface shall be as described on LMMS drawing 1C34103.	I	Verified at PL level
3.7.2.3.3	Gas Flow Rate	The flow rate of the spin-up gas at the interface shall be as per 3.2.1.7.1.	A,S,T	Verified at PL level
3.7.2.3.4	Gas Pressure	The helium gas flow impedance of the probe and SIA shall be such that the spinup inlet gas pressure at the top hat interface shall not exceed 4.0 x 10^4 Pa (300 torr) for the spin-up gas flow rate specified in 3.2.1.7.1.	T	Verified at PL level
3.7.2.3.5	Gas Temperature	The temperature at temperature sensor of the spin-up gas filter assembly at the inlet interface shall be adjustable over the range of 4- 12 K and stable to +/-0.25 K.	T	Verified at PL level
3.7.2.3.6	Exhaust Line Pressure Drop	The pressure drop of the exhaust line from the probe/SIA interface to free space shall be <= 60 Pa (0.45 torr) at a flow rate per 3.7.2.3.3 for a gas temperature range of 5 - 7 K.	A	Verified at lower level
3.7.2.3.7	Gas Leakage Into the Probe	The rate of spin-up gas leakage from the gyroscope into the probe interior shall be as per 3.2.1.2.1.	T	Verified at PL level
3.7.2.3.8	Pressure at the SIA During Spin-up	The pressure within the probe at the SIA shall be as per 3.2.1.2.1 for a gas leakage rate as per 3.2.1.2.1.	T	Verified at PL level
3.7.2.3.9	Cleanliness of the Gas	The spin-up gas inlet line shall incorporate a final filter with an absolute rating of 0.5 micrometers. The inlet lines after the filters and the exhaust lines shall be clean per cleanliness zone II standards as described in 3.3.1.2.6.	T	Verified at PL level

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PLSE-12 #	Title	Requirement	Method	Verification Status
3.7.2.4	Caging System Interface Requirements	.	N/A	.
3.7.2.4.1	Number of Caging Circuits	There shall be three (3) separate circuits for the caging of the science gyroscopes. The circuits are configured such that gyros 1 & 2 are caged independently and gyros 3 & 4 are caged together.	I	Verified at lower level
3.7.2.4.2	Location of Interface Connection	The physical location of the caging interface shall be as described on LMMS drawing 1C34103.	I	Verified at PL level
3.7.2.4.4	Volume of Displaced Gas	When the caging system is at its nominal operating pressure of 170 psi, the volume of liquid helium in each caging mechanism including the lines on the SIA side of the SIA/probe interface shall be <= 0.5 cm^3 (0.03 in^3). Each of the three independent caging circuits shall have a volume of liquid helium <= 1.0 cm^3 (0.06 in^3) on the SIA side of the SIA/probe interface when pressurized at the operating pressure.	I,A	Verified at lower level
3.7.2.5	Thermal Interface Requirements	The probe maintains the thermal interface conditions as specified in the following subsections during "normal operation", which is defined in section 1.4, unless otherwise specified.	N/A	.
3.7.2.5.1	On-Orbit Temperatures	The following temperature requirements shall be met while Science Data is collected.	N/A	.
3.7.2.5.1.1	Support Flange Temperature	The temperature of the Quartz Block Support (QBS) fingers shall meet the requirement specified in 12.8 of T003.	A,T	Verified at PL level
3.7.2.5.1.2	Support Flange Temperature Stability	The temperature stability of the QBS fingers shall meet the requirement specified in 12.8 of T003	A,T	Verified at PL level
3.7.2.5.1.3	SQUID Attachment Point Temperature	The temperature of each SQUID platform's attachment points shall meet the requirements specified in 12.8 of T003.	A, T	Verified at PL level
3.7.2.5.1.4	Telescope Detector Connector Interface Temperature	The telescope cables (SIA and probe) and connectors (SIA and probe) are designed to thermally ground the detector housings, assuming a heat source <= DPA power specified in 3.7.2.5.7, to Station 200, while satisfying the requirements of 3.7.2.5.1.1 (QBS fingers temp) and 3.7.2.5.1.3 (SQUID attachment points temp).	N/A	.
3.7.2.5.2	Ground Operation Temperatures	The probe/dewar system has the capability of meeting the following temperature requirements during ground operations assuming that the maximum heat powers are less than those in 3.7.2.5.7 except for an increase in the thermal radiation on the QB to compensate for the higher ambient temperature on the outside of the dewar.	N/A	.
3.7.2.5.2.1	SQUID Temperature	The temperature of the SQUID packages shall be <= 3.3 K.	T	Verified at PL level
3.7.2.5.3	Support Flange Thermal Resistance	The thermal resistance of the SIA/support flange during "normal operation" shall be such that the temperature of the QB flange does not exceed that of the QBS fingers by more than 50 mK.	A	Verified at PL level
3.7.2.5.6	Radiation Heat Input to the SIA	The radiation heat load into the SIA during normal operation shall be <= 0.25 mW.	A,T	Verified at PL level

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PLSE-12 #	Title	Requirement	Method	Verification Status
3.7.2.5.7	Heat Power into QBS	The maximum heat power into the QBS will not exceed the values given in the following while Science Data is being collected. (note: actual requirements are listed in 3.7.2.5.7.1 - 3.7.2.5.7.7.) Item / # of items / Power(mW)/item / Power (mw) SQUID Bracket Assy 2 0.250 0.500 QB GRTs (lot) 1 0.001 0.001 SDs (lot) not used 1 0.000 0.000 Thermal radiation on QB 1 0.250 0.250 Gyroscope Assemblies 4 0.001 0.004 Telescope DPA (2 ea. DMAs) 2 3.000 6.000 QBS heater 1 2.000 2.000 TOTAL 8.755	N/A	.
3.7.2.5.7.1	Heat Power to QBS in SQUID Bracket Assembly	The maximum heat power into the QBS shall not exceed the values given in the following while Science Data is being collected. Item: / #of Items / Power(mW)/item / Power(mW) SQUID Bracket Assy 2 0.250 0.500	T	Verified at PL level
3.7.2.5.7.2	Heat Power to QBS in QB GRTs (lot)	The maximum heat power into the QBS shall not exceed the values given in the following while Science Data is being collected. Item: / #of Items / Power(mW)/item / Power(mW) QB GRTs (lot) 1 0.001 0.001	A	Verified at PL level
3.7.2.5.7.3	Heat Power to QBS in SDs (lot) not used	The maximum heat power into the QBS shall not exceed the values given in the following while Science Data is being collected. Item: / #of Items / Power(mW)/item / Power(mW) SDs(lot) not used 1 0.000 0.000	A	Verified at PL level
3.7.2.5.7.4	Heat Power to QBS in Thermal Radiation on QB	The maximum heat power into the QBS shall not exceed the values given in the following while Science Data is being collected. Item: / #of Items / Power(mW)/item / Power(mW) Thermal Radiation on QB 1 0.250 0.250	A, T	Verified at PL level
3.7.2.5.7.5	Heat Power to QBS in Gyroscope Assemblies	The maximum heat power into the QBS shall not exceed the values given in the following while Science Data is being collected. Item: / #of Items / Power(mW)/item / Power(mW) Gyroscope Assemblies 4 0.001 0.004	A	Verified at PL level
3.7.2.5.7.6	Heat Power to QBS in Telescope DPA (2 each DMAs)	The maximum heat power into the QBS shall not exceed the values given in the following while Science Data is being collected. Item: / #of Items / Power(mW)/item / Power(mW) Telescope DPA (2 ea. DMAs) 2 3.000 6.000	T	Verified at PL level

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PLSE-12 #	Title	Requirement	Method	Verification Status
3.7.2.5.7.7	Heat Power to QBS in QBS Heater	The maximum heat power into the QBS shall not exceed the values given in the following while Science Data is being collected. Item: #of Items Power(mW)/item Power(mW) QBS Heater 1 2.000 2.000	T	Verified at PL level
3.7.2.5.8	Low Temperature Bake-Out of the SIA	During the special operation of low temperature bake-out, it shall be possible to raise the temperature of a sufficiently large (90%) area of the SIA to >= 6 K, by heating the QBS, without raising the temperature of any part of the lead bag above the temperature specified in 3.7.5.5.7.	A,T	Verified at PL level
3.7.2.5.9	Flux Flushing of the SIA	During the special operation of flux-flushing, it shall be possible to raise the temperature of the SIA (exclusive of the telescope) to >= 12K in <= 12 hours, by heating the QBS, without raising the temperature of any part of the lead bag above the temperature specified in 3.7.5.5.7.	A,T	Verified at PL level
3.7.2.6	Magnetic Interface Requirements	.	N/A	.
3.7.2.6.1	DC Magnetic Field	The steady state magnetic field shall be as specified in 3.2.1.3.1.	A,T	Verified at PL level
3.7.2.6.3	Location of Gyroscopes Within the Probe	The location of science gyroscope #1 shall be z* Station 153.29* +/- 0.10 inches. The location of science gyroscope #4 shall be z* Station 143.54* +/- 0.10 inches.	I	Verified at lower level
3.7.2.7	UV Fiber-Optic Cable Interface	The UV fiber-optic cable interface shall be per LMMS drawing 1C34103.	I	Verified at PL level
3.7.3	Probe Specification	The probe shall be designed to perform as specified in the following subsections while exposed to the orbital environments of 3.2.5.6. The probe shall survive exposure to the environments of 3.2.5.1 through 3.2.5.5 without degradation of its subsequent performance. The probe shall comply with the requirements of section 3.3.	I,A,T	Verified at lower level

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PLSE-12 #	Title	Requirement	Method	Verification Status
3.7.3.1	Probe Definition	The probe consists of the cylindrical tube that contains and supports the science instrument assembly and auxiliary instrumentation. Its function is to provide the vacuum required by the science gyroscopes during operation as well as the mechanical, electrical, and gas supply support of the entire science instrument assembly during low temperature operation. The probe consists of the following component parts: 1) Sunshade; 2) Cross Flange Assembly; 3) Top Hat Assembly; 4) Composite Neck Tube; 5) Windows 1,2,3,4; 6) False Wall/Heat Station Assemblies; 7) Thermal Shoes; 8) Quartz Block Support, Saddles and Lateral Bumpers; 9) Probe Vacuum Shell; 10) Plumbing Components (Heat Exchangers (HEX), tubing, valves, etc.); 11) Optical Cables and Connector; 12) Electrical Cables, Wiring and Connectors; 13) Probe Instrumentation; 14) Cryopump; 15) Shutter	N/A	.
3.7.3.2	Physical Characteristics	.	N/A	.
3.7.3.2.1	Probe Weight	The weight allocated to the probe assembly, including sunshade assembly, and excluding the SIA, is 180 kg, as specified in P024612.	A,T	Verified at lower level
3.7.3.2.2	Dimensions	.	N/A	.
3.7.3.2.2.1	External Dimensions	The probe shall conform to the envelope dimensions, mechanical and electrical interface locations, fluid interface locations and vent locations given in 3.7.2, 3.7.4, and 3.7.6.	T	Verified at lower level
3.7.3.2.2.2	Internal Compartment for SIA	The probe shall provide an internal location for the Science Instrument Assembly (SIA) that meets the interface requirements of section 3.7.2.	I	Verified at lower level
3.7.3.2.3	Structural Characteristics	The probe shall be designed to accommodate the launch loads of section 3.2.5.5 and meet the structural resonance requirements of 3.2.2.4.	A,T	Verified at lower level
3.7.3.2.5	Cryogenic Integration Capability	The probe shall be designed to be inserted and removed from the dewar while the dewar is at or above 4.2 K and the dewar well is filled with liquid helium at a pressure of >= 101 kPa (14.7 psia). It is not necessary to precool the probe prior to integration.	T	Verified at PL level
3.7.3.2.6	Handling Attachments	The probe shall provide a means of attaching GSE for the purpose of lifting and rotating the probe as stated in the following subsections.	I	Verified at lower level

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PLSE-12 #	Title	Requirement	Method	Verification Status
3.7.3.2.6.1	Lifting Support	The probe shall provide a lifting support to allow the probe to be raised by an overhead hoist with the z* axis vertical.	I	Verified at lower level
3.7.3.2.6.2	Orientation Capability	The probe shall provide GSE attachment points at z* Station 200*. The attachment points shall be designed to enable the probe to be tilted from horizontal to vertical and rotated about the z* axis.	I	Verified at lower level
3.7.3.2.7	Sunshade	The sunshade shall be a fixed length design with a sun-avoidance angle as close as possible to 18 deg within the space restrictions defined by the booster fairing and the mounting interface shown in 5833115.	I	Verified at PL level
3.7.3.2.8	Shutter	The probe shall provide the capability to block the optical path at a location outside of the probe vacuum enclosure. The shutter shall be capable of being opened and closed once per orbit for the entire mission lifetime.	I,T	Deferred
3.7.3.2.9	Preload System	A preload system shall be capable of clamping the probe to the dewar at Station 200 as specified in drawing 5833117. The system shall provide a minimum of 8896N (2000 lb) load force across the Station 200 interface for the worst case on-orbit temperatures.	A	Verified at lower level
3.7.3.3	Magnetic Environment	The probe occupies portions of magnetic zones 2A through 5 and SP described in section 3.3.1.1.14.1. The materials used in the probe shall conform to the requirements of 3.3.1.1.14.	I,T	Verified at lower level
3.7.3.3.1	Probe Residual Steady State Field	The residual field of the probe assembly shall be consistent with 3.2.1.3.1.	T	Verified at lower level
3.7.3.4	Thermal Requirements	The probe is designed to meet the thermal requirements as stated in the following subsections.	N/A	.
3.7.3.4.1	Heat Radiated Down the Neck	The probe shall be designed to meet the thermal interface requirement of 3.7.2.5.6.	A,T	Verified at PL level
3.7.3.4.2	Thermal Connections	The probe to dewar interface shall be designed to meet the thermal interface requirements of 3.7.2.5.	I	Verified at lower level
3.7.3.4.3	SIA Temperature Elevation	The probe shall be designed to allow SIA temperature elevation per the thermal interface requirements of 3.7.2.5.8 and 3.7.2.5.9.	A,T	Verified at PL level
3.7.3.4.5	Low Temperature Bakeout	The probe shall meet the requirements of the following subsections while maintaining the lead bag temperature requirement of 3.7.5.5.7 and the lifetime requirement of 3.2.1.10.	A,T	Verified at PL level
3.7.3.4.5.1	Warm Surface Area	The probe shall provide the capability to warm >= 90 percent of the probe internal surface area which operates at a nominal temperature < 6 K to a temperature >= 6 K.	A,T	Verified at PL level
3.7.3.4.5.1.1	Cryopump	The probe shall provide a bakeable cryopump at a location close to Station 200, with an effective surface area >= 30 m^2, and a bakeable temperature >= 6 K for a duration of 4-12 hrs.	A,T	Verified at PL level
3.7.3.4.5.2	Spin-up Inlet Line Filter Heating	The probe shall provide heaters with the capability to warm the spinup inlet filter to >= 10 K.	T	Verified at PL level
3.7.3.4.5.3	Spin-up Exhaust Lines	The probe shall provide heaters with the capability to warm the spin-up exhaust lines to >= 6 K to within 15 cm (6 inches) of STA 200.	A,T	Verified at PL level
3.7.3.4.5.4	Pressure Sense Line Heating	The probe shall provide heaters with the capability to warm the entire length of the pressure sense line to >= 6 K during helium partial pressure measurements.	A,T	Verified at PL level
3.7.3.4.6	Spin-up Gas Heating	The probe shall provide the capability to warm the spin-up inlet filter to meet the requirement of 3.7.2.3.5.	T	Verified at lower level

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PLSE-12 #	Title	Requirement	Method	Verification Status
3.7.3.4.7	Lead Bag Temperature	The probe shall be able to meet all of the requirements of 3.7.3 while maintaining the lead bag temperature below the requirement of 3.7.5.5.7.	A,T	Verified at PL level
3.7.3.4.8	Window Bakeout	The probe shall provide the capability of raising the temperature of the windows, through attached heaters, to the following temperatures within 8 hrs/window: 1) Window 1 (coldest) >= 60 K; 2) Window 2 >= 95 K; 3) Window 3 >= 220 K; 4) Window 4 (warmest) >= 280 K	A,T	Verified at PL level
3.7.3.5	Vacuum/Pressure Environment	The probe shall be designed to meet the vacuum/pressure requirements as stated in the following subsections.	N/A	.
3.7.3.5.1	Vacuum During Spin-up	The probe is designed to achieve the vacuum requirements of 3.2.1.2.1.	N/A	.
3.7.3.5.2	Vacuum at End of Low Temperature Bakeout Heating	The probe shall provide the capability to reach <= 1.3 x 10-5 Pa (1 x 10-7 torr) after 4-12 hours of pumping during the low-temperature bakeout before temperature is reduced.	T	Verified at PL level
3.7.3.5.3	Vacuum During Operational Life	After completion of spin-up and the low-temperature bakeout, the probe shall be capable of reducing and maintaining the internal pressure to meet the vacuum requirements of 3.2.1.2.2.	A	Verified at lower level
3.7.3.5.4	External Pressure	The probe shall withstand a one atmosphere [101 kPa (760 torr)] external pressure under all ground operating conditions.	T	Verified at lower level
3.7.3.5.5	Room Temperature Vacuum Requirements	.	N/A	.
3.7.3.5.5.1	Helium Permeation and Leak Rate through Top Hat and Cross Flange Region	The helium permeability rate and leak rate through the top hat section of the probe, not including the permeation through the elastomers of the vatterfly valves, with one atmosphere of helium outside the probe Top Hat and Cross-flange shall be <= 1 x 10-7 scc/s He (goal <= 10-8 scc/s He)	S	Verified at lower level
3.7.3.5.5.2	Helium Permeation and Leak Rate through Probe Walls	The helium permeability rate and leak rate through the probe walls with one atmosphere of helium outside the probe composite neck tube and vacuum shell shall be <= 1 x 10-6 scc/s He (goal <= 10-7 scc/s He)	S	Verified at lower level
3.7.3.5.5.3	Probe Outgassing Rate for All Gases	The probe shall achieve a room temperature outgassing rate of less than 1 x 10-4 scc/s (goal less than 10-5 scc/s) within 100 hours of pumping at room temperature.	T	Verified at lower level
3.7.3.5.5.4	Probe Outgassing Rate of Helium	The probe shall have a helium outgassing rate of <= 5 x 10-8 scc/s He (goal <= 10-9 scc/s He) after filling the interior of the probe with 1 torr of helium and immersing the exterior of the probe with 1 atmosphere of helium for 1 day and then pumping for 1 day.	S	Verified at lower level
3.7.3.5.5.5	Internal Pressure Measurement	The probe shall provide capability for measuring internal pressure with pressure gauges sensitive to probe pressure. One gauge is to be located at the top of the pressure sensing line (P-1 line) and two are located on the cross flange, as shown in ICD 1C34355.	I	Verified at lower level

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PLSE-12 #	Title	Requirement	Method	Verification Status
3.7.3.5.5.5.1	Provision for "T" in P1 line	The probe shall be designed with a "T" in the P1 line between the top hat and the P1 valve. This branch shall have a 2 +/-m filter, a Nupro valve and Gamah fitting for mating with the gas feed line coming up from the GMA.	I	Verified at lower level
3.7.3.5.5.6	Trapped Volumes	Designs shall not create trapped volumes that are difficult to pump out or other construction that may become virtual leaks.	I	Verified at lower level
3.7.3.6	Cleanliness and Contamination	The probe shall meet the requirements of the cleanliness and contamination zones as defined in section 3.3.1.2.6. The materials used in the probe shall conform to the requirements of 3.3.1.2.6.	I	Verified at lower level
3.7.3.7	Optical Requirements	The probe shall provide the optical interfaces for the SIA to meet the optical requirements in the following subsections.	N/A	.
3.7.3.7.1	Optical System Linearity	.	N/A	.
3.7.3.7.1.1	Sunshade-Induced Residual Position Error	The sunshade shall induce a residual position error over the linear range of <= 0.048 milliarcseconds after bias & scale factor corrections are applied.	A	Verified at lower level
3.7.3.7.1.2	Window-Induced Residual Position Error	The total set of probe windows shall induce a residual position error over the linear range of <= 0.048 milliarcseconds after bias & scale factor corrections are applied.	A	Verified at lower level
3.7.3.7.1.3	Ghost Image-Induced Residual Position Error	The ghost image induced residual position error shall be <= 0.048 milliarcseconds over the linear range after bias & scale factor corrections are applied.	A	Verified at lower level
3.7.3.7.1.4	Scattered Light-Induced Residual Position Error	The scattered light induced residual position error shall be <= 0.048 milliarcseconds over the linear range after bias & scale factor corrections are applied.	A	Verified at lower level
3.7.3.7.2	SIA View of Space	The probe shall provide the SIA with a straight optical path to space to meet the requirements of 3.2.1.5.2.2 and 3.2.1.5.2.3.	I	Verified at lower level
3.7.3.7.3.1	Transmissibility to the Telescope	The transmissibility through the probe windows combined shall average greater than 65% over the transmission band of 3.2.1.5.3.1.	T	Verified at lower level
3.7.3.7.4	Optical System EMI Filtration	The probe shall provide EMI shielding as listed in the following subsections and the ground surface requirement of 3.7.2.2.3.7.	A,T	Verified at PL level
3.7.3.7.4.1	Sunshade/Window #4 EMI Filtration	.	N/A	.
3.7.3.7.4.1.1	Sunshade/Window #4 EMI Filtration with Shutter Open	The EMI attenuation capability of the sunshade/window #4 combination with the shutter open shall be as follows: 80 dB from 10 kHz to 250 MHz 80 dB at 250 MHz decreasing to 65 dB at 1 GHz	A	Verified at lower level

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PLSE-12 #	Title	Requirement	Method	Verification Status
3.7.3.7.4.1.2	Sunshade/Window #4 EMI Filtration with Shutter Closed	The Sunshade/Window #4 combination, with the sunshade shutter closed, shall attenuate EMI to an amplitude <= 0.1 V/m behind Window #4 for the following EMI sources at the entrance to the sunshade: Frequency Amplitude 1.40 GHz 10.0 V/m 2.15 GHz 30.0 V/m 2.80 GHz 9.0 V/m 5.70 GHz 40.0 V/m 7.00 GHz 170.0 V/m 10.00 GHz 100.0 V/m In addition, the EMI attenuation capability of the sunshade/window #4 combination with the shutter closed shall be as follows: 80 dB from 10 kHz to 250 MHz; 80 dB at 250 MHz decreasing to 65 dB at 1 GHz	A	Verified at lower level
3.7.3.7.4.2	Window #4 EMI Filtration	The EMI attenuation capability of the window 4 coating shall be as follows: >= 40 dB at frequencies between 1 GHz and 100 GHz	A,T	Verified at lower level
3.7.3.8	Electrical Cables	The probe shall provide the quantity and type of electrical cables called out in table 3.7.3-1 and the following subsections. (See OLE tab.)	I	Verified at lower level
3.7.3.8.1	Coaxial Cables	Coaxial connectors and cables, shall meet or exceed the requirements specified in tables 3.7.3-2. (See OLE tab.)	I,A,T	Verified at lower level
3.7.3.8.1.1	Ground and UV Bias Cables	The ground and UV bias cables, shall have the pin-to-pin locations specified in Table 3.7.3-3. (See OLE tab.)	I	Verified at lower level
3.7.3.8.1.2	DC Electrochemical Induced Voltage	The maximum DC electrochemical induced voltage difference between all cables connected to any gyroscope cavity (suspension cables, high and low voltage grounding cables, and UV bias cables) shall be less than 3 mV.	N/A	.
3.7.3.8.2	SQUID Cables	The SQUID cables shall meet the performance requirements of tables 3.7.3-4 and 3.7.3-5. (See OLE tab.)	I,A,T	Verified at lower level

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PLSE-12 #	Title	Requirement	Method	Verification Status
3.7.3.8.3	Instrumentation	The instrumentation shall meet the requirements of tables 3.7.3-9 through 3.7.3-19 and the following subsections. Legend for all tables 3.7.3-9 to 3.7.3-19: GRT Germanium Resistance Thermometer SD Silicon Diode PRT Platinum Resistance Thermometer QB Quartz Block P Probe Notes for all tables 3.7.3-9 to 3.7.3-19: (1) All SD's to conform to standardized curve to within 0.1 K at 4.2 K, 1 K at 77 K, and 1% at 300 K (See OLE tab.)	I,A,T	Verified at PL level
3.7.3.8.3.1	Wire Routing Restriction	.	N/A	
3.7.3.8.3.1.1	SQUID GRTs Wiring	The SQUID Package GRTs identified as T-8Q, T-9Q, T-10Q and T-11Q shall have their drive and sense wires routed in separate shields. The GRT sense wires shall also be routed separately from any heater wires, with the exception that the SQUID loop and mounting bracket heater wires may be run with the GRT sense lines. The GRT drive wires may be routed in a shield with remaining heater wires.	I	Verified at lower level
3.7.3.8.3.1.2	Wiring for Other SIA GRTs	The GRT drive and sense wires for SIA instrumentation, other than what is identified in 3.7.3.8.3.1, may run together in the same shield.	I	Verified at lower level
3.7.3.8.3.1.3	Probe Instrumentation	The wires running from the probe sensors to the terminal blocks located at the end of the instrumentation cables may be unshielded. Probe is identified with a suffix designation of "P" (e.g. T-6P)	I	Verified at lower level
3.7.3.8.3.2	Twisted Pair Conductor Separation	The separation of the two conductors in any instrumentation circuit shall not exceed 5 mm (0.2 in) at any point in magnetic zone 1 or 10 mm (0.4 in) in any other magnetic zone.	I	Verified at lower level
3.7.3.8.3.3	Instrumentation to Suspension Cable Separation	The separation of instrumentation lines from suspension lines shall be >= 3 cm.	I	Verified at lower level
3.7.3.8.3.4	Flux Density Induced by Instrumentation	The flux density measured at a distance of 2 cm (0.8 in) from any instrumentation circuit while conducting its maximum current during normal operation shall be: In magnetic zone 1: <= 1 x 10-11 tesla (10-7 gauss) for frequencies from DC to 0.001 Hz <= 1 x 10-13 tesla (10-9 gauss) for frequencies from 0.001 to 0.1 Hz <= 1 x 10-11 tesla (10-7 gauss) for frequencies from 0.1 Hz to 1 GHz In other regions within dewar: <= 1 x 10-8 tesla (10-4 gauss) for frequencies from DC to 1 GHz	A	Verified at lower level

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PLSE-12 #	Title	Requirement	Method	Verification Status
3.7.3.8.4	Cable Mechanical Requirements	.	N/A	.
3.7.3.8.4.1	Cable Material	Materials used in the probe shall meet the requirements of 3.3.1.1 and the following requirements.	N/A	.
3.7.3.8.4.1.1	Connectors and Cables	Materials used in the connectors and cables shall have been tested to ASTM-E-595 or JSC-SSP-R-0022.	I	Verified at lower level
3.7.3.8.4.1.2	Center Conductor Material	Center conductors for all cables shall be UNS-C-510 phosphor bronze A, UNS-C-507 phosphor bronze E, or OFHC copper in accordance with QQ-B-750.	I	Verified at lower level
3.7.3.8.4.1.3	Conductor Material for UV Bias and Low Voltage Ground Wire	The wire material and size for the UV bias and low voltage ground wires shall be the same as the gyroscope suspension wires.	N/A	Need to update database
3.7.3.8.4.2	Cycle Life	The cables shall have a failure-free mechanical cycle life of 30 cycles. A cycle consists of one thermally-induced contraction and subsequent expansion.	A	Verified at lower level
3.7.3.9	Science Gyroscope Ultraviolet Charge Control	Probe-C shall provide a minimum of 2 fiber optic cables to each gyroscope, 2 cables to the proof mass and 2 spare cables for the gyroscopes. The cables shall meet the following requirements: frequency of light 254 nm; input energy 5 +/-W; duration of exposure 3 years; attenuation from output of cable at tophat to output of probe cable at SIA interface: <= 9 dB (end of life); <= 2 dB after 200 hrs at 5 +/- 3 +/-W; degradation profile: asymptotic (no degradation greater than measurement error in last 100 hours)	I,T	Verified at lower level
3.7.3.10	Probe Plumbing Requirements	.	N/A	.
3.7.3.10.1	Gyroscope Spin-up	The probe shall provide the piping, gas flow components, and fittings which connect the spin-up gas assembly to the SIA to meet the gyroscope spin-up requirements of 3.7.2.3 and the following requirements.	I	Verified at lower level
3.7.3.10.1.1	Spin-up Gas Components	Size and configuration shall be in accordance with the interface requirements of 3.7.2.3 and 3.7.6.1.2 and the following requirements.	N/A	.
3.7.3.10.1.1.1	Spin-up Inlet Warm Filter	There shall be a 2 +/-m filter in each spin-up inlet line external to the top hat.	A	Verified at lower level
3.7.3.10.1.1.2	Spin-up Inlet Cold Filter	The spin-up inlet line cold filter shall have a surface area five times the surface area of the spin-up inlet line from the filter to the point it reaches 20 K.	A	Verified at lower level
3.7.3.10.1.2	Cleanliness of Spin-up Gas Components	Cleanliness of the spin-up gas assembly components shall be per the cleanliness requirements of Zone II and VII per section 3.3.1.2.6.	I,T	Verified at lower level
3.7.3.10.2	Gyroscope Caging	The probe shall provide fluid lines from the top hat to the SIA caging interface to meet the caging requirements of section 3.2.1.6 and the following requirements.	I	Verified at lower level
3.7.3.10.2.1	Redundancy	Each independent circuit shall meet the redundancy requirement of section 3.2.1.6.3.	I	Verified at lower level

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PLSE-12 #	Title	Requirement	Method	Verification Status
3.7.3.10.2.2	Cleanliness of Caging Assembly Components	The caging assembly components shall be designed to meet the cleanliness and contamination requirements of Zones I, III, IV, V, and VII as stated in 3.3.1.2.6.	I	Verified at lower level
3.7.3.10.2.3	Volume of Caging Lines	The portion of the caging lines below HEX2 on the probe side of the SIA/probe interface shall have a volume of <= 4.0cubic centimeters (0.24 cubic inches) per caging circuit.	A	Verified at lower level
3.7.3.10.2.4	Backup Caging Splitter Assemblies	Backup caging splitter assemblies shall be provided for contingency operation in the event a caging line is found to be blocked during ground testing. A different splitter assembly shall be provided for each of the following situations: a) Line A, baselined for Gyro 2 is blocked. Line B to be retrofitted with splitter to handle Gyros 1 and 2. b) Line B, baselined for Gyro 1 is blocked. Line A to be retrofitted with splitter to handle Gyros 1 and 2. c) Line C, baselined for Gyros 3 and 4 is blocked. Line B to be retrofitted with splitter to handle Gyros 3 and 4. Line A to be retrofitted with splitter as in b) above.	N/A	.
3.7.3.10.3	Pressure Sense Line	The probe shall provide a pressure sense line from a fitting at the top hat to a point near the SIA.	I	Verified at lower level
3.7.3.11	Handling	At the completion of all cleaning procedures, all items shall be capped with Level 100 caps and bagged to control to a Class 100 environment. Items must be removed from their bags and then the caps must be removed in a Class 100 or better clean room.	I	Verified at lower level
3.7.3.12	Useful Life	.	N/A	.
3.7.3.12.1	Storage Life	The probe shall be designed to meet the requirements of 3.2.1.8.	A	Verified at lower level
3.7.3.12.2	Orbital Life	The probe shall perform as specified herein for the orbital life of 3.2.1.10.	A	Verified at lower level
3.7.4	Probe to Dewar ICD	.	N/A	.
3.7.4.1	Mechanical Interface	The dimensional interface between the probe and dewar is described by LMMS drawing 5833117.	I	Verified at lower level
3.7.4.1.1	Probe Structural Support	The probe shall be structurally supported by the dewar at the top plate to top hat interface, and preloaded against Station 200, as shown in drawing 1C34111.	T	Verified at lower level
3.7.4.1.2	Lead Bag Retainer Interface	The probe shall structurally interface with the dewar well via the lead bag retainer, as specified in drawing 5833117.	I,A,S	Verified at lower level
3.7.4.2	Electrical Interface	.	N/A	.
3.7.4.2.1	Top Hat to Top Plate Resistance	The resistance across the interface between the probe top hat and the top plate of the dewar vacuum shell shall be <= 10 mohms.	T	Verified at PL level
3.7.4.2.2	Conductive Loops	There shall be no conductive loops through the integrated probe and dewar assembly that cross a temperature differential of >= 5 K. Conductive loops through the integrated probe and dewar assembly in isothermal (<= 5 K differential) regions are permitted.	I	Verified at lower level
3.7.4.3	External Alignment Reference	A reference surface that is on the top exterior of the dewar shall be aligned to +/- 0.25 degrees, to the QBA mounting flange. This surface shall be controlled by LMMS ICD drawing 1C34102.	A,T	Verified at lower level
3.7.4.4	Thermal Interface	.	N/A	.

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PLSE-12 #	Title	Requirement	Method	Verification Status
3.7.4.4.1	Thermal Interface at Station 200	The thermal interface between the probe and dewar at Station 200 shall be designed such that the probe will meet all its thermal requirements as specified in Section 3.7.3.4.	I,A	Verified at lower level
3.7.4.4.2	Probe Thermal Grounding to Dewar	The probe shall be thermally grounded to the dewar via thermal conductance through 24 thermal shoes, 6 on each heat station ring, which contact the dewar thermal stop rings.	I	Verified at lower level
3.7.4.4.3	Temperature Exposure During Probe Insertion	The probe shall be capable of experiencing the temperatures during a cold insertion into the dewar, estimated to be as shown in figure 3.7.4-1 (See OLE tab.)	T	Verified at PL level
3.7.5	Dewar Specification	The Science Mission Dewar (SMD) shall be designed to perform as specified in the following subsections while exposed to the orbital environments of Stanford document P0149. The SMD shall survive exposure to the ground and launch environments of 3.2.5.1 through 3.2.5.5 without degradation of its subsequent performance. The SMD shall comply with the design requirements of section 3.3.	I,A,T,D	Verified at lower level
3.7.5.1	Dewar Definition	The SMD consists of the following major components: 1) Main Tank with Well, Axial Lock Ring and Mechanism, Cryoperm Shield, and Proton Shield; 2) Guard Tank; 3) Dewar Vacuum Shell with Support Ring, Alignment Reference Platform Ring; 4) Passive Orbital Disconnect Struts (PODS); 5) Vapor Cooled Shields, Multilayer Insulation (MLI); 6) Composite Neck Tube, Heat Exchanger Assembly; 7) Lead Bag, Lead Bag Retainer; 8) Porous Plug; 9) Fountain Effect Pump; 10) Burst Discs, Emergency Vent Lines; 11) Top Plate, Electrical Connectors; 12) Dewar Plumbing; 13) Dewar Instrumentation	N/A	.
3.7.5.2	Physical Characteristics	.	N/A	.
3.7.5.2.1	Mass Properties	.	N/A	.
3.7.5.2.1.1	Dry Weight	The dry weight allocated to the SMD in P024612-6 is 862 kg.	A,T	Verified at lower level
3.7.5.2.2	Axial Short Term Shift in Center of Gravity	The allowable short term shift in the center of gravity of the superfluid helium in the main tank shall be as shown in figure 3.7.5-1, for axial motion. Short term is defined as motion occurring over a time span of <= 1 week. (See OLE tab.)	A,T	Verified at lower level
3.7.5.2.3	Dimensions	The SMD shall conform to the maximum envelope dimensions, mechanical and electrical interface locations, fluid interface locations and vent locations given in drawings 5833115 and 5833117.	I	Verified at PL level
3.7.5.2.4	Main Tank Volume	The main tank shall provide a reservoir for storing superfluid helium of sufficient volume to satisfy the orbital lifetime requirement of 3.2.1.10.	I,A	Verified at lower level

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PLSE-12 #	Title	Requirement	Method	Verification Status
3.7.5.2.5	Vacuum Shell	The SMD Vacuum Shell shall provide the external shell for surviving the ground and launch environments of 3.2.5.1 through 3.2.5.5 and the orbital environments of Stanford document P0149, and provide thermal isolation of the main tank with respect to these environments.	I,A,T	Verified at lower level
3.7.5.2.5.1	Support Ring	A support ring shall provide the structural support interface between payload and spacecraft, as specified in drawing 5833115.	I,T	Verified at lower level
3.7.5.2.5.2	Dewar Solar Absorptivity	The average absorptivity of the external surfaces of the SMD at the time of delivery shall be < 0.09 and < 0.12 at the end of operational life as specified in section 3.2.1.10.	A,T,S	Deferred
3.7.5.2.5.3	Dewar Emissivity	The average infrared emissivity of the external surfaces of the SMD at the time of delivery shall be > 0.80. The average infrared emissivity shall not degrade below this value in orbit.	A,T,S	Deferred
3.7.5.2.5.4	Forward Cone Rings	Three rings shall be provided on the forward cone of the SMD vacuum shell at approximate locations Stations 193, 202, 210 to support cables, plumbing lines, and magnetometers. Regularly spaced mounting holes of approximately 0.5 cm (0.2 in) diameter shall be provided in the rings for flexibility in routing.	I,T	Verified at lower level
3.7.5.2.5.5	Magnetometer Locations	Four magnetometers shall be mounted on the forward cone between Stations 202 and 205. They shall be bolted to existing holes in the middle forward cone ring, clocked approximately 90 deg apart with arbitrary global clocking. Each magnetometer enclosure shall have approximate dimensions 38.1 mm wide by 63.5 mm long by 38.1 mm high (1.5" wide by 2.5" long and 1.5" high), and each magnetometer plus bracket shall weigh less than 1 lb.	I	Deferred
3.7.5.2.6	Probe Structural Interfaces	.	N/A	.
3.7.5.2.6.1	Well	The main tank shall include a well for housing the probe assembly that meets the interface requirements of section 3.7.4 and drawing 5833117.	I,T	Verified at lower level
3.7.5.2.6.3	Top Plate Assembly	The SMD top plate/bellows assembly shall provide the structural interface for the probe top hat as specified in drawing 5833117.	I,A,T	Verified at lower level
3.7.5.2.6.4	Lead Bag Retainer	The SMD lead bag retainer shall provide structural support for the lead bag, and the structural interface for the probe with the dewar well as specified in drawing 5833117, while meeting the magnetic requirements specified in section 3.3.1.1.14.1 and P0057A.	I,A,T	Verified at lower level
3.7.5.2.7	Guard Tank Volume	The guard tank shall provide a volume which satisfies the launch pad ground hold requirement of section 3.2.1.9.	I,A,T	Verified at lower level
3.7.5.2.8	Structural Characteristics	.	N/A	.
3.7.5.2.8.1	Structural Strength	The SMD shall be capable of accommodating the loads resulting from any dewar attitude which will occur during ground handling, or during launch, as specified in Sections 3.2.5.1 through 3.2.5.5.	A	Verified at lower level
3.7.5.2.8.2	Structural Dynamics	.	N/A	.
3.7.5.2.8.2.1	First Resonance During Launch	The SMD shall conform to the space vehicle lowest resonance of >= 9 Hz in the lateral direction and >= 28 Hz in the axial direction when in its launch configuration.	A,T	Verified at lower level
3.7.5.2.8.2.2	First Resonance In Orbit	The SMD shall conform to the primary payload resonance on orbit of >= 10 Hz.	A	Verified at lower level

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PLSE-12 #	Title	Requirement	Method	Verification Status
3.7.5.2.8.3	Probe to Dewar Roll Position Sensor Location Stability	The stability of the roll position sensor location with respect to the dewar to probe interface shall be as described in the following subsections.	N/A	.
3.7.5.2.8.3.1	Initial On-orbit Uncertainty	The initial on-orbit uncertainty in the roll position sensor mounting surface relative to the Quartz Block Support structure interface plane shall not exceed 1 degree.	I,A,T	Verified at lower level
3.7.5.2.8.3.2	Long Term Drift	The roll position sensor mounting surface, relative to the Quartz Block/support structure position, shall drift in a "random walk" fashion <= 5 arcseconds (+/- 2.5 arc-sec) per year about the space vehicle roll axis.	A	Verified at lower level
3.7.5.2.8.3.3	Roll Period Stability	The roll position sensor mounting surface, relative to the Quartz Block/support structure position, shall shift <= 0.5 arcseconds during a roll period, about the roll axis (assuming 10 +/-C vacuum shell variation during a roll cycle).	A	Verified at lower level
3.7.5.3	Magnetic Shielding	The SMD shall provide the magnetic shielding capability stated in the following subsections at the location of all science gyroscopes from the time the probe is installed and the SIA is <= 20 K through all ground handling and testing, through the launch environment specified in section 3.2.5, and over the operational lifetime specified in section 3.2.1.10. The assumed disturbance field is equal to the Earth's magnetic field.	N/A	.
3.7.5.3.1	Steady State Shielding	.	N/A	.
3.7.5.3.1.1	Cryoperm Steady State Shielding	The dc shielding of the cryoperm shield shall yield a flux density <= 3 x 10-6 tesla (.03 Gauss) at the science gyro locations, and <= 1 x 10-5 tesla (.1 Gauss) at the mouth of the lead bag (Station 191).	T	Verified at lower level
3.7.5.3.1.2	Lead Bag Plus Cryoperm Shield Steady State Shielding	The steady state shielding of the combined lead bag and Cryoperm shield shall yield a flux density <=2x10-10 tesla (2x10-6 Gauss) at the science gyro locations.	T	Verified at PL level
3.7.5.3.2	Cryoperm Shielding Factor	.	N/A	.
3.7.5.3.2.1	Cryoperm Longitudinal Shielding Factor	The cryoperm shield shall provide an attenuation factor of the external magnetic field <= 0.2 in the longitudinal direction, throughout the interior of the shield up to the mouth of the lead bag (Sta. 191), when the cryoperm is at a temperature <= 4 K.	T	Verified at lower level
3.7.5.3.2.2	Cryoperm Transverse Shielding Factor	The cryoperm shield shall provide an attenuation factor of the external magnetic field <= 0.015 in the transverse direction, throughout the interior of the shield up to the mouth of the lead bag (Sta. 191), when the cryoperm is at a temperature <= 4 K.	T	Verified at lower level
3.7.5.3.3	Lead Bag Shielding Factor	.	N/A	.
3.7.5.3.3.1	Cryoperm+Lead Bag Longitudinal Shielding Factor	The lead bag + cryoperm shall provide an attenuation factor consistent with the requirements of 3.2.1.3.2.	A,T	Verified at PL level

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PLSE-12 #	Title	Requirement	Method	Verification Status
3.7.5.3.3.2	Cryoperm+Lead Bag Transverse Shielding Factor	The lead bag + cryoperm shall provide an attenuation factor consistent with the requirements of 3.2.1.3.2.	A,T	Verified at PL level
3.7.5.4	Proton Shielding	The SMD shall incorporate a separate proton shield around the well to provide additional proton shielding in addition to the intrinsic shielding provided by the SIA, probe and dewar. The proton shield shall provide aluminum in the areas shown in figure 3.7.5-2. (See OLE tab.)	I	Verified at lower level
3.7.5.5	Thermal Performance	.	N/A	.
3.7.5.5.1	Temperature at Station 200	The dewar Station 200 shall be maintained below 1.85 K with a heat load from the probe of <= 65 mW, and the bath temperature <= 1.8 K.	A,T	Verified at PL level
3.7.5.5.2	Vapor Cooled Shields	Vapor cooled shields shall provide thermal grounding of the incoming parasitic heat load to the SMD heat exchangers.	I,A	Verified at lower level
3.7.5.5.4	Heat Exchangers	Heat exchangers shall provide heat exchange between the outgoing helium vent gas and the incoming parasitic heat load.	I,A,T	Verified at lower level
3.7.5.5.5	Passive Orbital Disconnect Struts	Passive Orbital Disconnect Struts (PODS) shall provide structural support for the main tank relative to the vacuum shell, and thermally isolate the main tank from the ambient environment in orbit.	I,A,T	Verified at lower level
3.7.5.5.6	Composite Neck Tube and Thermal Stop Rings	Thermal Stop Rings on the SMD Composite Neck Tube shall provide the physical interface for thermally grounding the probe neck tube to the heat exchangers of the SMD.	I,A,T	Verified at lower level
3.7.5.5.6.1	Neck Tube Liner	A titanium foil liner shall be provided on the interior surface of the CNT to act as a vacuum permeation barrier in the neck tube region.	I,A	Verified at lower level
3.7.5.5.7	Lead Bag Temperature	The temperature of the lead bag never rises above 6.5 K at any time after the final lead bag has been cooled below that temperature.	N/A	even though complete, no need to update database since there is no method of ver. specified
3.7.5.5.8	Well Fill Temperature Control	The SMD shall be capable of maintaining the helium that is being introduced into the well at a temperature less than or equal to the lead bag temperature of 6.5 K.	A,T	Verified at lower level
3.7.5.6	Vent Requirements	.	N/A	.
3.7.5.6.1	Venting to the Spacecraft Thrusters	Helium boiloff gas from the main tank shall be provided to the spacecraft thrusters as the propellant for the Spacecraft Force and Torque System.	I,A	Verified at lower level
3.7.5.6.1.1	Venting through the Porous Plug	Venting of the superfluid helium in orbit shall be through a Porous Plug, capable of a flow rate range encompassing 4 - 16 mg/s, at a bath temperature of 1.8 K.	A,T	Verified at lower level
3.7.5.6.2	Helium Vent Locations	The regions in which helium boiloff gas is vented during normal or emergency ground and orbital operations shall be as shown in drawing 5833115.	I	Verified at lower level

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PLSE-12 #	Title	Requirement	Method	Verification Status
3.7.5.6.3	Venting During Ground Operations	For ground operations, the SMD shall provide a main tank vent path which bypasses the spacecraft thrusters, and vents the main tank either to the ambient atmosphere, or to a vacuum pump.	I,A,T	Verified at lower level
3.7.5.6.3.1	Porous Plug Bypass Vent Path	For ground operations, a Porous Plug bypass valve shall be provided as an alternate vent path for the helium boil-off gas.	I	Verified at lower level
3.7.5.6.3.2	Venting of Guard Tank	A vent path independent of the main tank vent path shall be provided for venting the guard tank either to the ambient atmosphere or to a vacuum pump.	I,A	Verified at lower level
3.7.5.6.4	Venting of the Well When SFHe is Present	The SMD shall provide for venting of the well in the event SFHe is introduced in the well for launch.	I,A	Verified at lower level
3.7.5.7	Fill Requirements	.	N/A	.
3.7.5.7.1	Filling of the Main Tank	It shall be possible to fill the main tank up to 95% full from an external liquid helium supply dewar with the SMD vertical (+z* up).	T	Verified at lower level
3.7.5.7.1.1	Conditioning and Top-off of the Main Tank	With the SMD vertical, it shall be possible to condition the liquid helium in the main tank from NBPHe to He II, and top-off up to 95% full of He II at a bath temperature consistent with 3.2.1.9.	T	Verified at PL level
3.7.5.7.2	Filling of the Guard Tank	It shall be possible to fill the guard tank up to 95% full of NBPHe with the SMD vertical.	T	Verified at lower level
3.7.5.7.3	Fill Line Filter	There shall be a 10 +/-m filter in the dewar fill line just downstream of bayonet B3 and upstream of all RAVs. The pressure drop of this filter shall allow transfer of LHe at a temp <= 4.5K at a rate >= 200 liters/hour, with <= 207 torr (4 psid) overpressure in the supply dewar. For GHe over a temp range of 4.5 - 293 K, a 70 torr differential pressure across this filter shall produce a flow rate of 4 g/min or greater.	A,T	Verified at lower level
3.7.5.7.4	Filling of the Well	.	N/A	.
3.7.5.7.4.1	External Well Fill Capability	It shall be possible to fill the well with NBPHe from an external liquid helium supply dewar with the SMD vertical.	I,A,T	Verified at lower level
3.7.5.7.4.2	Internal Well Fill Capability	It shall be possible to transfer liquid helium, including both normal helium and superfluid helium, from the main tank to the well without the use of external plumbing. The SMD shall be vertical during well fill operations.	I,A,T	Verified at lower level
3.7.5.7.4.2.1	Fountain Effect Pump	The Fountain Effect Pump (FEP) shall provide sufficient flow of SFHe to fill the dewar well up to Station 200 in <= 3 hrs with the probe inserted and the bath temperature <= 1.8 K.	I,A,T	Verified at lower level
3.7.5.7.4.3	Well Fill Line Filter	There shall be a 2 +/-m filter in the well fill line downstream of all valves. The pressure drop of this filter shall be <= 10 torr at 60 liters/hour of liquid helium at a temperature <= 4.5 K.	I,A,T	Verified at lower level
3.7.5.8	Horizontal Hold Times	For ground operations, with the SMD horizontal, and either -x*, or -y* up, the SMD hold time shall support SMD ground operations for Test and Verification (nominally 1 month horizontal hold is adequate).	A,T	Verified at PL level
3.7.5.9	Plumbing Requirements	The SMD shall provide all plumbing lines and valves required to perform the filling, venting, and vacuum operations described in Section 3.7.5.	I	Verified at lower level
3.7.5.9.1	Pressure Vessel Relief Devices	Pressure relief devices shall be provided as necessary to comply with 3.3.6.2.2.2 and its subsections.	I,A	Verified at lower level

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PLSE-12 #	Title	Requirement	Method	Verification Status
3.7.5.9.1.1	Main Tank Burst Discs	Redundant burst discs on the main tank shall be provided to protect the main tank from damage due to over pressurization.	I,T	Verified at lower level
3.7.5.9.1.2	Emergency Vent Lines	An Emergency Vent Line (EVL) shall be provided on each burst disc of the main tank to exit the gas and/or liquid emanating from these burst discs through the vacuum space to burst discs on the Vacuum Shell.	I,A,T	Verified at lower level
3.7.5.9.1.2.1	EVL Flow Conductance	A single Emergency Vent Line shall provide sufficient flow conductance to maintain the main tank internal pressure below 262 kPa (38 psid) (relative to guard vacuum) for any emergency vent situation with a back pressure <= 21 kPa (3 psi).	A	Verified at lower level
3.7.5.9.1.2.2	EVL Leakage Rate	The leakage rate of a single EVL shall be <= 38,000 l/h at standard temperature and pressure at the maximum internal pressure of 262 kPa (38 psid) (relative to guard vacuum).	T	Verified at lower level
3.7.5.9.1.3	Vacuum Shell Burst Discs	Redundant burst discs on the vacuum shell shall be provided to protect the vacuum shell from damage due to over pressurization of the vacuum space.	I,T	Verified at lower level
3.7.5.9.1.4	Pyrotechnic Valves	Pyrovalves shall be provided for venting the guard vacuum and well to space. They shall comply with the safety requirements of Section 3.3.6.4.	I,T	Verified at PL level
3.7.5.9.1.4.1	Pyrovalve Shock	The SMD well pyrovalve shall be shock isolated as required to prevent shockwaves from being transmitted to the forward electronics.	I,T	Deferred
3.7.5.9.1.5	Guard Tank Relief Valve	A relief valve capable of opening the guard tank vent line under zero gravity shall be provided for preventing backflow of atmosphere into the guard tank vent line.	I,T	Deferred
3.7.5.9.1.6	Guard Tank Burst Disc	A burst disc on the guard tank shall be provided to protect the guard tank from damage due to over pressurization.	I,A,T	Verified at lower level
3.7.5.9.1.7	Fill Line Relief Valve	A relief valve on the fill line shall be provided to protect the fill line from damage due to over pressurization.	I	Verified at PL level
3.7.5.9.1.8	Well Relief Valve	A relief valve near the top of the well shall provide a well vent path during ground operations when helium is in the well.	I	Deferred
3.7.5.9.2	Pumpout Port	A pumpout port shall be provided for connecting a vacuum pump to evacuate the SMD vacuum space.	I	Verified at lower level
3.7.5.9.3	Ion Pump	An ion pump shall be provided for monitoring the pressure in the SMD vacuum space on the ground.	I	Verified at lower level
3.7.5.9.4	Remotely Actuated Valves	Remotely Actuated Valves (RAVs) shall be provided as required, to perform the venting and filling requirements of Section 3.7.5.	I,A,T	Verified at lower level
3.7.5.9.4.1	Vent to Thrusters	Redundant RAVs shall be provided for venting the helium boil off gas of the main tank to the spacecraft thrusters.	I,T	Verified at lower level
3.7.5.9.4.2	Shut off of Well Fill Path	Redundant RAVs shall be provided for closure of the lines for internal well fill.	I	Verified at lower level
3.7.5.10	Grounding and Shielding Requirements	.	N/A	.

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PLSE-12 #	Title	Requirement	Method	Verification Status
3.7.5.10.1	Vacuum Shell to Main Tank Resistance	The composite of all resistance paths between the SMD vacuum shell and the SMD main tank, with the exception of the path from the main tank to the top plate via the titanium foil of the neck tube, shall be >= 10 ohms. The resistance of each path shall be >= 20 ohms.	T	Verified at lower level
3.7.5.10.2	Component Grounding	All SMD components with a surface area greater than 0.09 m^2 (1 ft^2), except the conductive surfaces on both sides of the aluminized Mylar in the MLI, shall be grounded to the SMD top plate with a resistance between 20ohms and 10Mohms.	T	Verified at lower level
3.7.5.10.3	Conductive Loops	There shall be no conductive loops through the integrated probe and dewar assembly that cross a temperature differential of >= 5 K. Conductive loops in isothermal (<= 5 K differential) regions are permitted.	I	Verified at lower level
3.7.5.10.4	Ground Bond Resistance	Where two components are to be grounded together, the resistance of the connection between the two components shall comply with the requirement of 3.7.2.2.3.6.	T	Verified at lower level
3.7.5.10.5	Instrumentation Isolation	All SMD internal instrumentation shall be isolated from ungrounded conductive surfaces (i.e., the aluminized surfaces of the internal MLI) with insulation which has a breakdown voltage which exceeds 1500 Vdc.	I	Verified at lower level
3.7.5.10.6	EMI Shielding	The SMD shall be designed to provide a continuous Faraday shield, when combined with the probe top hat and dewar instrumentation EMI filters. Exceptions for openings are allowed for pyrovalves, and plumbing, upon approval of the EMI committee.	I	Verified at lower level
3.7.5.11	Mass Gauging	.	N/A	.
3.7.5.11.1	Heat Pulse Meter	A heat pulse meter shall be provided for measuring the residual superfluid helium in the main tank while in orbit, to within +/- 5% of its true value.	T	Verified at PL level
3.7.5.11.2	Flow Meter	A flow meter shall be provided for measuring the helium flow rate to the spacecraft thrusters while in orbit, to within +/- 5% of its true value.	I,T	Verified at PL level
3.7.5.12	Instrumentation	.	N/A	.
3.7.5.12.1	Redundant Heaters	Redundant heaters shall be provided for the following functions: Heat Pulse Meter operation ; Flow Meter operation; Depleting the guard tank (ground); Internal transfer of NBPHe to the well (ground); Internal transfer of SFHe to the well (ground); Increasing helium boiloff rate for thruster flow control ; Correct choking of Porous Plug; Correct breakthrough of Porous Plug;	I,A	Verified at lower level
3.7.5.12.2	Other Heaters	Non- redundant heaters shall be provided for the following functions: Prevent ice formation on guard tank vent line (ground)	I,A	Verified at lower level

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PLSE-12 #	Title	Requirement	Method	Verification Status
3.7.5.12.3	Redundant Temperature Sensors	Redundant temperature sensors shall be provided for the following functions: Measure helium bath temperature in main tank; Measure the downstream temperature of the Porous Plug; Measure the vent line flowmeter temperature; Measure the temperature on the exterior of the guard tank; Measure the temperature at Heat Exchanger 0 (near Station 200)	I,A	Verified at lower level
3.7.5.12.4	Other Temperature Sensors	Non- redundant temperature sensors shall be provided for the following functions: Measure temperature at HEX-1, HEX-2, HEX-3, HEX-4 ; Measure temperature gradients of Vapor Cooled Shield-1; Measure the temperature on the exterior of the main tank ; Measure the temperature at the support ring; Measure the temperature on the exterior of the vacuum shell; Measure the temperature at various locations of the lead bag; Measure the temperature at the top plate; Measure the temperature on the guard tank vent line (ground); Measure the temperature on the manual internal fill valve V13 (ground)	I,A	Verified at lower level
3.7.5.12.5	Liquid Level Sensors	Redundant liquid level sensors shall be provided for the following functions: Measure liquid level in main tank (ground); Measure liquid level in guard tank (ground); Measure liquid level in upper portion of well (ground)	I	Verified at lower level
3.7.5.12.6	Liquid Point Detector	A Liquid Point Detector shall be provided on the downstream side of the Porous Plug to detect liquid breakthrough through the plug in orbit.	I	Verified at lower level
3.7.5.12.7	PODS Resistance Sensors	Resistance sensors on each PODS shall be provided to verify disconnect for thermal isolation in orbit.	I	Verified at lower level
3.7.5.12.8	Accelerometers	Accelerometers shall be provided as required at critical locations for structural ground testing evaluation.	I	Verified at lower level
3.7.5.12.9	Connector Pins	Dewar connector locations and pin assignments shall be as specified in the SMD Instrumentation Installation drawing 5833394.	I	Verified at lower level
3.7.5.13	Useful Life	.	N/A	.
3.7.5.13.1	Storage Life	The SMD shall be designed to meet the requirements of 3.2.1.8.	I,A	Verified at lower level
3.7.5.13.2	Launch-ready Life	The SMD shall include a normal liquid helium guard tank to absorb the heat flowing into the probe/dewar assembly during ground operations. This tank shall be sized such that it will meet the requirements of 3.2.1.9 with a design margin of 0%.	A,T	Verified at lower level
3.7.5.13.3	Orbital Life	The SMD shall operate as specified herein for the orbital life of 3.2.1.10.	A,T	Verified at lower level
3.7.5.14	Magnetics	The SMD shall meet the requirements of the magnetic zones as defined in Section 3.3.1.1.14.	I	Verified at lower level

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PLSE-12 #	Title	Requirement	Method	Verification Status
3.7.5.15	Cleanliness	The SMD shall meet the requirements of the cleanliness and contamination zones as defined in Section 3.3.1.2.6.	I	Verified at lower level
3.7.5.16	Reliability	The SMD shall meet the reliability requirements of section 3.2.3.	I,A	Verified at lower level
3.7.5.17	Maintainability	The SMD shall meet the maintainability requirements of section 3.2.4.	I	Verified at lower level
3.7.6	Probe/Dewar Assembly to Science Payload Assemblies	.	N/A	.
3.7.6.1	Mechanical Interfaces	.	N/A	.
3.7.6.1.1	Top Hat Ground Attachment Points	There shall be attachment points on the top hat for external ground straps located as shown on LMMS drawing 1C34355.	I	Verified at lower level
3.7.6.1.2	Top Hat Spinup Gas Attachment Points	The physical location to the spin-up gas interface shall be as described on LMMS drawing 1C34355.	I	Verified at lower level
3.7.6.1.3	Fiber Optic Interface	The fiber optic interface between the probe and the electronics shall be per LMMS drawing 1C34355.	I	Verified at PL level
3.7.6.1.4	FEE Modules Mechanical Interface	The mechanical interface between the forward equipment section modules and the probe/dewar assembly shall be as shown in 1C34102.	I	Deferred
3.7.6.1.5	GMA Plumbing Lines Mechanical Interface	GMA plumbing lines shall be routed as defined in Spacecraft to Payload ICD, F277233.	I	Deferred
3.7.6.1.6	Cables Mechanical Interface	Payload cables shall be mounted to the PL/ SC in accordance with 8A02049, Cable Clamp Wire Harness Installation. Final Cable routing will be documented by photograph.	I	Deferred
3.7.6.1.7	Magnetometer Mechanical Interface	Payload Magnetometer shall be located as shown in 8A02025, Payload Magnetometer Installation Drawing	I	Verified at PL level
3.7.6.1.8	Dewar Interfaces with Ground Servicing Equipment	The dewar interface with the SMD cryogen ground servicing equipment shall be as described in layout drawings 5833828, 5833829, and 5833830.	I	Verified at PL level
3.7.6.2	Electrical Interfaces	Data required to define the electrical interfaces between the probe/dewar and the payload electronics are included in this section. In addition to the probe and dewar instrumentation, it includes the SIA instrumentation, since they connect through the probe top hat.	N/A	.
3.7.6.2.3	Probe Instrumentation Interface Data	Probe heater data shall be as shown in Table 3.7.6-4. (See OLE tab.)	I	Verified at PL level
3.7.6.2.4	Dewar Instrumentation Interface Data	SMD instrumentation interface data shall be as shown in Table 3.7.6-5 for dewar sensors, heaters, PODS resistors, liquid level sensors, liquid point sensor, accelerometers, and the Remotely Actuated Valves. This interface data covers SMD instrumentation to ground and spacecraft electronics, as well as to payload electronics. (see attached doc. file)	I	Verified at lower level

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PLSE-12 #	Title	Requirement	Method	Verification Status
3.7.6.3	Maximum Pressure at Spin-up Exhaust Exit	The maximum local pressure at the exit of the spin-up exhaust valves shall be 0.01 torr.	A,T	Verified at PL level
3.7.7	Science Payload Electronics Specification	.	N/A	.
3.7.7.1	Payload Electronics Subsystems	The Payload Electronics shall contain the following subsystems. SQUID Readout Electronics (SRE) ; Telescope Readout Electronics (TRE); Suspension Electronics (GSS); Experiment Control Unit (ECU) ; Payload Software and Computing (PSC); Payload Wire Harness (PWH)	N/A	.
3.7.7.2	Payload Electronics Forward/Aft Partitioning	The following Payload Electronics subsystems shall be functionally partitioned into forward and aft components according to the criteria set forth below. SRE, TRE, GSS, ECU.	N/A	.
3.7.7.2.1	Forward (Local) Electronics Partitioning Criteria	Circuits which must be close to the connectors on the top hat in order to perform their assigned functions shall be in the forward component of their subsystem. Circuits which must be precisely temperature controlled to perform their assigned functions shall be in the forward component of their subsystem. Circuits which must be especially well protected from EMI shall be located in the forward component of their subsystem. Circuits which neither dissipate significant amounts of heat nor dissipate significantly varying amounts of heat nor generate significant amounts of EMI may be in the forward component of their subsystem if it is shown that the total Space Vehicle mass, including ballast, is less for the forward configuration.	N/A	.
3.7.7.2.2	Aft (Remote) Electronics Partitioning Criteria	All circuits which do not meet the specific criteria of Section 3.7.7.2.1 for inclusion in the forward component of their subsystem shall be in the aft component of their subsystem. Circuits which dissipate significant amounts of heat or which dissipate significantly varying amounts of heat shall be located in the aft component of their subsystem. Circuits which generate significant EMI (switching regulators, dc/dc power converters, relay drivers, motor drivers, high-speed digital circuitry, etc.) shall be located in the aft component of their subsystem.	N/A	.
3.7.7.3	Payload Electronics Requirements	The Payload Electronics functional requirements are given in the subsections which follow. The individual box specifications are to be in presentation format, to be approved by appropriate managers at its review (usually PDR).	N/A	.
3.7.7.3.1	SQUID Readout Electronics Functional Requirements	The SQUID Readout Electronics shall provide a flux-locked loop for each SQUID in the probe. The SRE shall provide support functions (such as temperature control, calibration signals, modulation signals and bias signals) for each SQUID in the Probe. The SRE shall output data from which the orientation of the gyro rotor with respect to the pickup loop can be determined.	N/A	.

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PLSE-12 #	Title	Requirement	Method	Verification Status
3.7.7.3.2	Telescope Readout Electronics Functional Requirements	The Telescope Readout Electronics shall provide a charge-locked loop for each telescope detector diode in the probe. The TRE shall provide support functions (such as temperature control) for the telescope detector packages in the probe. The TRE shall output data from which the orientation of the Space Vehicle with respect to the apparent line-of-sight to the guide star can be determined.	N/A	.
3.7.7.3.3	Suspension Electronics Functional Requirements	The Suspension Electronics shall suspend the science gyroscopes (except the gyroscope being used as a drag-free sensor) to keep them from contacting the internal surface of the gyro cavities. The Suspension Electronics shall measure the charge of the science gyros.	N/A	.
3.7.7.3.4	Experiment Control Unit Functional Requirements	The Experiment Control Unit shall operate the flight instrumentation in the payload (except for those items called out in the Payload to Spacecraft ICD as being operated by the Spacecraft). The ECU shall provide the electrical interface between the proton monitor and the spacecraft. The ECU shall provide the electrical interface between the science magnetometers and the spacecraft.	N/A	.
3.7.7.3.5	Payload Software and Computing Functional Requirements	The Payload Software and Computing subsystem shall provide computational support for the other subsystems of the Payload Electronics as specified in the PSC Specification.	N/A	.
3.7.7.3.6	Payload Wire Harness Functional Requirements	The Payload Wire Harness shall interconnect the forward and aft electronics. The PWH shall connect the Payload Electronics to the dewar. The PWH shall connect the Payload Electronics to the probe. The PWH shall connect the Payload Electronics to the proton monitor. The PWH shall connect the Payload Electronics to the science magnetometers. The PWH shall connect the spacecraft to the payload as documented in the Payload to Spacecraft ICD.	N/A	.
3.7.7.4	Science Data Requirements	The Payload Electronics shall output the science data as required by section 9 of the Flight Software Design Specification.	N/A	.
3.7.7.4.1	Payload Electronics Thermal Environment Requirement	The thermal environment is provided by exposure to space on the rolling space vehicle, and radiative and conductive coupling to other parts of the Space Vehicle.	N/A	.
3.7.7.4.1.1	Forward Electronics Thermal Environment	The FEE will provide the operating temperatures of the cases of the forward electronics boxes as specified in GPB-100735, FEE Specification.	N/A	.
3.7.7.4.1.2	Aft Electronics Thermal Environment	The aft electronics boxes will be on pallets attached to the spacecraft structure. They will be exposed to space.	N/A	.
3.7.7.4.1.3	Thermal Control	The Science Payload Electronics shall provide the thermal control (passive, active, or a combination) required to meet its performance specifications in the presence of the thermal environments. The power for internal active thermal control of any electronics box components shall be included in that box's power budget. Active external thermal control (heaters at the box level or above) is undesirable and shall be avoided to the extent possible. The power for active external thermal control of the Payload Electronics shall be included in the Payload Electronics Thermal Control power budget.	N/A	.

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PLSE-12 #	Title	Requirement	Method	Verification Status
3.7.7.4.1.3.1	Forward Payload Electronics, Normal Science Mission Operation	Active external thermal control (heaters at the box level or above) shall not be used during normal Science Mission operation.	N/A	.
3.7.7.4.1.3.2	Forward Payload Electronics, Load Shed Science Mission Operation	Active external thermal control (heaters at the box level or above) shall not be used during load shed Science Mission operation.	N/A	.
3.7.7.4.1.3.3	Forward Payload Electronics, Pre Science Mission Operation	Active external thermal control (heaters at the box level or above) may be used during Pre Science Mission operation.	N/A	.
3.7.7.4.1.3.4	Aft Payload Electronics, Normal Science Mission Operation	Active external thermal control (heaters at the box level or above) shall not be used during normal Science Mission operation.	N/A	.
3.7.7.4.1.3.5	Aft Payload Electronics, Load Shed Science Mission Operation	Active external thermal control (heaters at the box level or above) may be used during load shed Science Mission operation only on boxes which are completely turned off.	N/A	.
3.7.7.4.1.3.6	Aft Payload Electronics, Pre Science Mission Operation	Active external thermal control (heaters at the box level or above) may be used during Pre Science Mission operation.	N/A	.
3.7.7.5	ATC Data Requirements	The Payload Electronics shall output the Attitude and Translation Control (ATC) data as required by section 9 of the Flight Software Design Specification.	N/A	.
3.7.7.6	Command Requirements	The Payload Electronics shall accept the commands as required by section 9 of the Flight Software Design Specification.	N/A	.
3.7.7.7	Timing Requirements	The Payload Electronics shall conform to the Timing and Frequency Control Specification.	N/A	.
3.7.7.7.1	Master Clock	All frequencies in the Payload Electronics shall be counted down from the SRE-16 fo signal.	N/A	.
3.7.7.7.2	Payload Time	The payload shall keep Payload Mission Elapsed Time (PMET) by counting the SRE-16fo signal. The PMET rollover interval shall be at least 3 years.	N/A	.
3.7.7.7.3	Timestamping	All payload data shall be timestamped with PMET.	N/A	.
3.7.7.7.4	GPS-Pulse Per Second Signal	The Payload Electronics shall receive the Global Positioning System - Pulse Per Second (GPS-PPS) signal and timestamp it with PMET.	N/A	.
3.7.7.7.5	ATC-Strobe	The Payload Electronics shall generate an ATC-Strobe signal for synchronizing the payload to the spacecraft and for internal synchronization within the payload and for internal synchronization within the spacecraft. The Payload Electronics shall timestamp each ATC-Strobe with PMET.	N/A	.

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PLSE-12 #	Title	Requirement	Method	Verification Status
3.7.7.7.6	Robustness to Transient Errors	It is expected that there will be transient upsets to the timing hardware which will take the form of either missing or extra timing pulses.	N/A	.
3.7.7.7.6.1	Automatic Recovery from Transient Errors	The Payload Electronics shall automatically recover from missing timing pulses. The Payload Electronics shall automatically recover from extra timing pulses. All clocks shall continue to run; all DC/DC converters shall run; the SQUID FLLs shall remain locked, the Gyros shall continue to be suspended.	N/A	.
3.7.7.7.6.2	Knowledge of Transient Errors	The Payload Electronics shall telemeter sufficient information that the occurrence of transient errors in the timing hardware can be observed during Ground Data Processing.	N/A	.
3.7.7.7.7	Robustness to Clock Switching	The GPS receivers may suffer periods of no GPS solution, they may fail, or they may be switched off for load shedding. The Payload timing distribution hardware may be turned off and then on again because of anomalies.	N/A	.
3.7.7.7.7.1	Operation During Clock Switching	All Payload Electronics shall operate normally, except that the timing and synchronization accuracy may be affected, through the switching of either the GPS receivers or of the Payload Timing Hardware off and back on. All clocks shall continue to run; all DC/DC converters shall continue to run; the SQUID FLLs shall remain locked, the Gyros shall continue to be suspended .	N/A	.
3.7.7.7.7.2	Knowledge of Clock Switching	The Payload Electronics shall telemeter sufficient information to the Spacecraft that the occurrence of clock switching can be observed during Ground Data Processing.	N/A	.
3.7.7.7.8	Timing Distribution	.	N/A	.
3.7.7.7.8.1	Distribute Timing from AFT SRE	The Aft SRE shall accept the GPS-PPS signal from the GPS receivers and distribute all other timing signals to the Payload Electronics and Spacecraft as specified below.	N/A	.
3.7.7.7.8.2	Timing Signals Distributed to Forward SRE and TRE	The Aft SRE shall distribute SRE-16fo to generate the timing signals which it supplies to the Fwd SRE and TRE.	N/A	.
3.7.7.7.8.3	Timing Signals Distributed to ECU and Suspension Electronics	The Aft SRE shall distribute SRE-16fo and ATC-Strobe (10Hz) to the ECU and Suspension Electronics. No other timing signals shall be distributed to the ECU and Suspension Electronics.	N/A	.
3.7.7.7.8.4	Timing Signals Distributed to Spacecraft	The Aft SRE shall distribute ATC-Strobe (10Hz) to the Spacecraft. No other timing signals shall be distributed to the Spacecraft.	N/A	.
3.7.7.7.8.5	Synchronization of Remote Timing Chains to Aft SRE	The ECU and the Suspension Electronics shall derive all of their timing signals by counting down the SRE-16fo signal from the Aft SRE. These remote countdown chains shall be synchronized to the countdown chain in the Aft SRE by resetting each remote countdown chain with the ATC-Strobe (10Hz) from the Aft SRE.	N/A	.
3.7.7.7.8.6	SRE-16fo Oscillator in Aft SRE	The aft SRE shall contain an oscillator with a nominal frequency of 16fo (16.368 MHz +/- 100 Hz) from which all the other timing signals are counted down. This signal shall be called SRE-16fo. This signal shall have a frequency stability and phase noise consistent with the timing accuracy requirements in Section 16 of T003.	N/A	.

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PLSE-12 #	Title	Requirement	Method	Verification Status
3.7.7.8	Auxiliary Test Requirements	The Payload Electronics shall meet the auxiliary test requirements of section 12 of T002.	N/A	.
3.7.7.9	Science Gyro Spinup	The Suspension Electronics in combination with the SQUID Readout Electronics shall meet the requirements of Section 5 of T003 with respect to spin axis alignment of the science gyros.	N/A	.
3.7.7.10	Environmental Requirements	The Payload Electronics shall meet its performance requirements in the environments specified in Stanford document P0149, "Natural Orbital Environment Specification".	N/A	.
3.7.7.11	Safemodes	The Payload Electronics shall meet the safemodes requirements of Section 26, of the Space Vehicle Hardware Requirements, T003.	N/A	.
3.7.7.12	Gain Margin	All control loops shall have a gain margin of >= 3 (approx. 10 dB), unless it can be shown that compliance will result in significant penalty to the vehicle or subsystem. Exceptions will be reviewed on an individual basis.	N/A	.
3.7.7.13	Phase Margin	All control loops shall have a phase margin of >= 45 degrees, unless it can be shown that compliance will result in significant penalty to the vehicle or subsystem. Exceptions will be reviewed on an individual basis.	N/A	.
3.7.8	Gas Management Assembly Specification	.	N/A	.
3.7.8.1	GMA Definition	The Gas Management Assembly (GMA) is the assembly of valves, regulators, supply tank, plumbing lines, and fittings which remotely control the spin-up of the science gyroscopes, both on orbit and on ground. The GMA also includes the Vatterfly Valves, for both spinup and leakage gas exhaust. Vatterfly valve requirements are contained in section 3.7.8.13.	N/A	.
3.7.8.2	Location and Envelope	The GMA pallet, with mounted components, shall be located on the spacecraft frame within the triangular truss area located at a rotation angle about +Z* of 60 degrees from the +X* axis toward +Y*. The envelope dimensions are as specified in the GMA Interface Control Drawing 8A00188.	I	Deferred
3.7.8.3	Temperature During GMA Operation	The GMA shall provide thermal control to maintain average baseplate temperature during GMA operation to 293 K +/- 10 K (20 deg C +/- 10 deg C). The temperature variation across the GMA Baseplate shall be <= 10 K (10 deg C).	A,T	Deferred
3.7.8.4	Spinup Function	The GMA shall provide the capability of delivering 500 sccm +/- 10% and 700 sccm +/- 10% He to the spinup inlet of any individual gyro.	I,T	Deferred
3.7.8.4.2	Low Speed Spin-up Function	The GMA shall provide gas flow for low speed gyro spinup. The gas flow shall be between 1 and 50 sccm.	T	Deferred
3.7.8.4.3	Pressurized Helium Gas Supply	The GMA shall provide a reservoir of pressurized helium (He3 or He4) >= 1200 STP-l	I	Deferred
3.7.8.4.3.1	Spin-up Gas Composition	The GMA shall be capable of delivering He of purity better than 99.999% when filled with He of purity at least 99.9995% pure.	I,T	Deferred
3.7.8.4.4	Venting Function	The GMA shall be capable of being pumped down to <= 6.7 x 10^-2 Pascal (0.5 mtorr) to facilitate evacuation of an individual gyro spinup line.	T	Deferred

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PLSE-12 #	Title	Requirement	Method	Verification Status
3.7.8.6	Spin-down Function	The GMA shall provide helium gas into the probe through the P1 pressure sense line. This gas shall be provided at a flow rate of 1.0 +/- 0.5 sccm. This gas flow is usable for both gyro spindown and exchange gas.	T	Deferred
3.7.8.7	Allowed Leakage Rate	The GMA shall be designed to meet the leakage requirements of this section.	N/A	.
3.7.8.7.1	Allowable Permeation	The maximum amount of air allowed to enter any one of the spin-up inlet lines after the probe has been cooled to liquid helium temperatures, but while the spin-up gas is not flowing, shall be less than 54.0 Pa-L (.53 Atm-cc). For a 90 day hold, this corresponds to a steady state leak rate of 6.8x10^-8 scc/s.	A,T	Deferred
3.7.8.7.2	Allowable Leakage	The amount of air allowed to enter the spin-up inlet line with the helium gas shall be less than 100 Pa-L (1.0 Atm-cc).	A,T	Deferred
3.7.8.8	Cleanliness and Contamination Control	The interior of the spin-up lines and valves which are in contact with the flowing gas shall be cleaned to level 100. Assembly and handling of the GMA hardware shall be in a Class 100 or better facility when the internal gas flow elements are exposed.	I	Deferred
3.7.8.8.1	Particle Control	Gas flow lines shall be filtered with 2 micrometer filters to prevent particles from entering the SIA.	I	Deferred
3.7.8.9	GMA Instrumentation	The GMA shall provide instrumentation for evaluating performance and controlling temperature.	D	Deferred
3.7.8.10	Redundancy	Redundancy of GMA valve or regulator failures shall be provided for all mission critical functions.	I	Deferred
3.7.8.11	Environments	The GMA is designed and tested to survive the environments of this section	N/A	.
3.7.8.11.1	Survival Temperature Range	The GMA shall be designed to survive a temperature range of -49 degrees C to +51 degrees C.	I,T	Deferred
3.7.8.11.2	Random Vibration Environment	The GMA shall be tested to the following protoqualification vibration environment in all 3 axes: 20 Hz: .00265 g^2/Hz 20-150 Hz: +3dB/octave 150-600 Hz: .02g^2/Hz 600-2000 Hz: -6dB/octave 2000 Hz: .0018 g^2/Hz 4.3 GRMS overall	T	Deferred
3.7.8.12	Structural Characteristics	The GMA is designed to the safety factors of this section.	N/A	.
3.7.8.12.1	Structural Safety Factors	The inertial safety factors for the GMA shall be 1.25 for yield and 1.5 for ultimate for all structure except the base plate; the safety factor for the base plate shall be 2.0 for ultimate.	A	Deferred
3.7.8.12.2	Pressure Safety Factors	All pressure systems shall be designed to the requirements of MIL-STD-1522A: Lines and fittings design with burst pressure factor =2.5 Pressure bottles designed and tested per section 5.2.1 of MIL-STD-1522. Components designed and tested to a burst pressure factor = 2.5	I	Deferred
3.7.8.13	Vatterfly Valves	.	N/A	.
3.7.8.13.1	Spinup Exhaust Valves	A 2.5 inch motorized Vatterfly exhaust valve shall be provided on each of the 4 spinup exhaust lines for exhausting spinup gas. They shall be installed on the probe Top Hat, as specified in the Probe-C to SU External Interface Drawing 1C34355.	I	Verified at lower level

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PLSE-12 #	Title	Requirement	Method	Verification Status
3.7.8.13.2	Leakage Exhaust Valves	Two 6 inch diameter exhaust valve shall be provided for exhausting the probe. They shall be installed on the probe Cross Flange, as specified in the Probe-C to SU External Interface Drawing 1C34355.	I	Verified at lower level
3.7.8.13.3	Leak Rate, Permeation and Temperature	Leak rates shall meet the requirements listed in the tables below for the temperatures and durations specified. The test configuration shall be one (1) atmosphere of helium on one side and vacuum on the opposite side. See OLE tab for tables.	I,T	Verified at lower level
3.7.8.13.4	Random Vibration Environment	The Vatterfly valves shall be tested to the protoqualification vibration environment as shown in Table 3.7.8-2. See OLE tab for table.	T	Verified at lower level
3.7.8.13.5	Valve Motors	Each Vatterfly valve shall have redundant motor windings on a common drive shaft for opening and closing the valve. Each shall be driven independently by the Valve Control Unit (VCU).	I	Verified at lower level
3.7.8.13.5.1	Input Voltage	The valve shall meet its performance requirements within an input voltage range of 22 to 35 Vdc.	T	Verified at lower level
3.7.8.13.5.2	Force Margins for Opening and Closing	The force margin to close the valve is herein defined as the ratio of the force available to close the valve (provided by the motor mechanism), divided by the force required to close the valve (i.e. force to overcome the bellows, mechanical mechanism and squeeze of the elastomer). Similarly for the definition of force margin to open the valve. To compare to margins often defined in other mechanical analyses, simply subtract one (1) from the following numbers.	N/A	.
3.7.8.13.5.2.1	2.5 Inch Vatterfly Closing Force Margin	The mechanical margin of safety to close the valve shall be >= 3.0 throughout the temperature range 210 K to 313 K.	T	Verified at PL level
3.7.8.13.5.2.2	2.5 Inch Vatterfly Opening Force Margin	The mechanical margin of safety to open the valve shall be >= 5.0 throughout the temperature range 210 K to 313 K.	T	Verified at PL level
3.7.8.13.5.2.3	6 inch Vatterfly Closing Force Margin	The mechanical margin of safety to close the valve shall be >= 1.5 throughout the temperature range 210 K to 313 K.	T	Verified at PL level
3.7.8.13.5.2.4	6 inch Vatterfly Opening Force Margin	The mechanical margin of safety to open the valve shall be >= 5.0 throughout the temperature range 210 K to 313 K.	T	Verified at PL level
3.7.8.13.6	Redundant Valve Sensors	Each Vatterfly valve shall have redundant sensors for determining whether the valve is open or closed.	I	Verified at lower level
3.7.8.13.7	Response Time	The time to open or close the valves shall be <= 60 seconds.	T	Verified at lower level
3.7.8.13.8	Design and Operating Life	.	N/A	.
3.7.8.13.8.1	Mechanical Design Life	The mechanical elements of the valves shall be designed for >= 5000 cycles.	S	Verified at lower level
3.7.8.13.8.2	Elastomer Seal Life	The valve shall meet the leak requirements listed in Table 3.7.8-1 for >= 250 cycles.	T	Verified at lower level

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PLSE-12 #	Title	Requirement	Method	Verification Status
3.7.9	Forward Electronics Enclosure Specification	.	N/A	.
3.8.	SMD GROUND SERVICING EQUIPMENT	.	N/A	.
3.8.1	Facilities Compatibility	The applicable SMD GSE shall be compatible with the facility requirements at the following facilities: Western Range B1610 and SLC-2W Launch Tower, Lockheed buildings B205 high bay, B181 vibration facility, B156 (Spin Balance, T-V), B159 (Acoustic Chamber), and Stanford HEPL FIST Area	I	GSE review
3.8.1.1	Explosion Proofing	GSE electrical equipment to be placed on the launch tower shall be "explosion proof" per article 500 of NEC article 500, or hazard proof by positive pressurization of dry air.	I	GSE review
3.8.1.2	Electrical Interface	GSE electrical equipment shall be compatible with 208 V, 3 phase, or 120 VAC, single phase, voltage source. Current requirements shall be coordinated with facilities, as required.	I	GSE review
3.8.2	Liquid Helium Transfers	.	N/A	.
3.8.2.1	NBPHe Transfers from External Supply	The GSE shall be capable of filling and topping-off the main tank, guard tank, and well with NBPHe from an external Liquid Helium Supply Dewar (LHSD).	I,T	Verified at PL level
3.8.2.2	He II Top-off from External Supply	The GSE shall be capable of filling and topping-off the main tank with He II from an external Liquid Helium Supply Dewar containing subatmospheric liquid helium.	I,T	Verified at PL level
3.8.3	Vacuum Requirements	.	N/A	.
3.8.3.1	Vacuum Space Evacuation	The GSE shall include a Vacuum Module, with a turbo pump speed >= 400 l/s, capable of achieving a blank-off pressure <= 10-7 torr, for the function of evacuating the SMD vacuum space.	I,T	GSE review
3.8.3.2	Well Evacuation	The GSE shall be capable of evacuating the dewar well.	I,T	GSE review
3.8.3.3	Guard Tank Evacuation	The GSE shall be capable of evacuating the guard tank to a pressure of 10 millitorr.	I,T	GSE review
3.8.3.4	Conditioning LHe in Main Tank to He II	The GSE shall include a Pump Module, based on a Roots pump with a nominal displacement of >= 700 cfm (330 l/s) (which can be started at one atmosphere) and a vane forepump with a displacement >= 200 cfm (94 l/s), for the function of conditioning the liquid helium in the main tank from He I to He II.	I,T	Verified at PL level
3.8.3.5	Conditioning LHe in LHSD to Subatmospheric Helium	The GSE shall include a Pump Module, based on a Roots pump with a nominal displacement of >= 700 cfm (330 l/s) (which can be started at one atmosphere) and a vane forepump with a displacement >= 200 cfm (94 l/s), for the function of conditioning the liquid helium in the liquid helium supply dewar from He I to subatmospheric helium.	I,T	GSE review
3.8.3.6	Reconditioning LHe in Main Tank from He II to NBPHe	The GSE shall be capable of reconditioning the LHe in the main tank from He II to NBPHe.	I,T	Verified at PL level

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PLSE-12 #	Title	Requirement	Method	Verification Status
3.8.3.7	Plumbing Connectors Guard Manifolds	All GSE plumbing connectors shall have a guard manifold with vacuum or 1 atm He during transport.	I	GSE review
3.8.4	Gaseous Helium Purge	The GSE shall be capable of purging the lines and vessels with gaseous helium prior to transfer and backfill operations.	I,T	GSE review
3.8.5	Vent Requirements	.	N/A	.
3.8.5.1	Venting of Helium Gas	The GSE shall be capable of venting 70,000 l/hr STP, with backpressure < 50 torr.	I,T	GSE review
3.8.5.2	Warming of Exhaust Gas	The GSE shall be capable of warming 70,000 l/hr STP of vent gas from 20 K to 300 K prior to its reaching the facility vent lines.	I,T	GSE review
3.8.6	Leak Detection	The GSE shall be capable of providing leak detection to a level of <= 10-10 scc/s He.	I,T	GSE review
3.8.7	Electrical Requirements	.	N/A	.
3.8.7.1	Remotely Actuated Valves Electronics	The GSE shall provide power supplies and electronics for all Remotely Actuated Valves (ground and flight).	I,T	GSE review
3.8.7.2	Dewar Instrumentation	The GSE shall provide power supplies and signal conditioning for all SMD instrumentation (ground and flight).	I,T	GSE review
3.8.7.3	Pressure Sensor Readouts	The GSE shall provide power supplies and electronics for all dewar and GSE pressure sensor readouts.	I,T	GSE review
3.8.7.4	Alarms	The GSE shall provide alarms for critical pressures, temperatures, and liquid levels.	I	Verified at PL level
3.8.8	Data Acquisition and Processing	The GSE shall provide the capability to condition, collect, reduce, and store all SMD (except accelerometers) and GSE generated data, and display desired data.	I	GSE review
3.8.9	Temperature Monitor and Alarm	The GSE shall provide a portable system for collecting, reducing, and storing SMD data , and providing an alarm system.	I,T	Verified at PL level
3.8.10	Structural Requirements	.	N/A	.
3.8.10.1	Modularity	The GSE shall be of modular construction for ease of handling, servicing, transporting, and floor configuration flexibility.	I	GSE review
3.8.10.2	Dimensions	The dimensions of the modules shall be compatible with the space allocated on the launch tower.	I	GSE review
3.8.10.3	Weight	The weight of the modules shall be within the floor loading capability of the launch tower.	T	GSE review
3.8.10.4	Lifting and Handling Structures Factors of Safety	Lifting and handling structures shall be proof tested to 2 times the maximum expected operating load, and designed with an ultimate safety factor of 5.	T	GSE review
3.8.10.5	Pressure System Structures Factors of Safety	GSE pressure systems structures shall be proof tested to 1.5 times the maximum expected operating pressure, and designed with an ultimate safety factor of 4.	T	GSE review
3.8.11	Cleanliness Requirements	The GSE interior lines shall be cleaned to Zone VI of Section 3.3.1.2.6.	I	GSE review

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PLSE-12 #	Title	Requirement	Method	Verification Status
3.8.12	Grounding Requirements	All external surfaces of GSE shall be at common ground potential at all times.	I	GSE review
3.8.13	Safety Requirements	.	N/A	.
3.8.13.1	Electrical Switches	All external switches shall have protective covers.	I	GSE review
3.8.13.2	Alarms for Purge Pressure	An alarm audible to 200 ft shall be provided when the purge-gas pressure drops below its minimum allowable pressure. A visual alarm shall be visible to 50 ft when viewing within 60 deg of normal to the front panel.	I	GSE review
3.8.13.3	Anchors	The modules shall be anchored to be seismically safe while on the launch tower.	I	GSE review
3.8.13.4	Connector Codes	.	N/A	.
3.8.13.4.1	Plumbing Connectors	GSE Plumbing Connectors shall be clearly labeled with regard to mating with dewar plumbing.	I	GSE review
3.8.13.4.2	Electrical Connectors	GSE Electrical Connectors shall be clearly labeled and color coded.	I	GSE review