National Aeronautics and
Space Administration
Lyndon B. Johnson Space Center
2101 NASA Road 1
Houston, Texas 77058-3696

TO: Kennedy Space Center
SA/C3/Executive Secretary, Mission Assurance Engineering Branch

FROM: EA3/Project Manager, Alpha Magnetic Spectrometer-02

SUBJECT: Alpha Magnetic Spectrometer 02 (AMS-02) Submittal of Phase III Ground Safety Data Package

Please find enclosed the signature pages for the AMS-02 Phase III Ground Safety Data Package, a completed Certificate of NSTS/ISS Payload Safety Compliance (JF1114a), and the signed cover pages of the hazard reports of that package. The electronic version of this document has been uploaded to the Payload Safety Data Management System. The AMS-02 Project requests the John F. Kennedy Space Center (KSC) Ground Safety Review Panel (GSRP) schedule a phase III ground safety review of this package with a requested review date of February 22-24, 2010. If you have any questions, please contact me at (281) 483-3296 (trent.d.martin@nasa.gov) or Mr. J. Chris Tutt at (281) 461-5703 (john.tutt@escg.jacobs.com). Please address technical comments to the above and our ground safety engineer, Mr. Eric Harvey at (281) 461-5509 (eric.harvey@escg.jacobs.com).

Trent Martin

Enclosures
ESCG/L.Hill
ESCG/E.Harvey
ESCG/EA2/J.C. Tutt
ESCG/EA3/M.F. Fohey
NASA/EA3/K.Bollweg
NASA/EA3/S.Porter
NASA/EA3/W.W. Guy

JSC 65716

ESCG-6110-10-SS-DOC-0003

Phase III Ground Safety Data Package for the Alpha Magnetic Spectrometer-02 (AMS-02) and Ground Support Equipment

Systems Architecture and Integration Office
Engineering Directorate

Verify this is the correct version before use

For correct version go to: http://ams-02project.jsc.nasa.gov/html/GSDP.htm

Phase III

January 15, 2010

EXPORT CONTROL STATEMENT:

The AMS-02 payload has been reviewed by the Department of State and has been declared public domain data under ITAR (see ODTC Case CJ 015-01). The payload has also been reviewed by the Department of Commerce and has been categorized 1A999 (see CCATS# G026926), which allows free distribution of data to foreign nationals of all countries apart from North Korea, Syria, and Sudan. All data included in this package has been reviewed and found to be in the public domain.

National Aeronautics and
Space Administration

Lyndon B. Johnson Space Center
Houston, Texas 77058

JSC 65716

ESCG-6110-10-SS-DOC-0003

NASA - LYNDON B. JOHNSON SPACE CENTER
HOUSTON, TEXAS

Phase III

Ground Safety Data Package
For the
Alpha Magnetic Spectrometer-02 and Ground Support Equipment

Prepared By:

01/14/10

E. Harvey, System Safety Engineer, ESCG

Approved by:

01/14/10

J. Jyi, Systems Safety Group Manager, ESCG

14-JAN-10

P. Mott, Chief Engineer, ESCG

14 Jan 2010

C. Tutt, Project Manager, ESCG

1/14/10

T. Martin, Project Manager, NASA

DESCRIPTION OF CHANGES TO

AMS and Ground Support Equipment Ground Safety Data Package

CHANGE LTR.	Originator/Phone Number	DATE	PAGES AFFECTED
Basic	Eric K. Harvey/281-461-5509	Jan 2010	All

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

List of Payload Unique Acronyms and Definitions

ACRONYMS AND ABBREVIATIONS

ACAS	Active Common Attach System
ACC	Anti-Coincidence Counters
AMICA	Astro Mapper for Instrument Check of Attitude
AMS	Alpha Magnetic Spectrometer
ASTC	AMICA Star Tracker Camera
BD	Burst Disk
CAB	Cryo magnet Avionics Box
CAN	Controller Area Network
CCD	Charged Coupling Device
CEWS	Cargo Element Workstand
CFC	Carbon Fiber Composite
cg	center of gravity
CGSE	Cryomagnet (or Cryogenic) Ground Support Equipment
CGSE-ES	CGSE Electrical System
CGSE-MS	CGSE Mechanical System
cm	centimeter
CO_2	Carbon Dioxide
COPV	Composite Overwrapped Pressure Vessel
COTS	Commercial Off The Shelf
CPA	Corrugated Polyallomer
CRF	Canister Rotation Facility
DV	Digital Valve
EBCS	External Berthing Camera System
ELC	Express Logistics Carrier
EVA	Extravehicular Activity
FRGF	Flight Releasable Grapple Fixture

ACRONYMS AND ABBREVIATIONS

G	Gauss
GFE	Government Furnished Equipment
GHe	Gaseous Helium
GHE	Ground Handling Equipment
GPS	Global Positioning System
Grms	Gravity, root mean square
GSDP	Ground Safety Data Package
GSE	Ground Support Equipment
GUI	Graphical User Interface
He	Helium
HV	High Voltage
IR	Infrared
ISF	Intermediate Support Fixtures
ISS	International Space Station
IVT	Interface Verification Tests
JINF	J-Crate Interface Card Designator
JMDC	J-Crate Main Data Computer
K	Kelvin
Kg	Kilogram
KHB	KSC Hand Book
kJ	Kilo Joule
KNF	Kurt Neuberger Freiburg
KSC	Kennedy Space Center
kW	Kilowatt
L	Liters
lbs	Pounds
LED	Light Emitting Diode
LHe	Liquid Helium

ACRONYMS AND ABBREVIATIONS

LSSO	Launch Site Safety Office
LTOF	Lower Time of Flight
LUSS	Lower Unique Support Structure
M	Millimeters
mbar	Millibar
MDP	Maximum Design Pressure
MHT	Main Helium Tank
MLI	Multilayer Insulation
MMOD	Micro-Meteoroid and Orbital Debris
MPLF	Multi-Purpose Lifting Fixture
MV	Manually-actuated Valve
NEC	National Electric Code
NFPA	National Fire Protection Association
OBP	On-board Pump
ODA	Orbiter Disconnect Assembly
OSHA	Occupational Safety and Health Administration
PAS	Payload Attach System
PCR	Payload Changeout Room
PCU	Plasma Contractor Unit
PDA	Payload Disconnect Assembly
PDL	Process Data Library
PDS	Power Distribution System
PGHM	Payload Ground Handling Mechanism
PLC	Programmable Logic Controller
PLF	Primary Lifting Fixture
PMT	Photo Multiplier Tube
PPE	Personal Protective Equipment
psdi	Pounds per square inch differential

ACRONYMS AND ABBREVIATIONS

psi	Pounds per square inch
psia	Pounds per square inch atmosphere
PSS	Primary Support Stand
PVGF	Power Video Grapple Fixture
PVVV	Pilot Valve Vacuum Vessel
RF	Radio Frequency
RICH	Ring Imaging Cerenkov Counter
RLS	Return to Launch Site
ROEU	Remotely Operated Electrical Umbilical
RSS	Rotating Service Structure
RTD	Resistance Temperature Detector
RWTH	Rheinisch-Westfälischen Technischen Hochschule (University of Technology)
SFCL	Superfluid Cooling Loop
SSPF	Space Station Processing Facility
STS	Space Transportation System
TAL	Trans-Atlantic Landing
TCS	Thermal Control System
TCDT	Terminal Countdown Test
TeV	tera-electron volts
	Tera-meters squared
TOF	Time Of Flight
TRD	Transition Radiation Detector
TTCS	Tracker Thermal Control System
UG	Unigraphics
UHVD	TRD High Voltage Distribution Boards
UHVG	TRD High Voltage Generation Boards
µm	Micrometers

ACRONYMS AND ABBREVIATIONS

UMA	Universal Mating Assembly
UPS	Uninterruptible Power Supply
USB	Universal Serial Bus
USCM	Universal Slow Control Module
USS	Unique Support Structure
UTOF	Upper Time of Flight
V	Volts
VAC	Volts Alternating Current
VDC	Volts Direct Current
VC	Vacuum Case
VCS	Vapor Cooled Shields
W	Watts
WIF	Worksite Interface Fixture
Xe	Xenon

Applicable Documents

Document Number	Title
KHB 1700.7C	Space Shuttle Payload Ground Safety Handbook
NSTS/ISS 13830	Payload Safety Review and Data Submittal Requirements
JSC 49978B	Phase II Flight Safety Data Package for AMS-02
SSP 30425	Space Station Program Natural Environment Definition for Design
MIL-STD-1472	Department of Defense Design Criteria Standard
MIL-P-27407	MIL-P-27407 - Propellant Pressurizing Agent Helium.
NSTS 07700	Space Shuttle Program Description and Requirements Baseline
NASA-STD-3000	Man-Systems Integration Standards

1 PURPOSE

The purpose of the Ground Safety Data Package (GSDP) is to provide a safety assessment of the Alpha Magnetic Spectrometer-02 (AMS-02) and associated Ground Support Equipment (GSE) during ground operations at Kennedy Space Center (KSC) and to demonstrate compliance with the Shuttle ground safety requirements.

2 SCOPE

This document provides the results of the safety assessment performed on the AMS-02 and its Ground Support Equipment (GSE). The GSDP will be presented for review and approval to the Ground Safety Review Panel (GSRP).

3 MISSION SCENARIO

The AMS-02 experiment is a state-of-the-art particle physics detector being designed, constructed, tested, and operated by an international team organized under United States Department of Energy sponsorship. The AMS-02 experiment will use the unique environment of space, outside the limitation imposed by Earth's atmosphere, to advance knowledge of the universe and potentially lead to a clearer understanding of the universe's origin. Specifically, the science objectives of the AMS are to search for antimatter (anti-helium and anti-carbon) in space, dark matter (90% of the missing matter in the universe), and to study astrophysics (to understand cosmic ray propagation and confinement time in the galaxy).

4 PAYLOAD OVERVIEW

The following is a top-level review of the major components of the AMS-02 flight hardware (Payload illustrated in Figure 4-1). A detailed analysis and description of the flight hardware can be found in JSC 49978B, "Phase III Flight Safety Data Package for the Alpha Magnetic Spectrometer-02 (AMS-02)". The flight safety review was held on January 12 through 15, 2010.

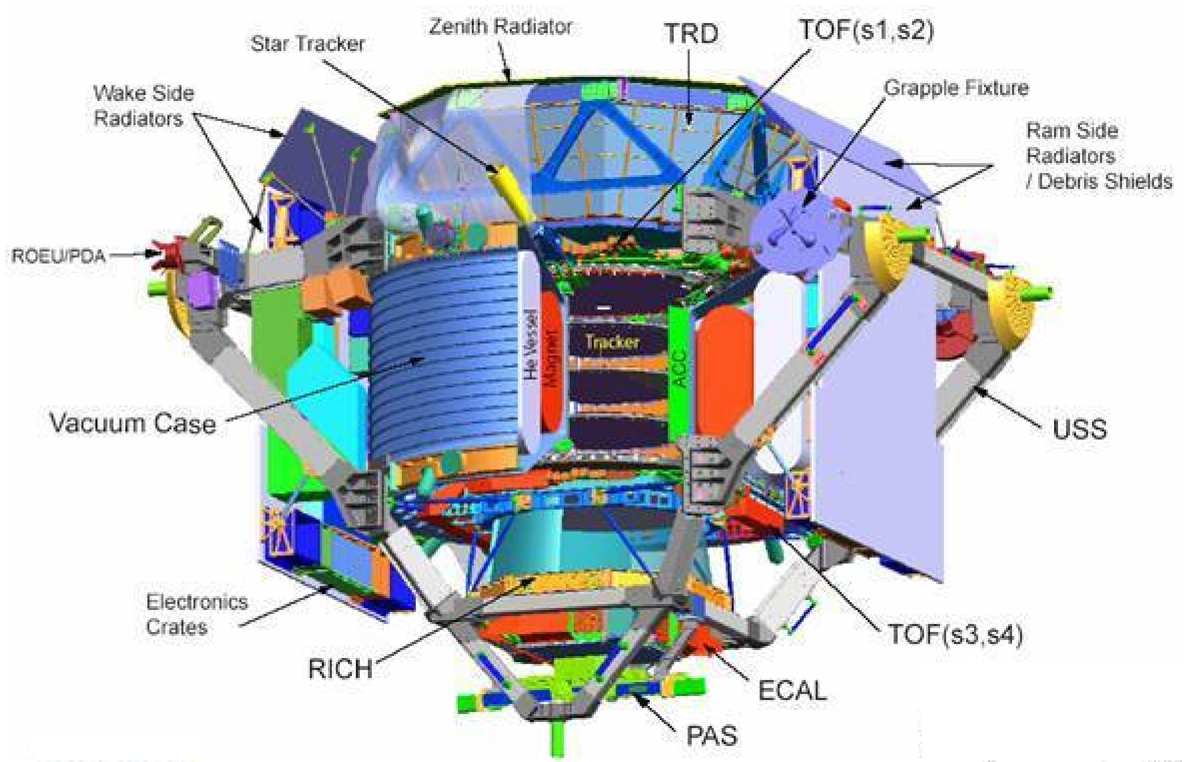


Figure 4-1: AMS-02 Flight Hardware

(Multilayer Insulation (MLI) not shown)

4.1 CRYOGENIC SUPERCONDUCTING MAGNET (CRYO MAGNET)

The Cryo magnet is at the heart of the AMS-02 experiment. Trajectories of incoming charged particles are bent by the magnetic field generated by it. The Silicon Tracker detects this trajectory, which allows AMS-02 to identify the magnitude and sign of the particles' electrical charge. The Cryo magnet has a maximum bending power of 0.86 tesla-meters squared (Tm^2), which combined with the spatial resolution of the Tracker, allows measurements of particles extending into the multi-tera-electron volts (TeV) energy range. The high field strength of the Cryo magnet is possible through the use of superconductors that are chilled by a superfluid helium cryo system serving as a heat sink operating at 1.8 Kelvin (K). Careful Cryo magnet coil design and placement minimizes the exterior magnetic field.

4.1.1 Magnet Coils

The magnet, shown in Figure 4.1.1-1, consists of 14 coils wired in series. The primary component of the field is created by the two large dipole coils. Twelve racetrack coils further shape the field, raising the strength within the bore of the magnet to a maximum of 8600 Gauss (G) while minimizing the stray field external to the Vacuum Case (VC). The external field has a maximum value of 2000 G at the outer surface of the VC and drops rapidly as distance increases away from the center of the AMS-02. Figure 4.1.1-2 shows the maximum strength of the field at various radii from the geometric center of the magnet. The field in the primary measurement volume and the fringe field will be mapped as part of the magnet functional testing.

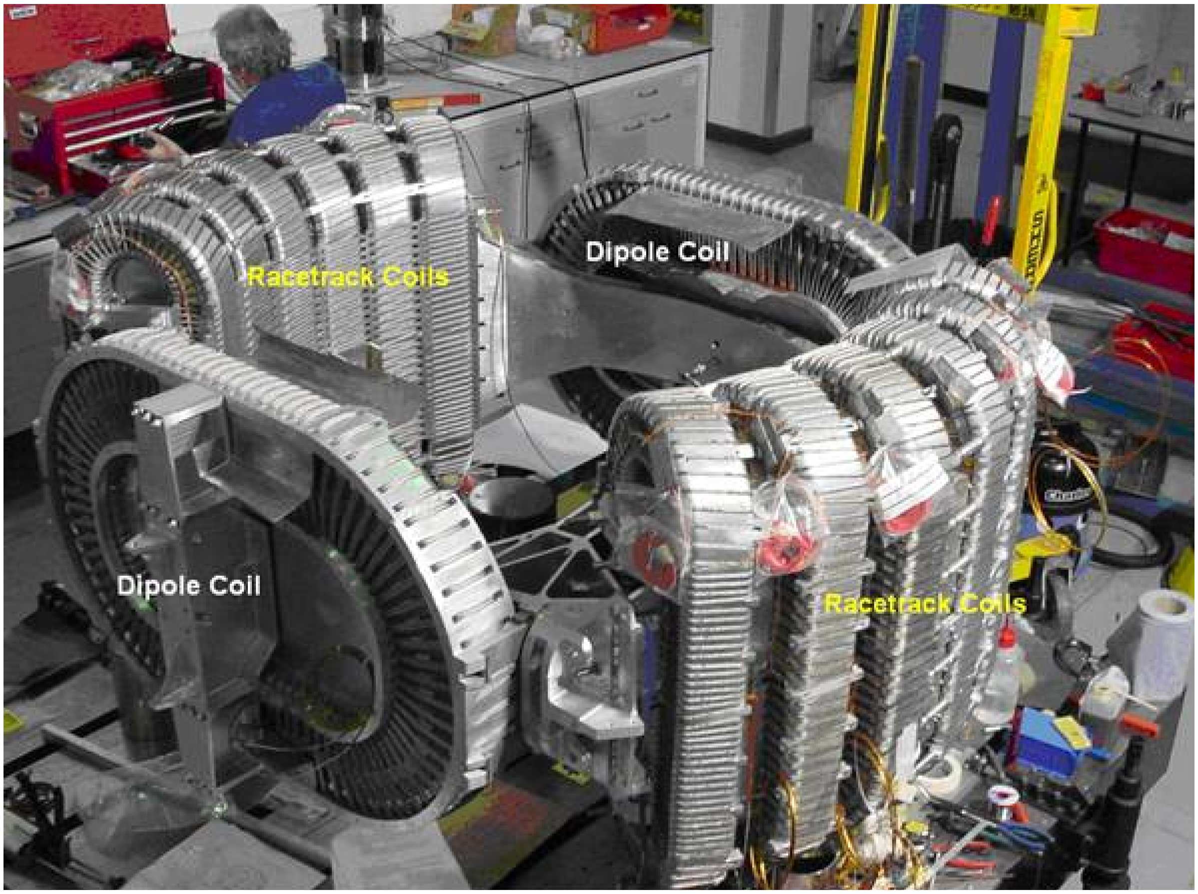


Figure 4.1.1-1: Magnetic Coils

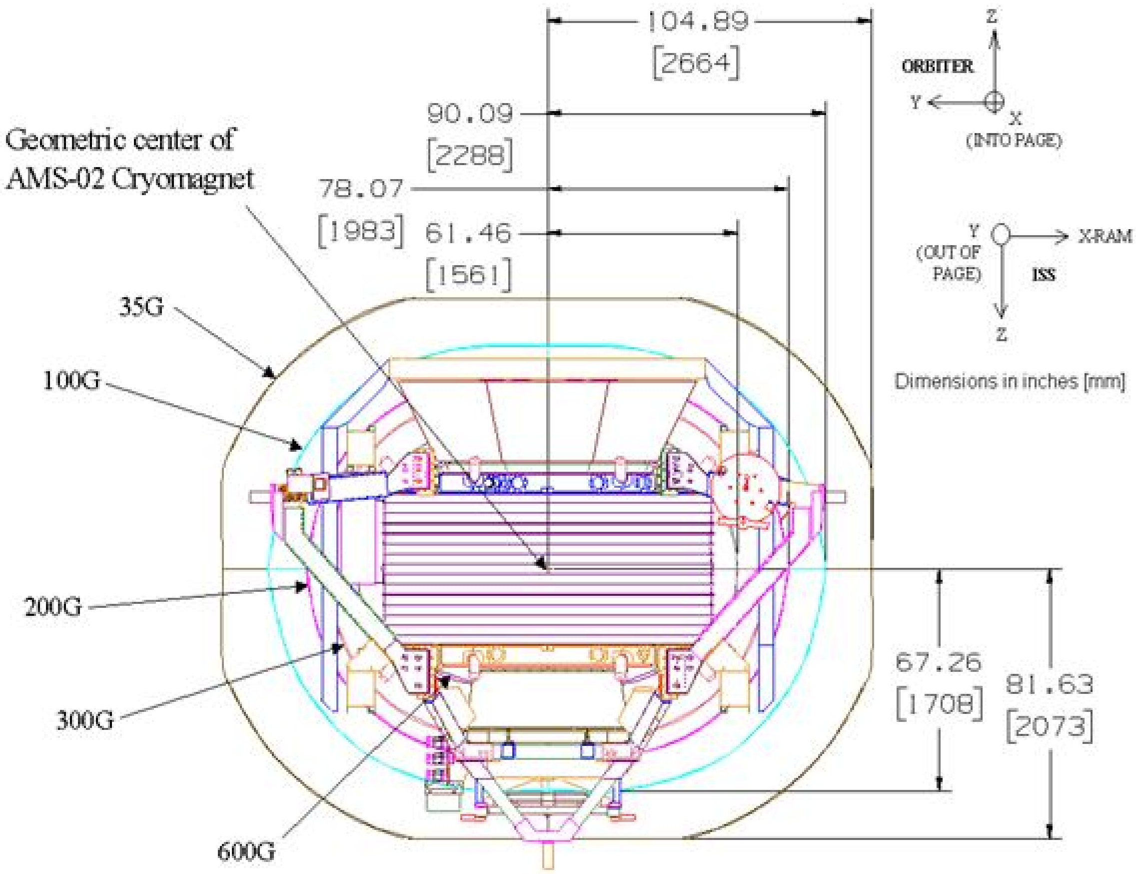


Figure 4.1.1-2: External Magnetic Field

4.1.2 Structural Support

Each coil is wrapped around a structural support made of Aluminum 6061, which keeps the coil in its elliptical shape. The large racetrack end frames seen in Figure 4.1.1-1 are also made of Aluminum 6061. These frames hold the coils in their proper relative positions and resist the magnetic forces generated when the magnet is active. These magnetic forces are on the order of 250 tons and are much larger than any other loads the magnet will see during either flight or ground operations. Since the magnet will be activated on the ground multiple times for functional testing, the flight unit will have been shown by demonstration to survive the maximum expected load conditions without deformation or damage.

The magnet is attached to the VC by sixteen support straps which are shown in Figure 4.1.2-1. Each strap attaches to one of the VC support rings and a clevis at the corner of the racetrack end fittings. The design prevents the high magnetic operational loads from being transmitted back to the rest of the structure and the thermal loads of the rest of the structure from being transmitted to the coils.

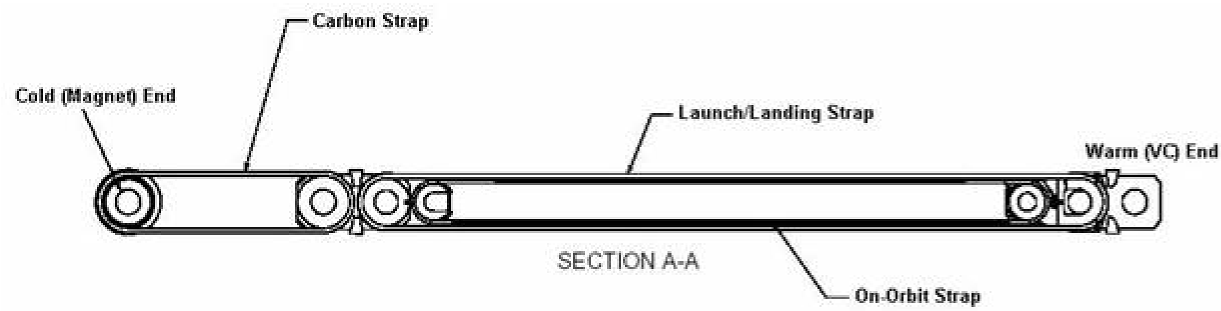


Figure 4.1.2-1: Magnet Support Strap

4.1.3 Cryogenic System

The purpose of the Cryogenic System is to maintain the temperature of the Cryo magnet coils at a temperature of 4 K or below in order to keep the magnet superconductive. It also has the capability to cool the Cryo magnet after an on-orbit quench* without Extravehicular Activity (EVA) support. The cryogen for this system is helium, which has a high thermal conductivity when it becomes superfluid. The superfluid transition temperature is 2.17 K.

The AMS-02 cryogenic system schematic is shown in Figure 4.1.3-1. Heat is removed from the Cryo magnet coils through the Superfluid Cooling Loop (SFCL), which then conducts the heat into the 2500-liter main helium tank. This tank contains the bulk of the cryogen used by AMS-02 and is separate from the Cryo magnet. It is at 1.8K and is the ultimate heat sink for the entire system. As the helium slowly boils away, vapor is removed from the system and flows through a series of four vapor cooled shields operating between 1.8K and 60K which surround the Cryo magnet assembly. Small thermal connections run between these shields and the metallic fittings on the support straps to further reduce the heat leak into the main tank from the structural supports. The outermost vapor-cooled shield is thermally attached to four cryo coolers, which further reduce the overall temperature and slow the rate of helium loss. In flight the helium is then released through a zero-thrust vent. During ground processing, it is exhausted to one of two vacuum pumps, either an on-board pump for short durations (e.g., between L-88 hours and L-30 minutes) or, for longer durations, a large GSE Roots pump.

The following sections provide details of the major components of the cryogenic system. For more information, refer to the AMS-02 Flight Safety Data Package, JSC 49978B.

---

* The coils of the AMS-02 magnet are made of NbTi, embedded in a copper matrix, all of which is encased in a sheath of aluminum. They are cooled down to superconducting temperatures (4K and below) so that they can conduct electricity without losses and the magnet can retain its charge without an outside power source. If any part of the coils goes above 4K, that particular section will develop a resistance. This phenomenon is known as a quench. The energy in the cryomagnet will be dissipated as heat in the resistive area and the magnetic field will collapse. If this energy is allowed to dissipate at a single location, the affected wire could burn through, breaking the circuit and rendering the magnet inoperative. The aluminum sheathing surrounding the wire helps spread the heat over a wider area, reducing the risk of wire damage. In addition, AMS-02 has a quench detection system. If an imminent quench is detected, heaters are activated on all the coils, forcing a controlled quench throughout the magnet and spreading the heat evenly across all the coils. This reduces the risk of permanent deformation of the magnet. Finally, the coils are connected in series, so a loss of current in one coil leads to a loss of current in all the coils. This is an added measure to prevent an increase in current and subsequent build-up of magnetic load in the other coils.

A possible safety concern is the resulting vaporizing of helium. The magnet thermal control system is sunk to AMS-02 main helium tank and all the energy released in the quench is eventually transferred into the helium. This thermal transfer vaporizes the helium, which is then vented. For ground operations on the ground, the vaporized helium is carried away with vacuum pumps, described in section 5.1.4. There is no safety hazard since the vacuum pump system will carry away the vented helium as designed.

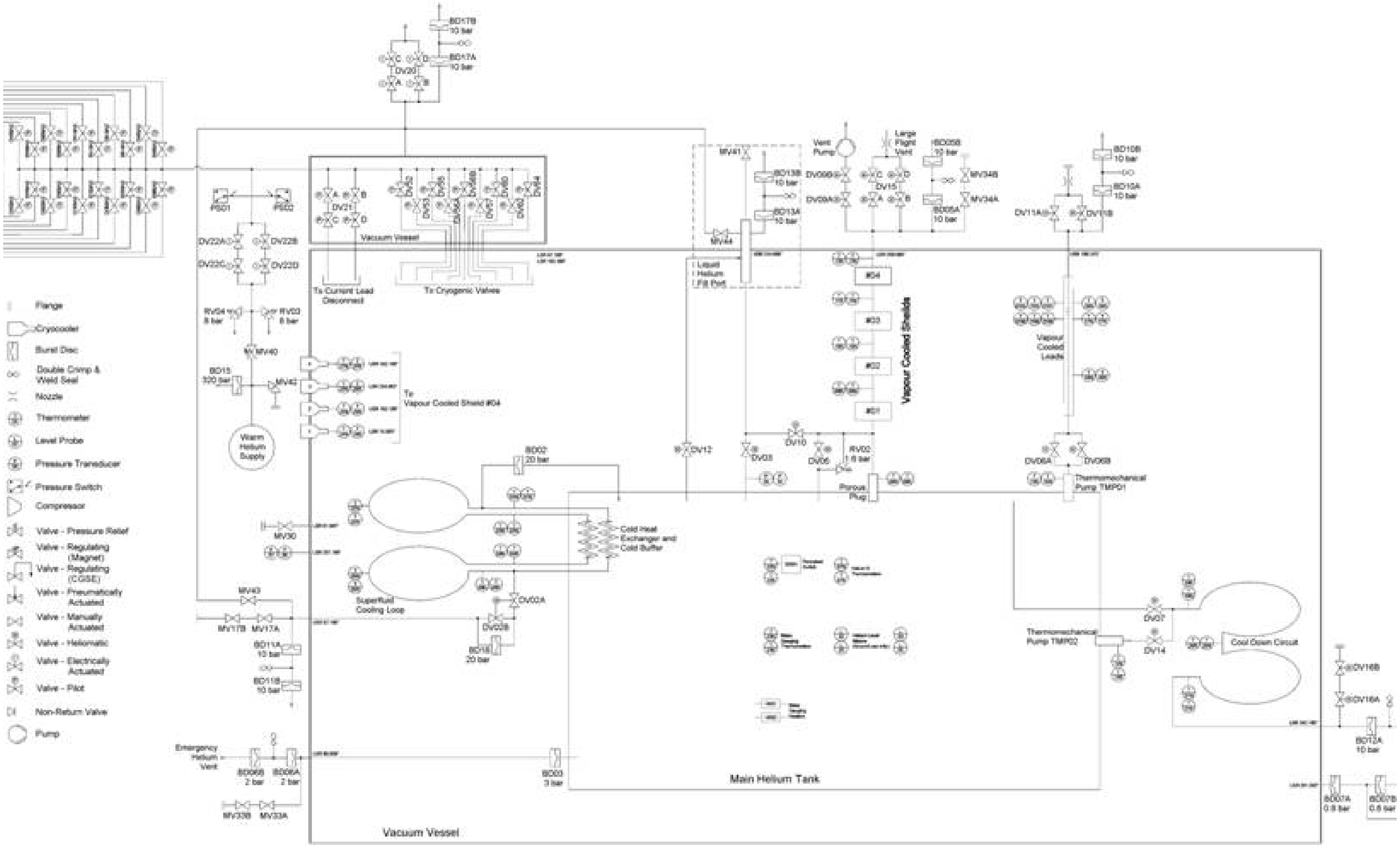


Figure 4.1.3-1: AMS-02 Cryogenic Schematic

4.1.3.1 Coil Cooling

Each Cryo magnet coil has two thermal shunts attached to the SFCL, which runs along the top and bottom of the magnet. The loop is an aluminum pipe filled with superfluid helium. Heat in the coils is conducted through the shunt into the liquid inside the loop. The cooling loop in turn extends into the main helium tank where a serpentine heat exchanger (Figure 4.1.3.1-1) dissipates the heat into the superfluid helium.

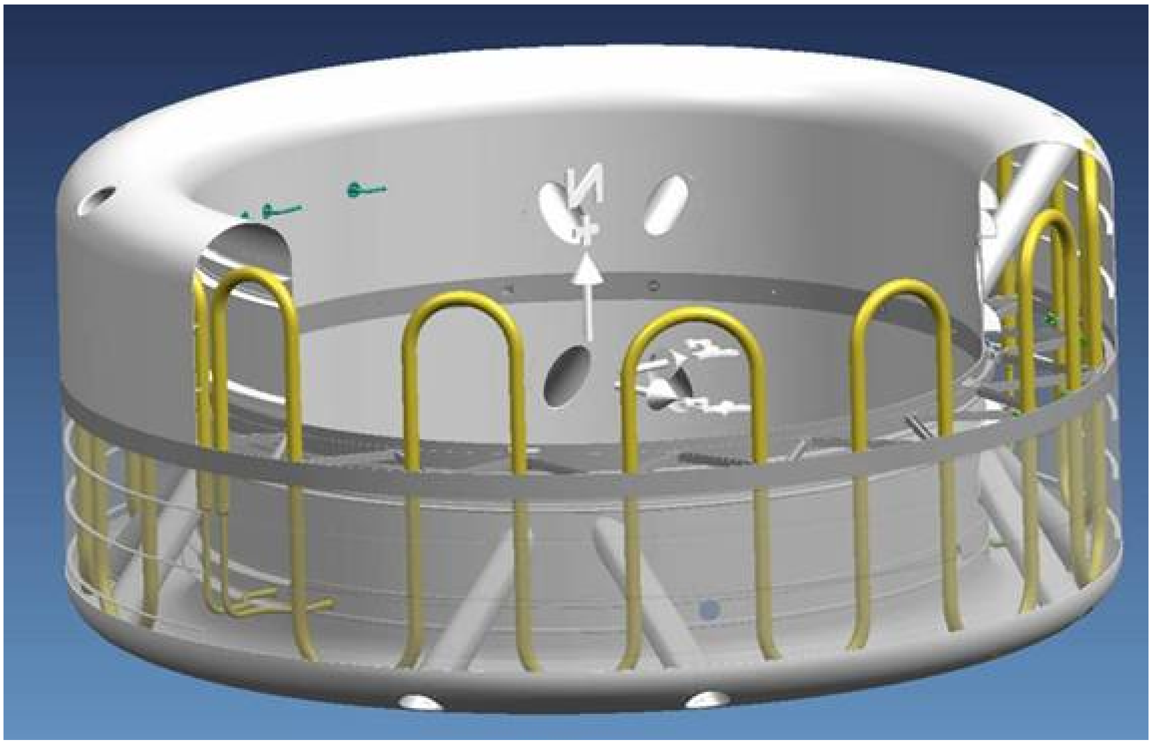


Figure 4.1.3.1-1: Heat Exchanger

The SFCL is filled on the ground through valve DV02 and MV17A and B, which are then closed on the ground and never reopened (Filling of the SFCL is accomplished prior to arriving at KSC). This loop has been designed to a maximum design pressure of 20 bar and is protected from over-pressurization by Burst Disk (BD) BD02. This disk vents the loop into the main helium tank. Since the volume expansion presents no significant pressure rise to the tank, it presents no safety hazard. For this reason, only one disk has been used.

4.1.3.2 Helium Tank

The main helium tank (Figure 4.1.3.2-1) is a 2,500 Liters (L) toroidal vessel which contains the bulk of the cryogen used by AMS-02. As shown in Figure 4.1.3.2-1, the tank consists of a central support ring attached to two rib-stiffened cylinders. The inner cylinder has a radius of 0.96 Millimeters (m) and the outer cylinder has a radius of 1.29 m. The tank is made up of aluminum 5083 forgings and all interfaces are welded. The construction technique used to fabricate the tank optimizes its ability to withstand helium permeation of the aluminum by careful control of the material grain orientation. The helium tank design takes into account the cryogenic effects on the housing materials. The tank has been designed to a maximum positive pressure of 3 bar and a maximum negative pressure of one bar. The maximum pressure is ensured through three BDs), one set to three bar (BD03) and two in parallel set to 0.8 bar (BD06A and B).

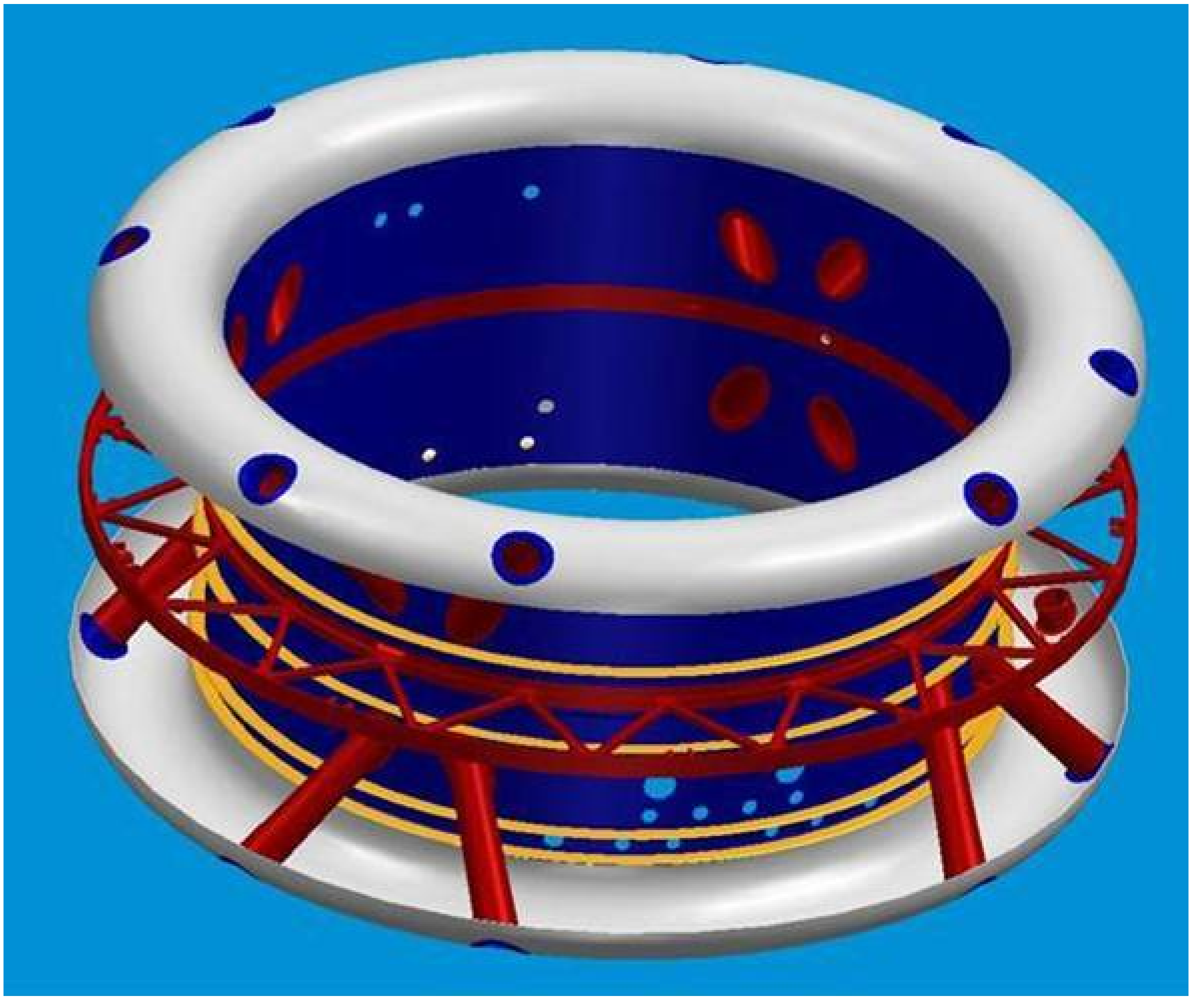


Figure 4.1.3.2: Helium Tank (Outer Cylinder Not Shown)

4.1.3.3 Vapor Cooled Shields (VCS)

As heat is dissipated into the main helium tank, the vapor generated is separated from the liquid by means of a porous plug. This vapor then flows into small tubes inside a series of four VCSs. These shields surround the magnet and helium tank assembly. They are connected via small thermal shunts to the metallic portions of the support strap assemblies. These intermediate heat sinks reduce the overall heat leak into the helium tank itself and greatly increase the overall endurance of the system. The shields are thin foils of nearly pure aluminum. Two shields have carbon fiber honeycomb structures underlying them for additional structural support. As with the helium tank, each shield has 16 holes to allow passage of the support straps.

Figure 4.1.3.3-1: Vapor Cooled Shield Structural Support

4.1.3.4 Cryo coolers

The final stage of the magnet thermal control system is four Stirling-cycle cryo coolers which attach to the outermost VCS. Together they remove approximately 12 Watts (W) of heat from the system. This additional temperature drop reduces helium consumption by a factor of four. After this final cooling, the helium gas is allowed to vent to space from a zero-thrust vent aligned with the International Space Station (ISS) Y-axis.

4.2 VACUUM CASE (VC)

The VC serves a dual purpose. It is a primary structural support that works in conjunction with the Unique Support Structure (USS-02) to form the foundation structure of the AMS-02. The VC also serves as the outer surface of the superfluid helium dewar enclosing the main helium tank and the Cryo magnet. The VC attaches to the USS-02 at the eight interface plates and the two clevis plates. The VC assembly is shown in Figure 4.2-1.

Figure 4.2-1: Vacuum Case

4.3 UNIQUE SUPPORT STRUCTURE-02 (USS-02)

The USS-02 is the primary structural element of the AMS-02 payload. Its purpose is to structurally support the Cryo magnet and the AMS-02 experiment during launch, landing, and on-orbit loading. It also integrates them with Shuttle and ISS. Figure 4.3-1 shows the USS-02 (in blue) attached to the VC of AMS-02.

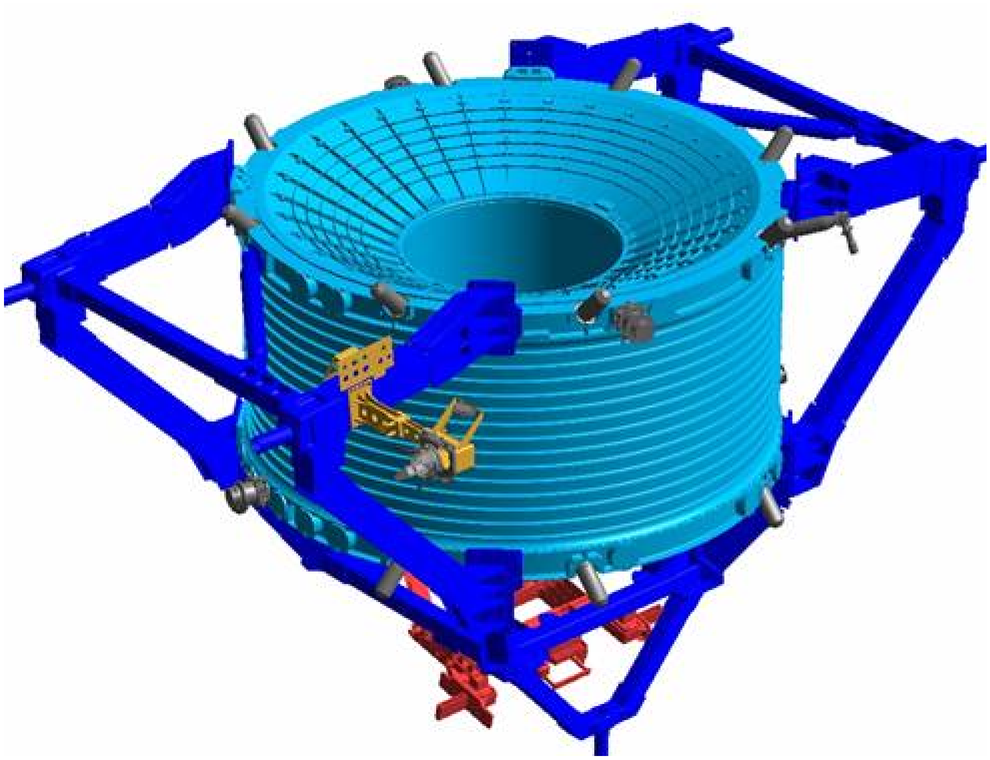


Figure 4.3-1: USS-02 Attached to Vacuum Case

4.4 TRANSITION RADIATION DETECTOR (TRD) AND ASSOCIATED GAS SYSTEM

The role of the TRD is to discriminate between electrons/anti-protons and positrons/protons. This is accomplished by detecting X-ray photons emitted by electrons and positrons when they pass through a radiator. As this effect depends on the velocity of the particle, it is used to discriminate against heavier particles. The radiation is detected by .001” gold-plated tungsten wires in tubes filled with xenon (Xe) and carbon dioxide (CO_2) gas in an 80:20 ratio.

4.4.1 TRD Structure

The TRD detector (Figure 4.4.1-1) is composed of 5248 proportional tubes which are made from a multilayer wound composite structure. The composite includes layers of polyurethane, carbon-polyimide, aluminum, and Kapton. The straw tubes are grouped into ten separate segments which are connected through gas manifolds. The straws have an inner diameter of 0.24”, a wall thickness of 0.003”, and vary in length from 31.5”to 78.7” (See Figure 4.4.1-2 for straw wall composition).

A straw module consists of 16 straws glued together with six stiffeners running alongside the straws. Every 3.94”, additional stiffeners are glued across the module for extra rigidity. The straw ends are glued into polycarbonate end pieces. The end pieces contain the wire fixation pieces, the gas distributor, and the gas seal. These straws operate at very low pressure and will be protected from negative pressure during the majority of ground operations by GSE-supplied gas.

The TRD is constructed from 20 layers of the straw modules. The gap of 0.91" between the layers is filled with a polypropylene fleece which forms the radiator required by the detector. The upper four layers (72 modules) and the lower four layers (56 modules) are oriented in the X direction and the 12 middle layers (200 modules) in the payload Y-direction.

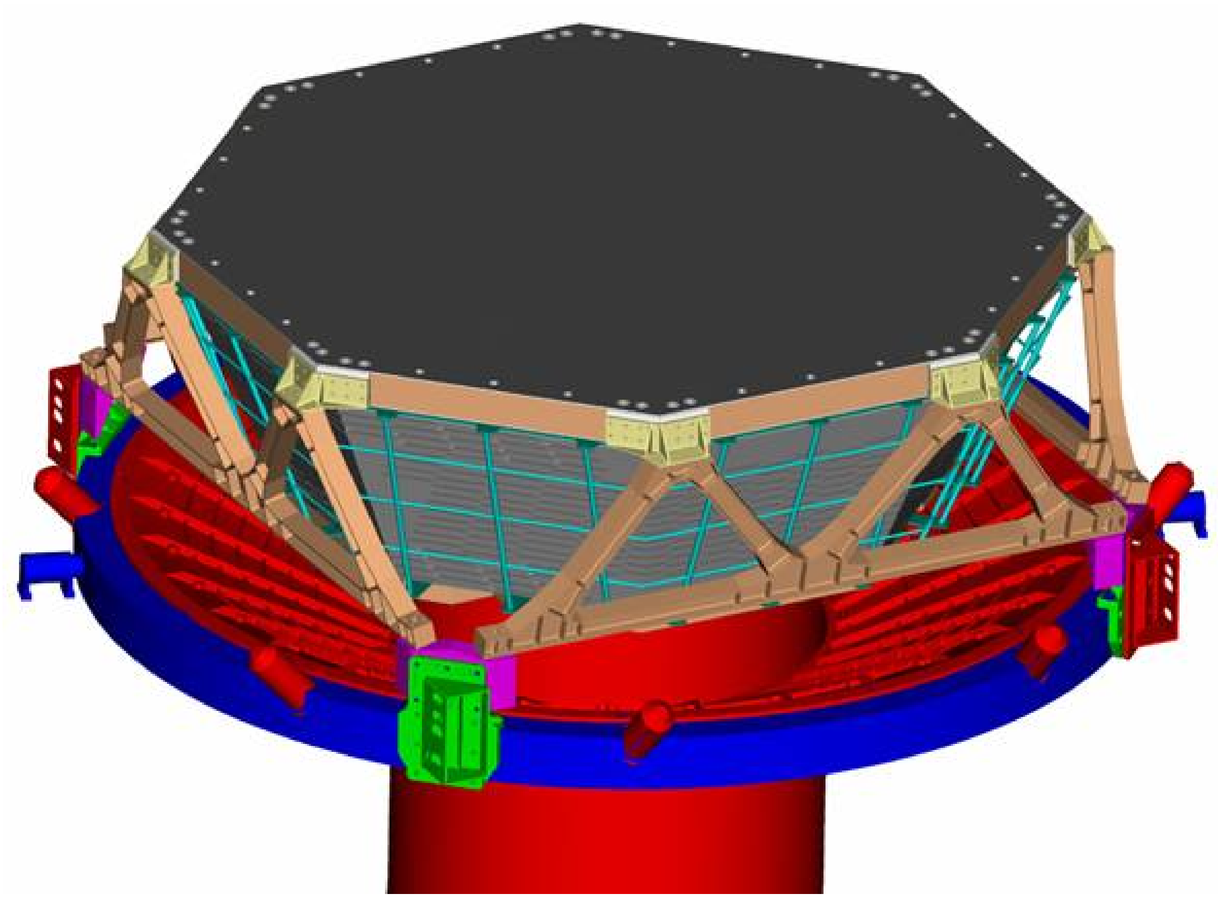


Figure 4.4.1-1: TRD Structure

The 20 layers of straw modules and radiators are mounted in an octagon structure which consists of eight honeycomb side panels [1.18" thick], a lower honeycomb support plate, and an upper honeycomb plate. The size of the octagon structure is 91" x 24.5". The combined weight of the TRD is 742.3 lbs. Inside the octagon structure, the straw modules are further supported by four 0.1" thick bulkheads, two in the Y-direction and four smaller ones in the X-direction.

The TRD is located at the top of the experiment stack, just above the Upper Time of Flight (UTOF). The octagon structure is supported by the M-Structure, which is mounted to the USS-02 at four locations on the upper USS-02 just above the VC interface.

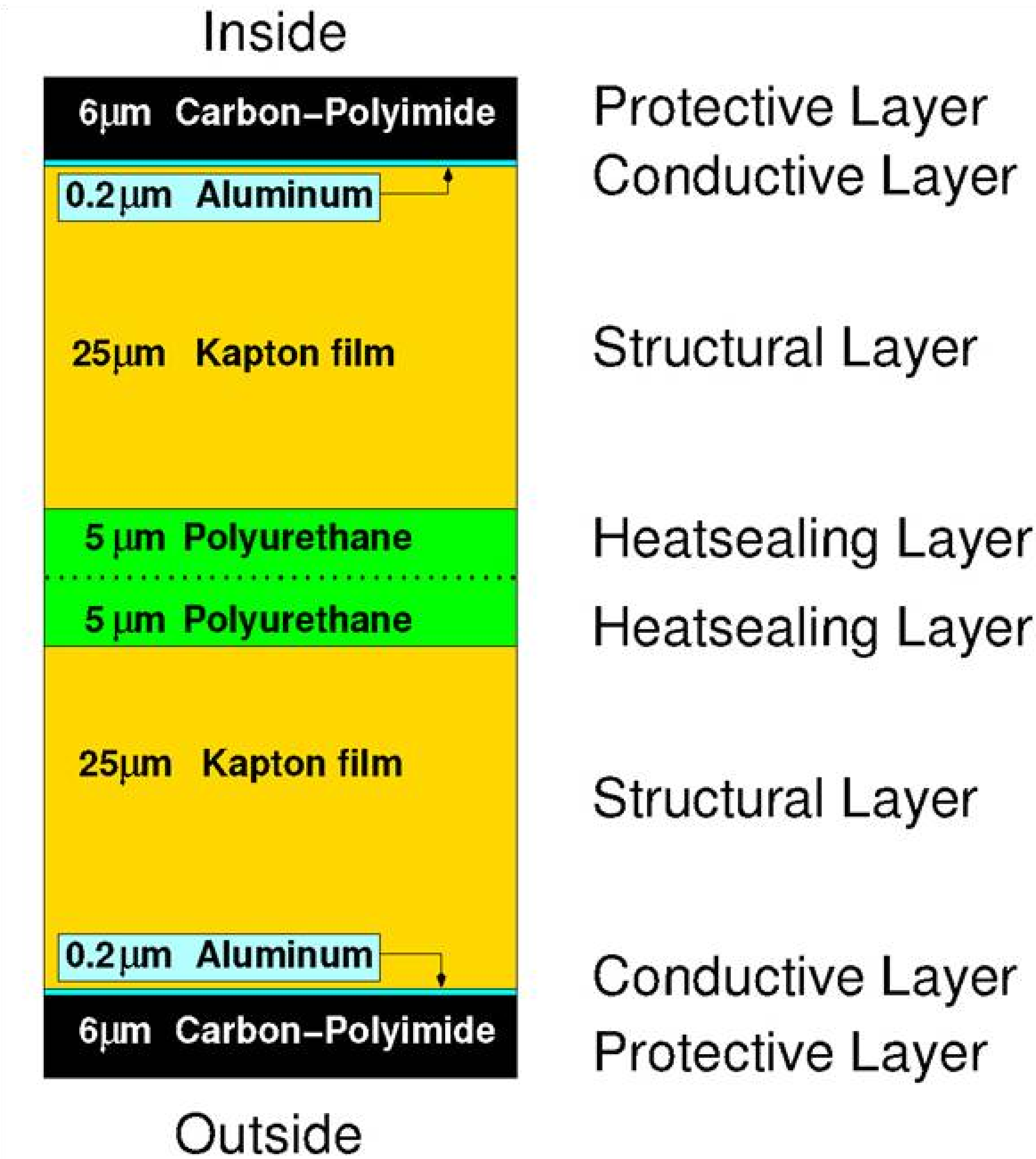


Figure 4.4.1-2: Composition of Straw Wall

4.4.2 TRD Gas Supply System

The TRD Gas Supply System (Figure 4.4.2-1) supplies a mixture of 80% Xe and 20% CO_2. The density and purity of the gas mixture is monitored and adjusted to ensure efficient detection. The gas supply system includes three tanks: one for the Xe, one for the CO_2, and one mixing tank (Figures 4.4.2-2 and 4.4.2-3). These tanks are mounted to a support bracket and covered by shields to protect them from orbital debris. The support bracket is mounted to the wake side of the USS-02 which also helps protect them from debris.

The Xe tank is a composite over-wrapped stainless steel tank that is designed and built by Arde, Inc. This tank is identical to the one used on the Plasma Contactor Unit (PCU) for ISS. It has a maximum design pressure of 3000 psid during flight with a minimum temperature rating of –60°F and a maximum temperature rating of 150°F (tank rating, not Maximum Design Pressure (MDP) temperature). The tank is designed with a proof test factor of 1.5 x MDP and a minimum burst factor of 3.1 x MDP. It has an outside diameter of 15.4” (390 mm) and a volume of 1680 cubic inches (27.5 liters). It carries a maximum of 99 lbs (45 kg) of Xe at launch and has been tested to a random vibration load of 8.9 Grms.

The CO_2 tank is also a composite over-wrapped stainless steel tank designed and built by Arde, Inc. This tank was designed for use on the X-33 vehicle and has a maximum design pressure of 3000 psid with a minimum operating temperature of –100°F and a maximum operating temperature of 300°F (tank capabilities, not AMS-02 application). The tank is designed with a proof test factor of 1.5 x MDP and a minimum burst factor of 2.125 x MDP. MDP is only under worst case on-orbit temperature exposure. The outside diameter is 12.4” (315 mm) and it has a volume of 813 cubic inches (13.3 liters). The tank weighs 9.5 lbs (4.3 kg) and is designed to hold a maximum of 11 lbs (5.0 kg) of CO_2. A random vibration test has been performed to 8.9 Grms axially and 4.5 Grms laterally.

The small, stainless steel mixing tank, was also manufactured by Arde, Inc. It has a nominal operating pressure of 200 psia, a normal operating temperature of 77°F and an MDP of 300 psid established by dual pressure relief devices and the source gas supply control. A proof test factor of 1.5 x MDP and a minimum burst factor of 4 x MDP has been used. The volume is 61 cubic inches (1 liter).

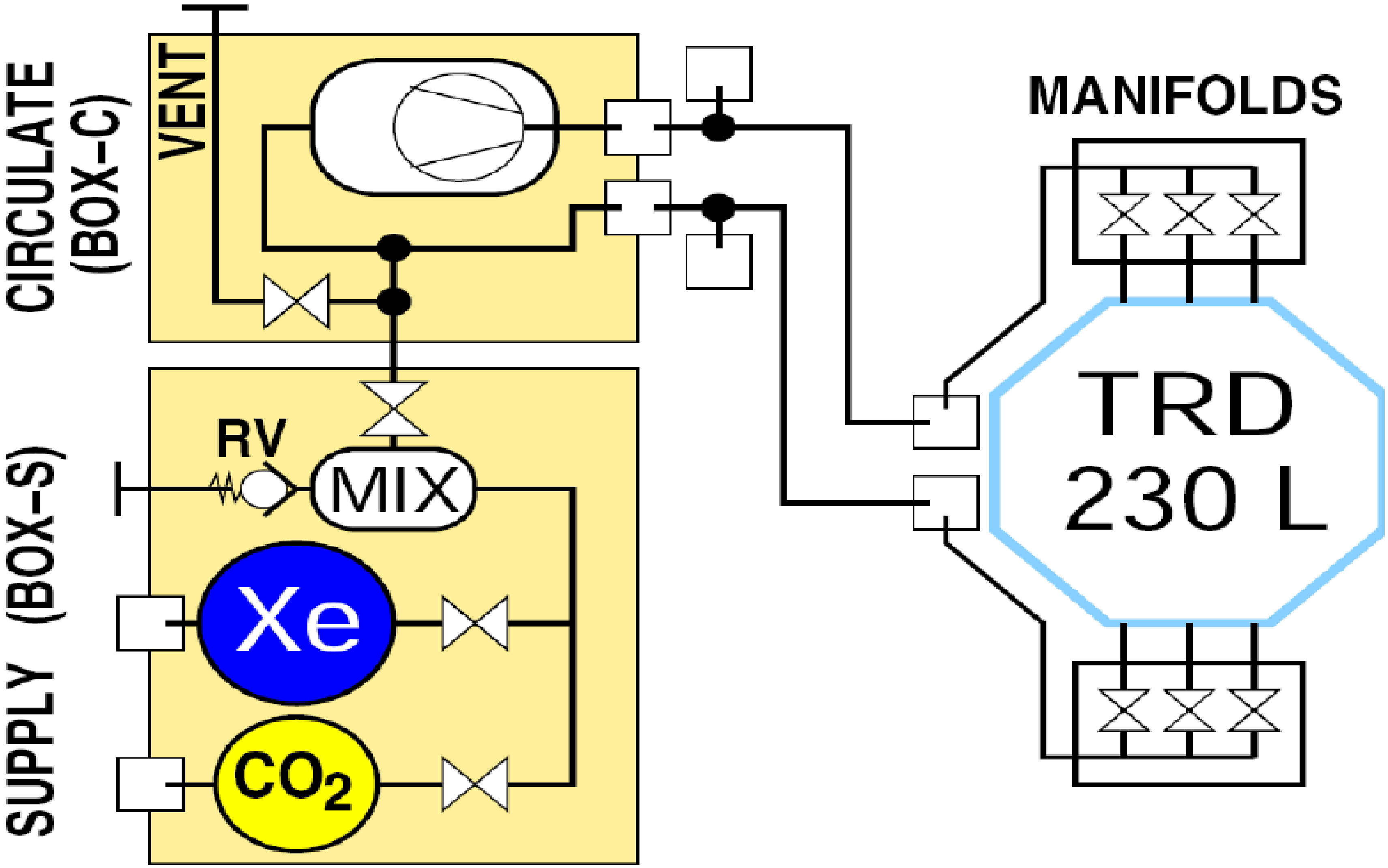


Figure 4.4.2-1: Schematic of TRD Gas Supply System

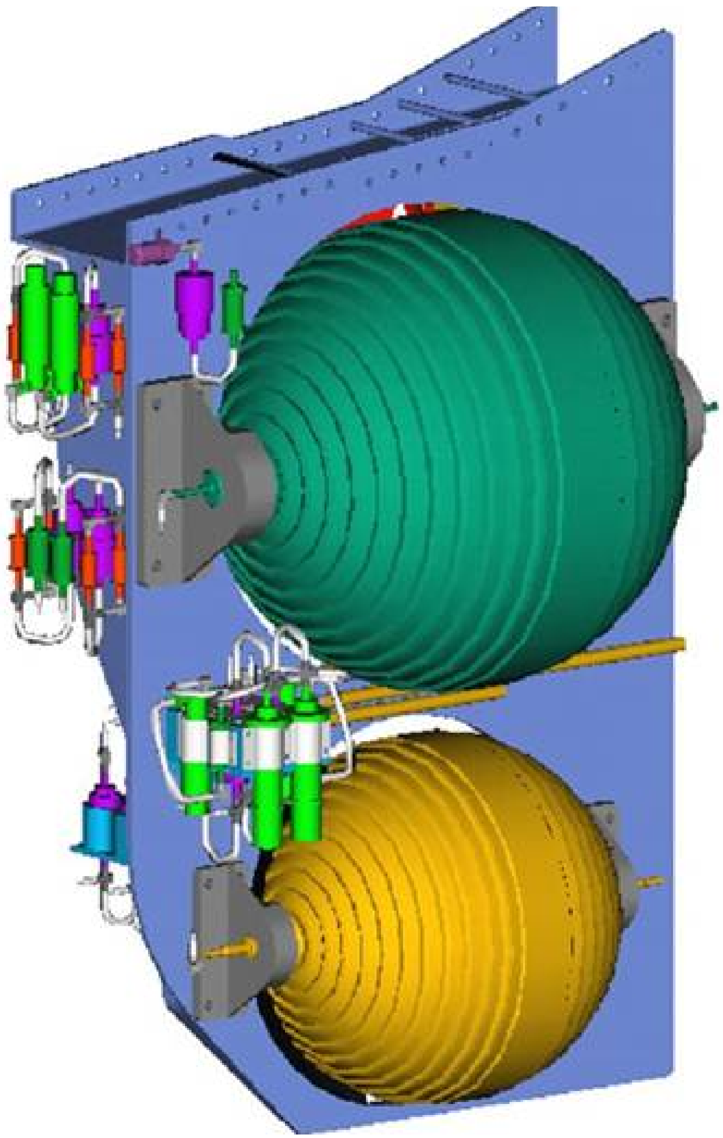


Figure 4.4.2-2: TRD Gas Supply System

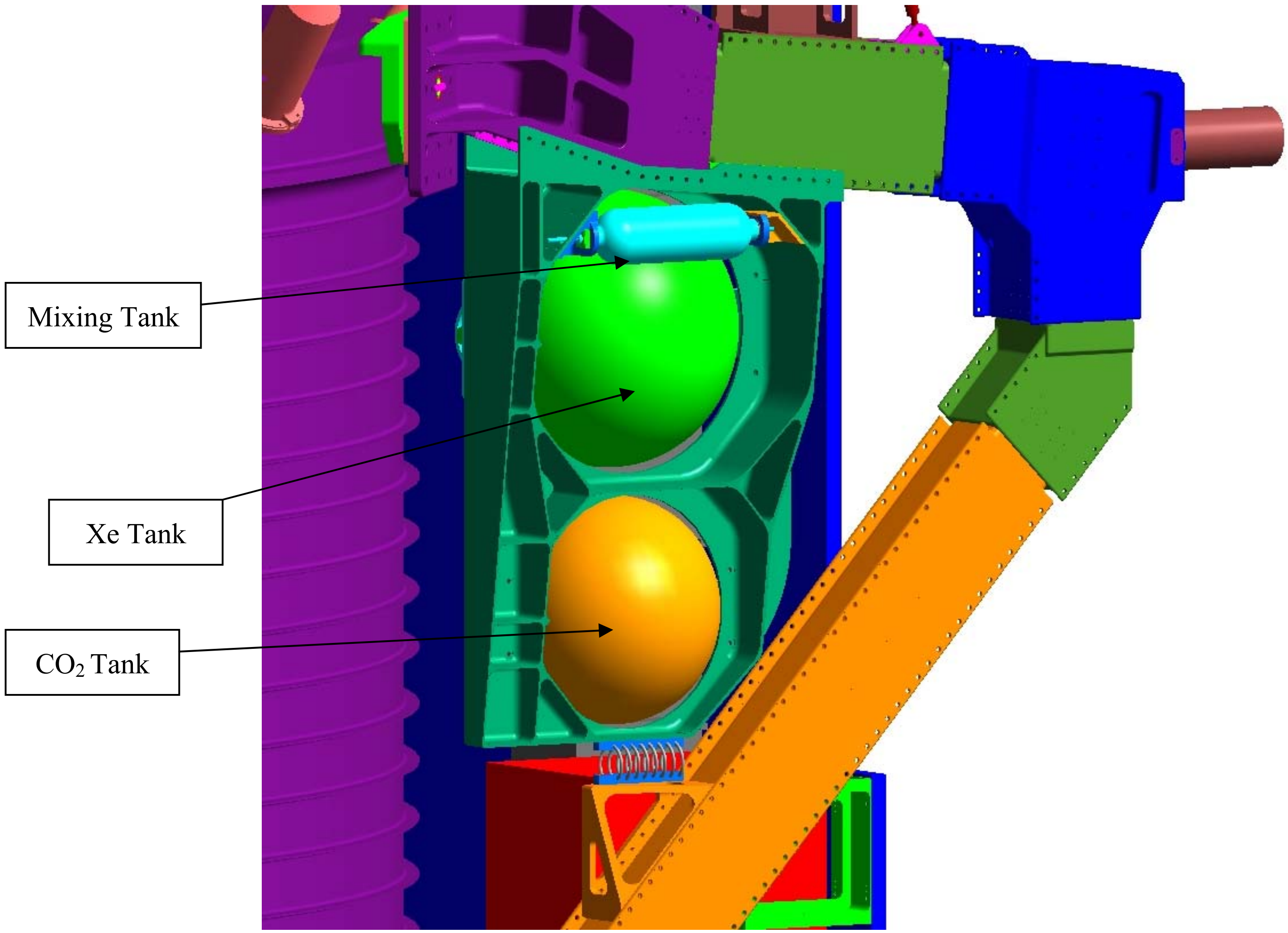


Figure 4.4.2-3: TRD Gas Supply System (Box S) as Mounted on USS Structure

(With Outer Debris Shield Removed)

There are two sections to the TRD gas system, a Box S and a Box C. Box S contains all the high pressure elements. Box C and the TRD itself operate at pressures just above 1 atm. Descriptions of both sections follow.

4.4.2.1 Box S Description

Box S, shown in Figure 4.4.2.1-1, contains the gas reserves for the TRD. Gas is released from the two reservoirs into the mixing vessel (D), where it is combined in the required ratio and stored until such time as the straw tubes need to be replenished. The combined gas is transferred to Box C for circulation as needed.

The reservoirs are filled through fill ports with different GSE threads to make interchange impossible. If performance is as desired, then each of the fill ports are capped with two independent caps with metal seals.

Maximum design pressure for the gas reservoirs, the buffer volumes, and the associated piping through valves V3a and V3b have been determined through thermal analysis and all items have been shown to have sufficient structural margin. MDP of the mixing vessel and all plumbing between V3a/V3b and V4a/V4b is set at 300 psi based on the redundant BDs shown in Figure 4.4.2.1-1. This hardware has also been shown to have adequate margin through structural analysis.

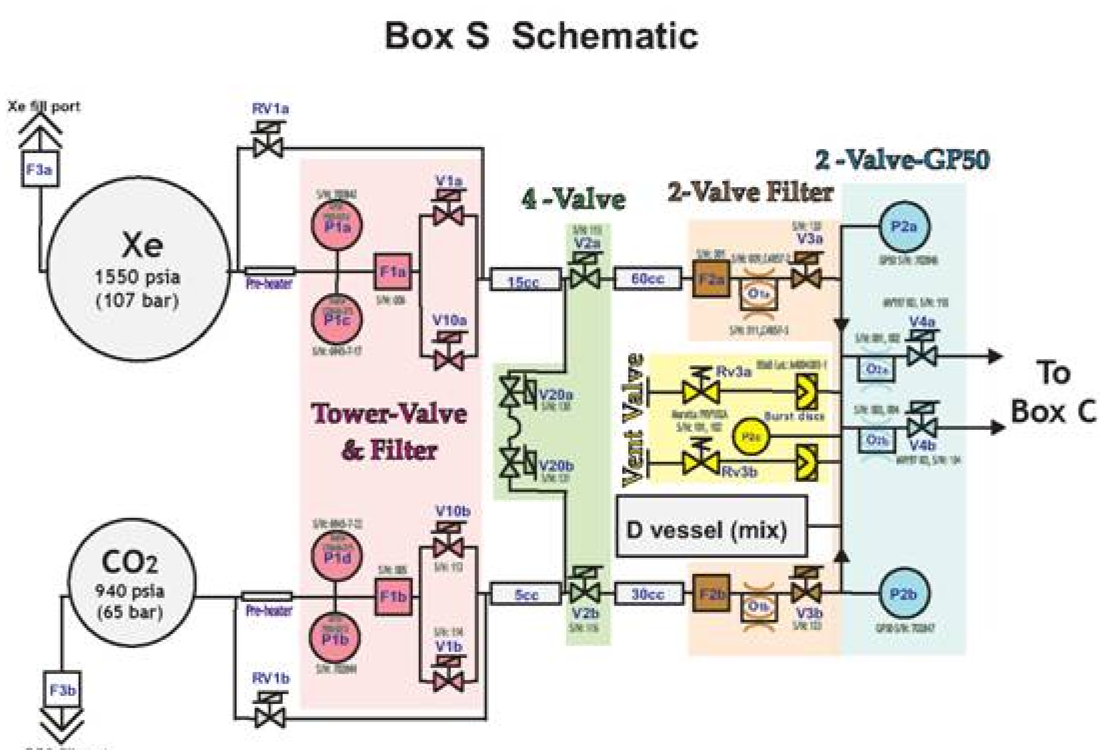


Figure 4.4.2.1-1: Box S Schematic

4.4.2.2 Box C Description

Box C, shown in Figure 4.4.2.2-1, contains the pumps which circulate the gas throughout the TRD. Pumping the gas after refreshment through each of the TRDs 328 straw modules prevents the gas from separating into pockets and, ensuring a uniform mix. Box C is mounted on the USS-02 just above the main TRD Gas Supply.

Newly mixed gas from Box S arrives in Box C through valves V6A or V6b. Here it merges with the gas circulating through the TRD. Next, the gas enters the canister (pressurized at two bar), where two Kurt Neuberger Freiburg (KNF) UNMP 30 pumps provide the circulation through the system. These pumps operate in the open environment of the canister, with only one side of the pump connected directly to the TRD plumbing lines. Only one pump is needed – the redundant pump is for mission success. Inside the canister the gas flows through an ultrasonic spirometer, which measures the CO_2 in the gas flow and provides an independent check of the Xe/CO_2 ratio. The gas then flows back into the manifolds and re-enters the straw tubes.

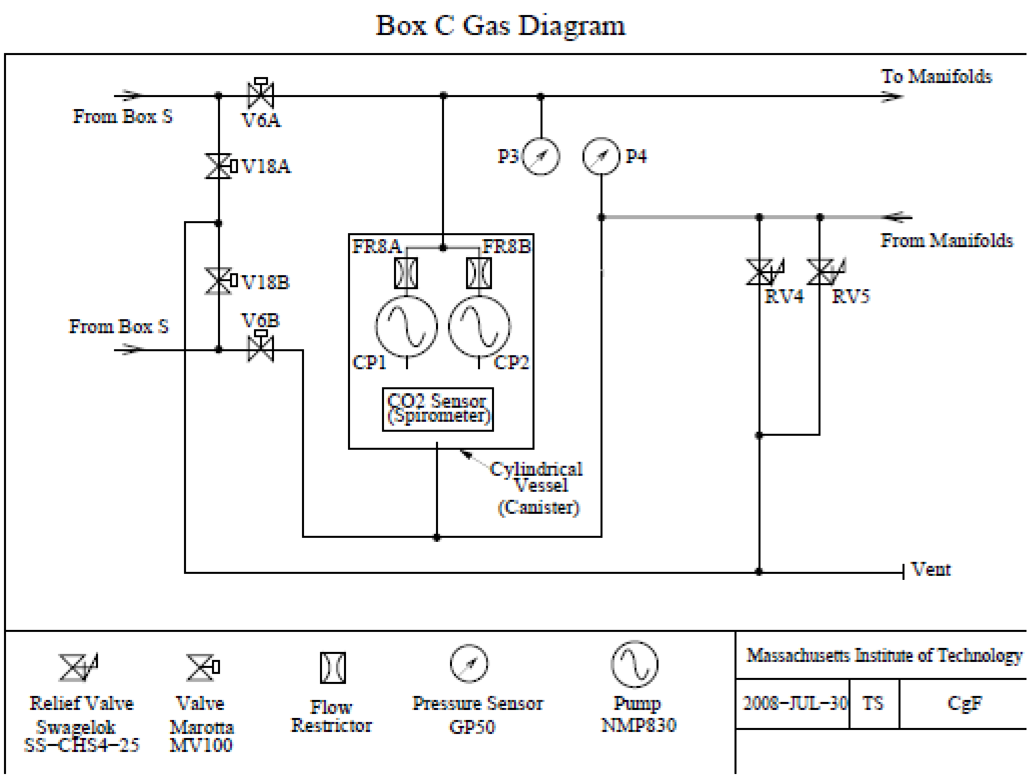


Figure 4.4.2.2-1: Box C Schematic

4.4.2.3 Straw Tube Segments

From Box C, 3 mm stainless steel gas lines run to the top rim of the TRD, where input and output manifolds are located. The 5248 tubes of the TRD are grouped into ten distinct segments; each separately attached to input and output manifolds (Figure 4.4.2.3-1). Each segment is small enough so as not to be considered a pressure vessel (1 bar x 28 liters=2.8 kJ). Each manifold line is connected to four TRD segments via pressure controlled isolation valves. Steel tubing—which is 0.06”—runs from the isolation valves to the segment inputs and outputs, where it is joined to the straws via special connectors designed by Rheinisch-Westfälischen Technischen Hochschule (RWTH) in Aachen. Cajon fittings are used where other connections need to be made. The straw manifolds are extremely sensitive. In order to maintain the ability to achieve their science goals, they will be protected against possible negative pressure by introducing a steady flow of a Xe/CO_2 mixture pressure slightly above 1 atm through the tubes.

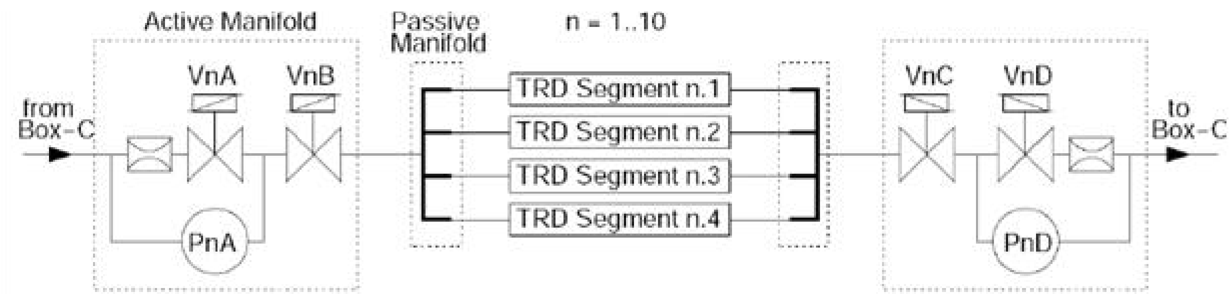


Figure 4.4.2.3-1: One of the 10 TRD Straw Tube Segments

4.4.2.4 Monitoring and Control

The electronics that control the gas system are located in the Unigraphics (UG)-crate. This crate will contain a Universal Slow Control Module (USCM) computer that manages the monitoring and control tasks, as well as maintain communication with the AMS-02 Main Computer (J-Crate Main Data Computer (JMDC)). The USCM is provided with interface electronics to the various gas transducers and actuators scattered throughout the gas system. The USCM and interface electronics will perform the following tasks:

- Close or open emergency isolation valves in the manifolds.
- Provide housekeeping data (temperature of valves, pressure vessels, etc.).
- Store calibration constants.
- Condition and perform analog to digital conversion for 29 pressure sensors and approximately 500 temperature sensors distributed around the TRD and gas system.
- Control two recirculation pumps.
- Provide logic control for approximately 56 gas valves.
- Provide the power electronics to drive valves, etc.
- Read out digital signals from the gas analyzer (spirometer).

- Switch the gas system to “Safe Mode” (for mission success) in case of communication failure.

The USCM interface electronics are doubled to provide single fault tolerance for mission success. The USCM does not use batteries. If there is a power failure, the pumps stop, and all the Marotta valves close (they require power and commands to open). This ensures that the Xe and CO_2 gas tanks are sealed, and that no gas is transferred, either within Box S (e.g. to the mixing tank or other sealed volumes) or from Box S to Box C and the rest of the gas system. All mechanical safety release valves, for overpressure, remain operational. All of the flipper valves, which are used to isolate individual sectors of the gas system in case of leak, remain in whatever state they were when power went off. This means that, if there is a leak on orbit which develops in the TRD when power is off, the worst that would happen is that the TRD would slowly lose the approximately 230 L of gas, which is small compared to the 10,000 L of gas in the Xe and CO_2 tanks. Any sector previously isolated because of a leak would remain isolated. On the ground, a leak with power off would slowly contaminate the gas in the TRD with air, but would have no safety impact.

The TRD High Voltage (HV) system consists of High Voltage Generation Boards (UHVG) with six boards located in each of the two U-crates controlled by the J-Crate Interface Card Designator (JINF). Each UHVG card drives seven HV lines with twofold internal redundancy to provide single fault tolerance for mission success. Each line is connected via shielded HV cabling to a HV distribution board (High Voltage Distribution Boards (UHVD)) mounted on the octagon in the vicinity of the readout cards to distribute the HV to four modules (64 tubes). The schematic of the HV system is shown in Figures 4.4.2.4-1 and 4.4.2.4-2. Each unit provides +1600V (control range: 700-1750V) with current limited to <100 microamperes.

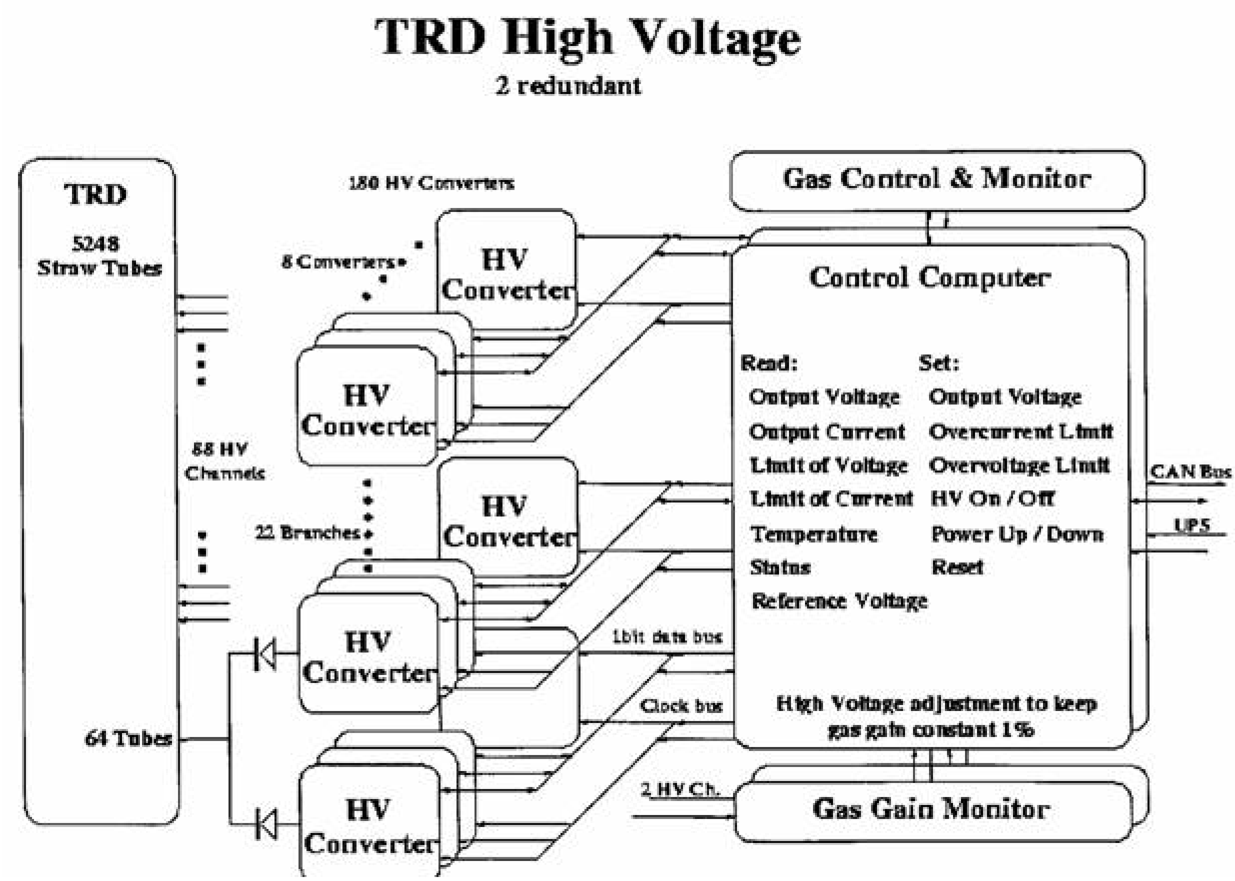


Figure 4.4.2.4-1: High Voltage System

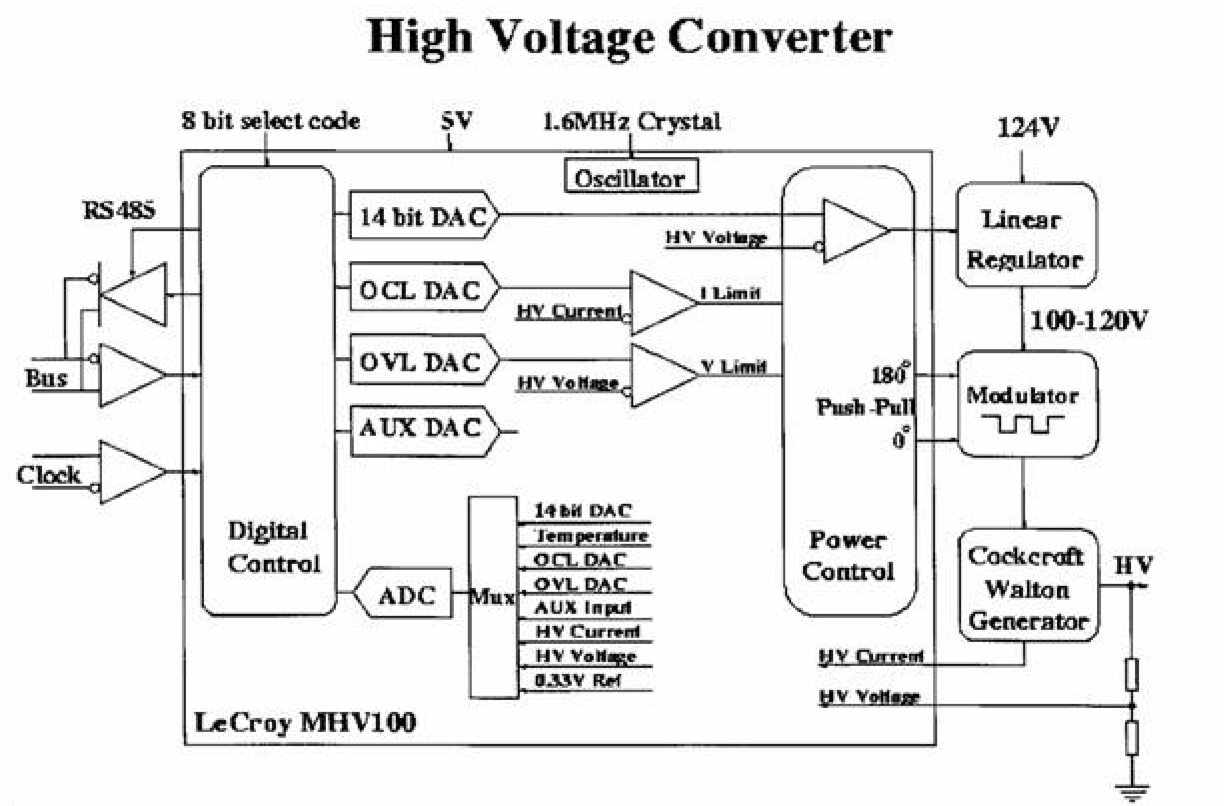


Figure 4.4.2.4-2: High Voltage Converter

4.5 TIME OF FLIGHT (TOF) SCINTILLATOR COUNTERS

The TOF serves to: 1) function as a fast trigger to the experiment for traversal of a particle across the bore of the Cryo magnet and Silicon Tracker; 2) distinguish between upward and downward traveling particles; and 3) measure the absolute charge of the particle. Particles that pass through the scintillators generate photons as they pass through the counter paddles. These photons are detected by groups of two or three sensitive Photo Multiplier Tubes (PMTs) on either end of the detector element, the counter paddles.

The TOF is composed of four planes of detectors--two atop the AMS tracker, two below as shown in Figure 4.5-1. Numbered from the top down, detector assemblies 1, 2, and 4 have eight detector paddles per plane and detector assembly 3 has ten. The pairs of detector assemblies are oriented 90° to each other. This configuration gives a 12 x 12 cm^2 resolution for triggering particle events over the 1.2 m^2 area the TOF covers.

Each individual detector paddle is made of polyvinyl toluene (a Plexiglas-like material) which is 12 cm wide and 10 mm thick. End paddles of each layer are trapezoidal with a width of 18.5 cm to 26.9 cm. Each detector paddle is wrapped in aluminized Mylar® and enclosed in a cover made of carbon fiber. Each detector paddle includes a depressurization pipe to allow for pressure equalization. In the center of each detector is a Light Emitting Diode (LED) that is used for calibration and testing. At the ends of each panel are light guides which direct the light of scintillation to photo multipliers. These light guides are curved to orient the photomultiplier tubes within the AMS-02 magnetic field for minimum impact to photomultiplier operations.

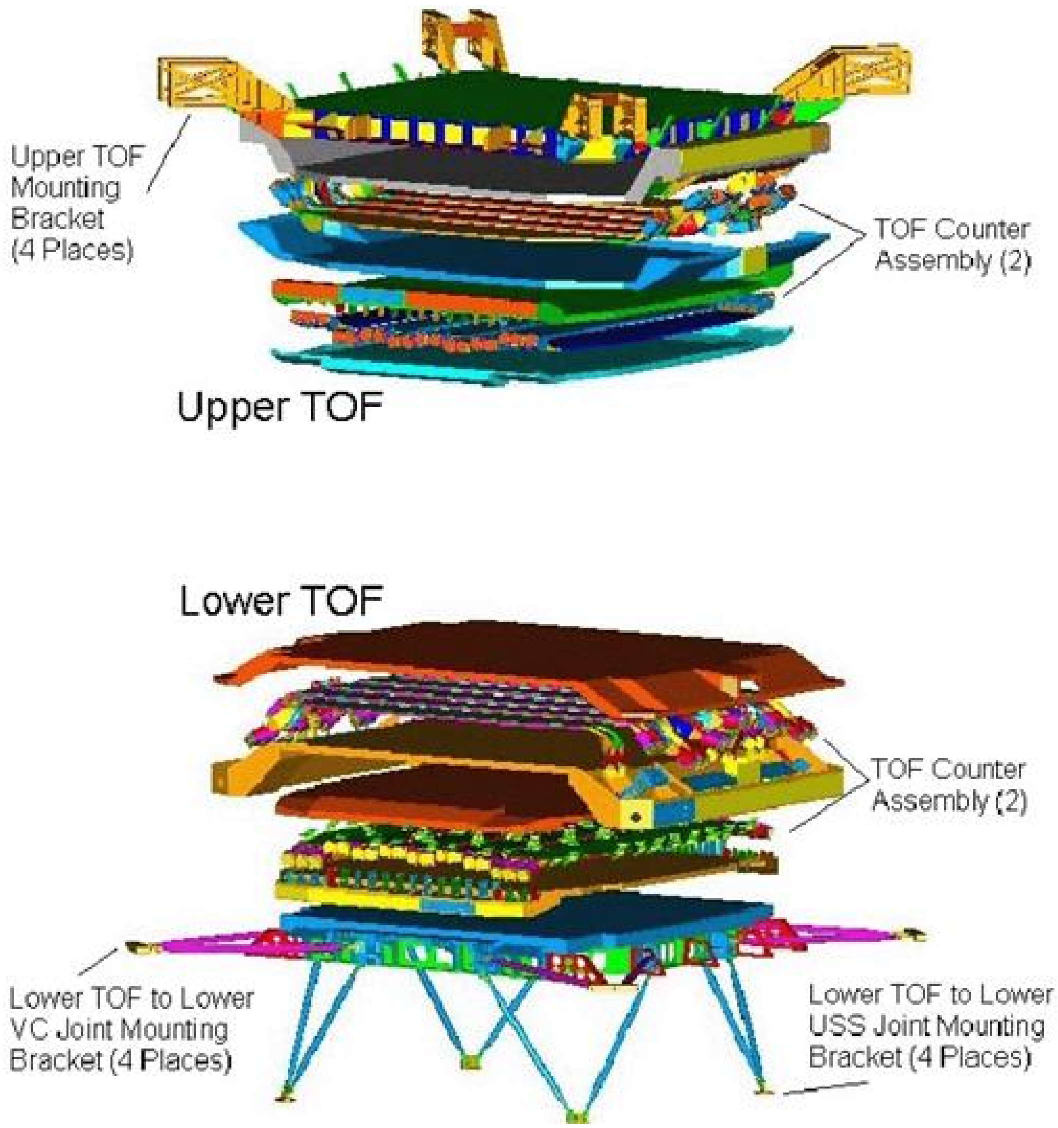


Figure 4.5-1: Time of Flight Counter Construction

4.6 STAR TRACKER

To accurately determine its position, AMS carries a Star Tracker called Astro Mapper for Instrument Check of Attitude (AMICA). The AMICA is equipped with a pair of small optical telescopes (AMICA Star Tracker (ASTC)). The ASTCs are mounted to the tracker conical flange on opposite sides of AMS to increase the probability that one has a clear view of the stars.

The hardware consists of an f/1.25 lens with 75 mm focal length and a 6.3° X 6.3° field of view, a lens cover containing a 3 mm thick blue filter and a 2 mm thick red filter; a low noise frame-transfer Charged Coupling Device (CCD) (512 X 512 pixels); and a baffle to limit the stray light intrusion to the optics. The baffle is made of black anodized aluminum 6061 that is 1 mm thick. The baffle is not mechanically connected to the lens assembly and is supported independently by a bracket mounting the baffle to the M-Structure. This configuration allows for relative motion between the baffle and the lenses without leaking light into the optical path. The interface between the baffle and the lens assembly is made light tight by a fabric Multi-Insulation (MLI) cover.

4.7 ANTI-COINCIDENCE COUNTERS (ACC)

The ACC is a single layer of scintillating panels that surround the AMS-02 Silicon Tracker inside the inner bore of the superconducting magnet. The ACC identifies particles that enter or exit the Tracker through the side. This provides a means of rejecting particles that have not passed through all the detectors and may confuse the charge determination if they leave “hits” in the Tracker close to the tracks of interest.

The ACC scintillating panels are fitted between the Tracker shell and the inner cylinder of the VC, which contains the Cryo magnet system. The ACC is composed of 16 interlocking panels fabricated from BICRON BC414 (Figure 4.7-1). The panels are 8-mm thick and are milled with tongue and groove interfaces along their vertical edges to connect adjacent panels. This provides hermetic coverage for the ACC detection function around the Silicon Tracker. The panels are supported by a 33.46” tall x .78” diameter x 0.047” thick M40J/CE Carbon Fiber Composite (CFC) Support Cylinder.

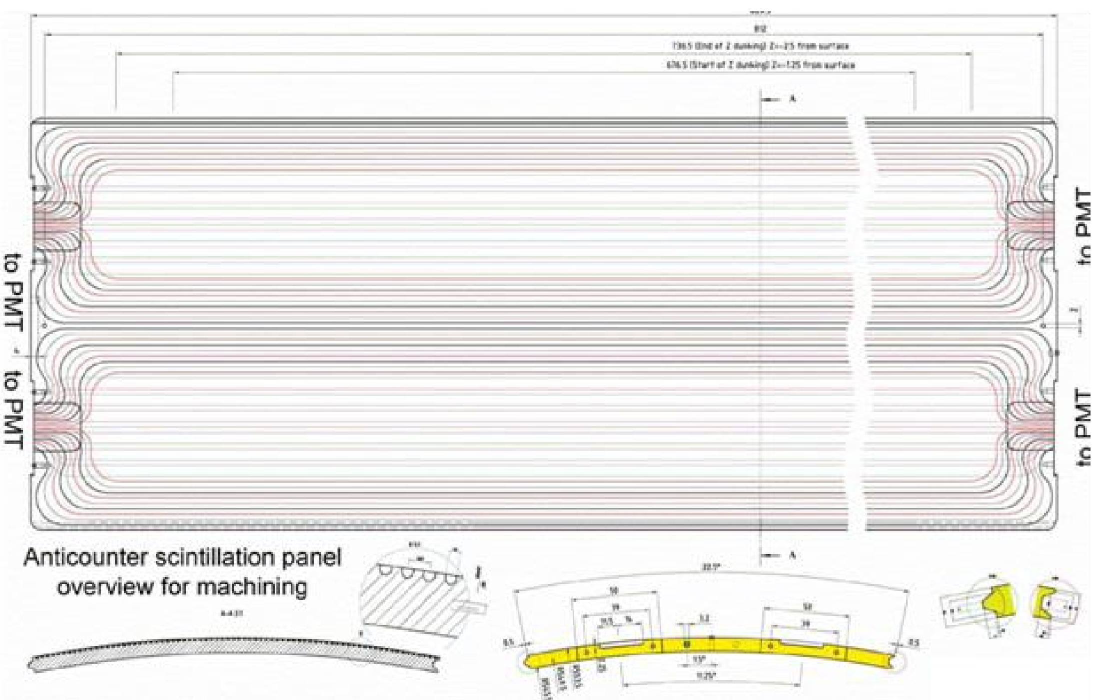


Figure 4.7-1: Design of an ACC Scintillator

4.8 SILICON TRACKER

Combined with the Superconducting Cryo magnet, the Silicon Tracker represents the centerpiece of the AMS-02 suite of detectors. The Tracker (Figure 4.8-1) consists of eight layers of double-sided silicon micro-strip detectors (ladders) on five support planes. The spatial resolution is better than 10 μm in the magnet's bending plane and 30 μm perpendicular to that. The planes are placed inside the bore of the magnet, with the six innermost combined to build pairs. The three interior planes are ≈ 3.6' in diameter and the top and bottom planes are ≈ 4.9' in diameter. The Tracker is ≈ 3.9' high and weighs ≈ 438 lbs. The two outermost layers serve as the entrance and outlet windows. All eight tracker planes together are comprised of 192 silicon ladders corresponding to an active area of about 6 m^2 of silicon and 200,000 readout channels. The entire tracker electronics consume 800 W of power.

Additionally, the Tracker is equipped with an infrared (IR) laser Tracker Alignment System (TAS). It will periodically monitor the x- and y-position of the tracker layers with respect to each other. The laser beam passes through selected alignment holes in each detector plane where the beam can penetrate but still be detected by the layer. For redundancy, the full alignment system consists of ten pairs of beams, placed in the center of the tracker. Five pairs of beams traverses up and the other five pairs traverses down.

The AMS-02 Tracker is a modification of the Tracker that flew on AMS-01. It utilizes the same honeycomb panels and exterior cylindrical shell. The Tracker mounts on eight attach locations (four at the top, four at the bottom) to the VC conical flanges.

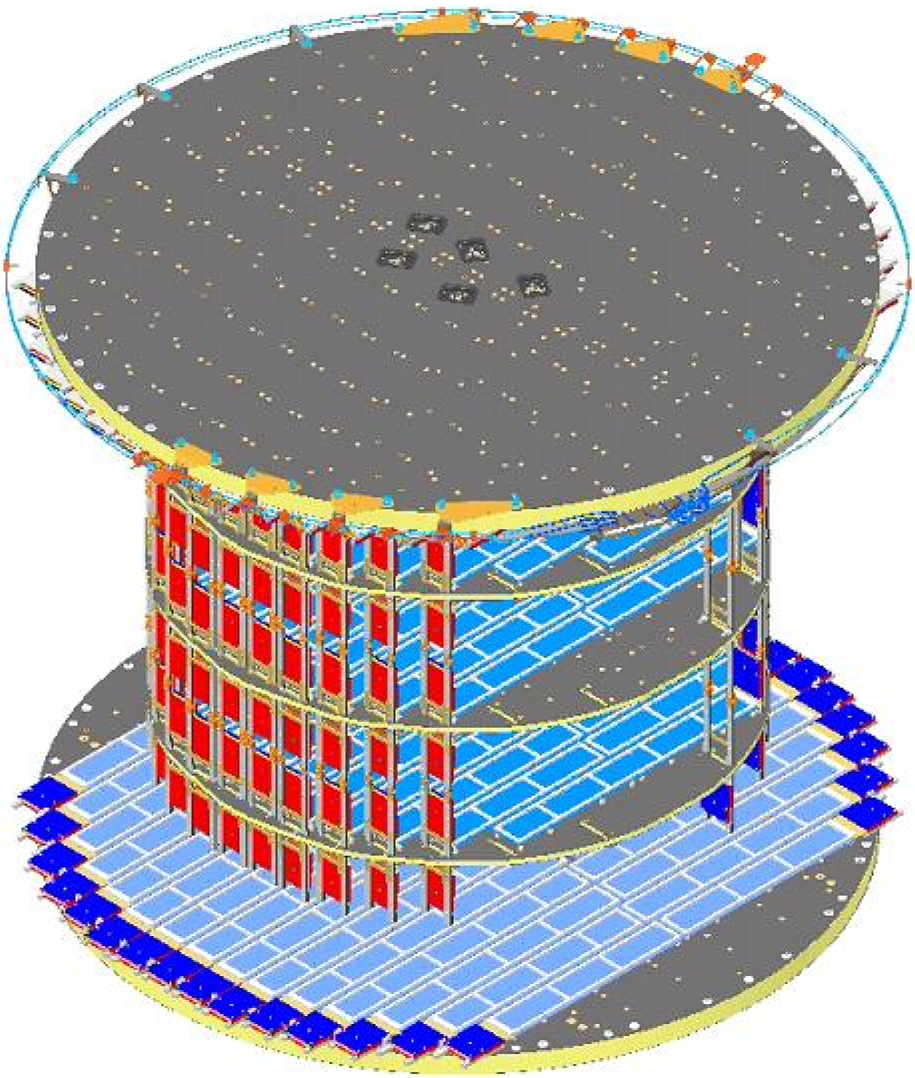


Figure 4.8-1: Silicon Tracker

4.9 RING IMAGING CERENKOV COUNTER (RICH)

The RICH (Figure 4.9-1) is located near the bottom of the experiment stack, below the Lower TOF and above the Electromagnetic Calorimeter (ECAL). The RICH is used in conjunction with the Silicon Tracker to establish the mass of particles that traverse the AMS-02. The RICH is composed of three basic elements. The top layer, the Cerenkov radiator, is composed of silica aerogel and sodium fluoride blocks that serve as sources for the Cerenkov radiation generated by the passage of the high energy particles. The intermediate layer is the conical mirror and the PMT Structural interfaces make up the third layer.

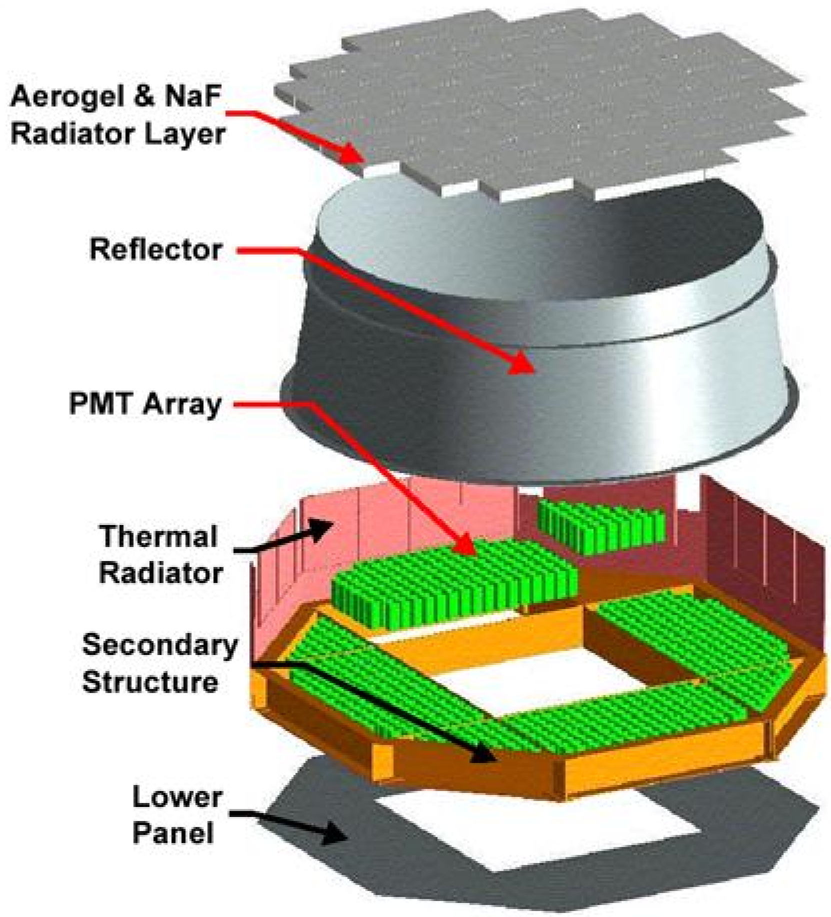


Figure 4.9-1: RICH Basic Elements

4.10 ELECTROMAGNETIC CALORIMETER (ECAL)

The ECAL (Figure 4.10-1) is a scintillating fiber sampling calorimeter that allows precise, 3-dimensional imaging of the shower of smaller particles generated when a particle collides with the calorimeter. The calorimeter also provides a stand-alone photon trigger capability to AMS. The ECAL measures the energy of electrons, positrons and gamma rays up to one TeV. Refer to Figure 4.10-1 for a general diagram of the ECAL.

The active sensing element of the ECAL consists of layers of lead foils and polymer scintillating fibers. Each lead foil is a lead-antimony alloy with a density of 11.2 ± 0.5 gr/cm3 with an effective thickness of 0.04”. Each lead layer is grooved on both sides to accommodate the PolyHiTech Polifi 0244-100 scintillating fibers. Each fiber is 1.0 mm in diameter and is secured in the aligned grooves with BICRON BC-600 optical glue that is applied as lead layers are assembled and pressed together. Each layer consists of 490 fibers across the 25.9” width. Lead layers are grouped together in “superlayers” that are comprised of eleven layers of lead foil and ten layers of scintillating fibers. Each superlayer has all scintillating fibers oriented in the same direction while the nine superlayers alternate direction orthogonally. Once assembled and pressed, each cured superlayer is milled to a uniform thickness of 0.7”. The superlayers are assembled as larger elements and milled for flight into 25.9” squares. The bottom layer of the ninth superlayer has been replaced with a milled aluminum plate to reduce the weight of the overall ECAL. The assembled ECAL is approximately 31.5” square x 9.8” high and weighs approximately 1478 lbs. Approximately 75% of this weight is the lead foils.

The superlayer assembly, or “pancake”, is supported by the ECAL box. The box is made of six elements (Figure 4.10-1). The top and bottom pieces are aluminum honeycomb plates framed with aluminum. The plates are bolted to four lateral panels along the edges. The four lateral panels are made of 4” thick aluminum plate carved with a series of 1.26” square holes to house the light collection system. Four corner brackets, made of aluminum plate, link the four plates together and connect the detector to the bottom of the USS-02. The four mounting locations include a pair of radially-slotted holes to limit the loads from the USS-02 that are transferred into the ECAL.

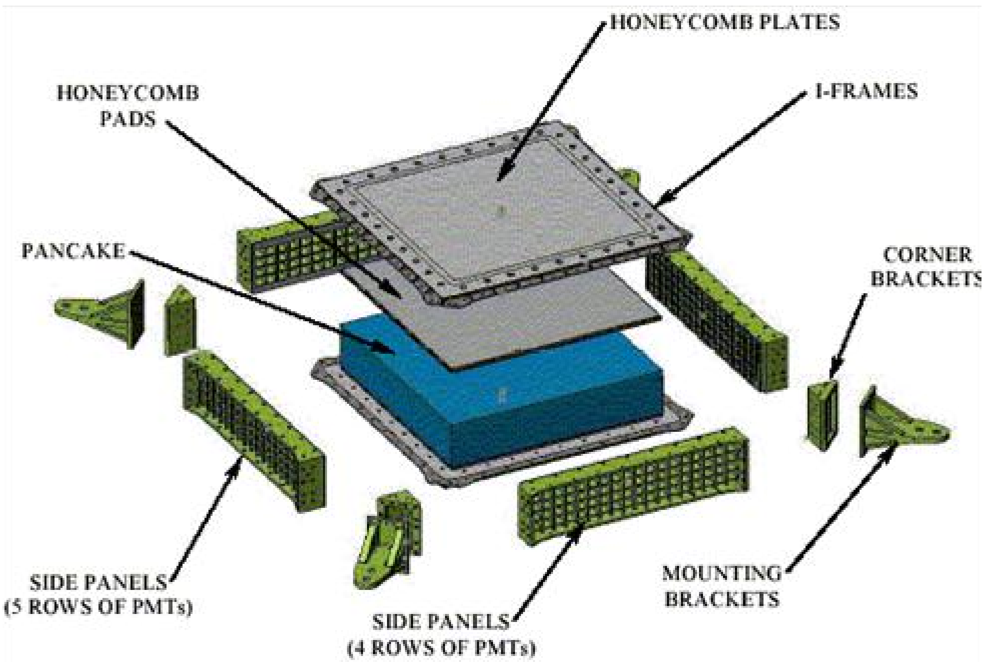


Figure 4.10-1: ECAL

4.11 Power Distribution System (PDS)

The AMS-02 PDS serves as the primary front-end for the input power management and power distribution to the subsystems and experiment detector electronics. It also provides the isolation and protection functions necessary to protect the Shuttle Transportation System (STS) and ISS vehicles from damage.

The PDS (Highlighted in yellow in Figure 4.11-1) consists of four distinct sections: 120 Volts Direct Current (VDC) Input; 120 VDC Output; 28 VDC Output; and Low Voltage Control and Monitor. The PDS has two independent “channels”: side A and side B (Figure 4.11-1), which have four identical subsections. The only difference between the two channels is that side A is the only side that provides power to the Cryo magnet Avionics Box (CAB) for magnet charging.

Isolation between the 120V input buses A & B is provided either within the PDS by DC-to-DC converters for the 28V outputs, by the end-subsystem by either DC-to-DC / DC-to-Alternating Current (AC) converters or with double pole relays for the 120V outputs. The inputs use diode protection or connector protective covers to prevent crew or ground personnel from potential exposure to hot pins.

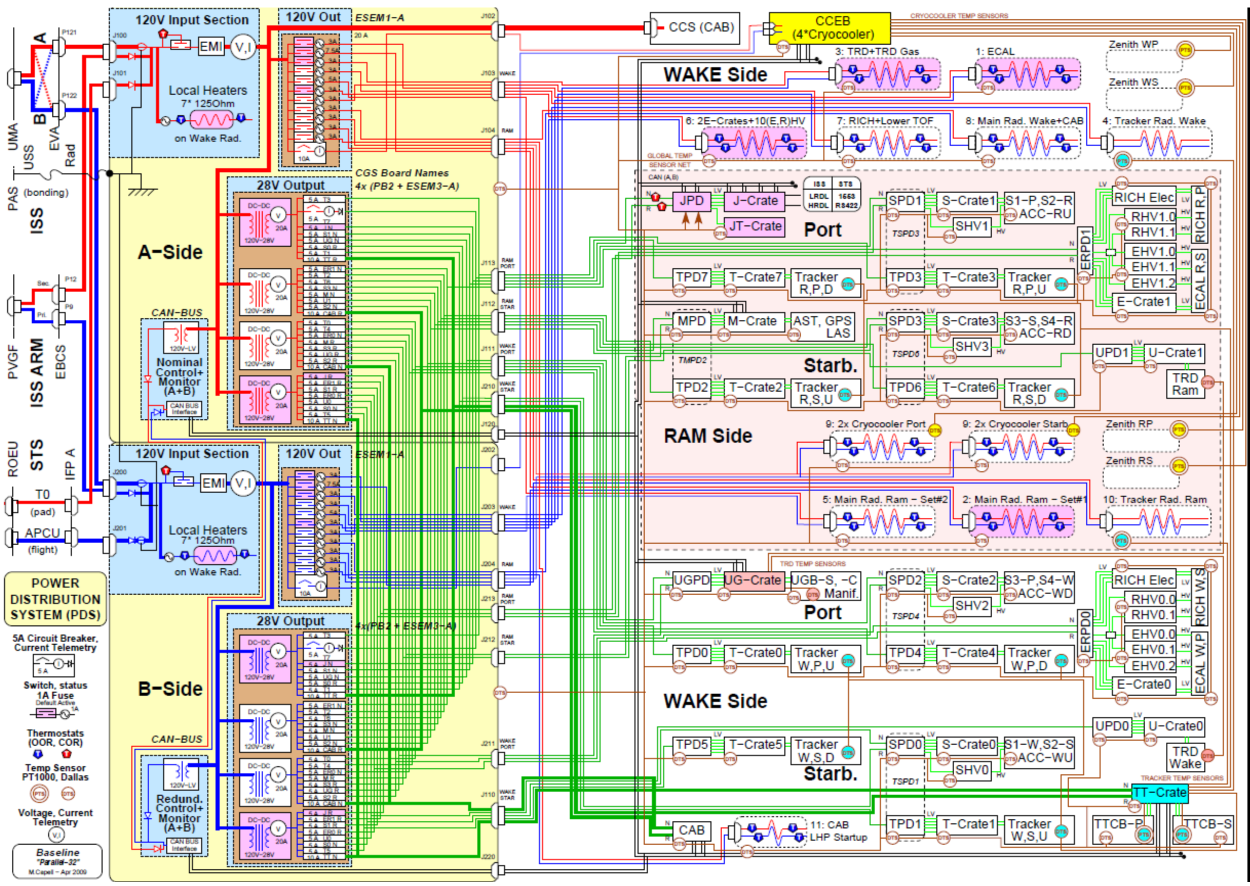


Figure 4.11-1: AMS-02 Power Distribution System, Slides A and B

4.12 CRYO MAGNET DUMP DIODES (CDDS)

The CDDs are another component of the cryo magnet system. They consist of a total of nine diodes, arranged in three series sets, each consisting of three diodes in parallel with each other and are located on the starboard wake-side sill trunnion joints (Figure 4.12-1 and 4.12-2). The joint was selected due to its large thermal mass. The purpose of the CDD's is to convert electrical energy to thermal energy during a nominal power down of the Cryo magnet. When a power down occurs, current is diverted from the magnet, to the CAB, then to the diodes. Once delivered to the CDDs, the electrical energy is converted to thermal energy and dissipated. The total time required to dissipate the Cryo magnet energy is approximately 140 minutes. Ground personnel are protected from incidental contact with the diodes by a metal cover (Figure 4.12-

3). Further safety controls for the CDDs are covered in Section 7.6 and Hazard Report GHR-AMS-02-015.

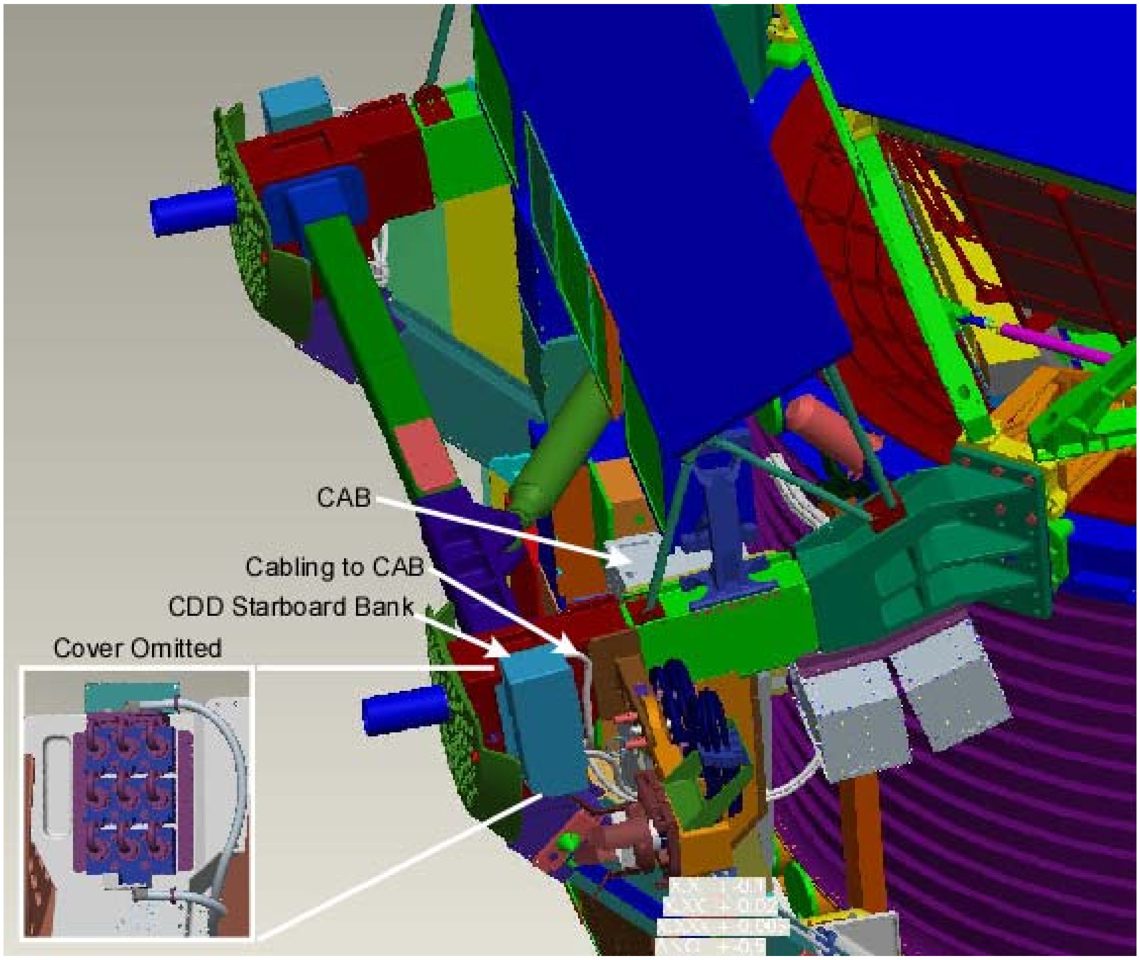


Figure 4.12-1: Location of Dump Diodes

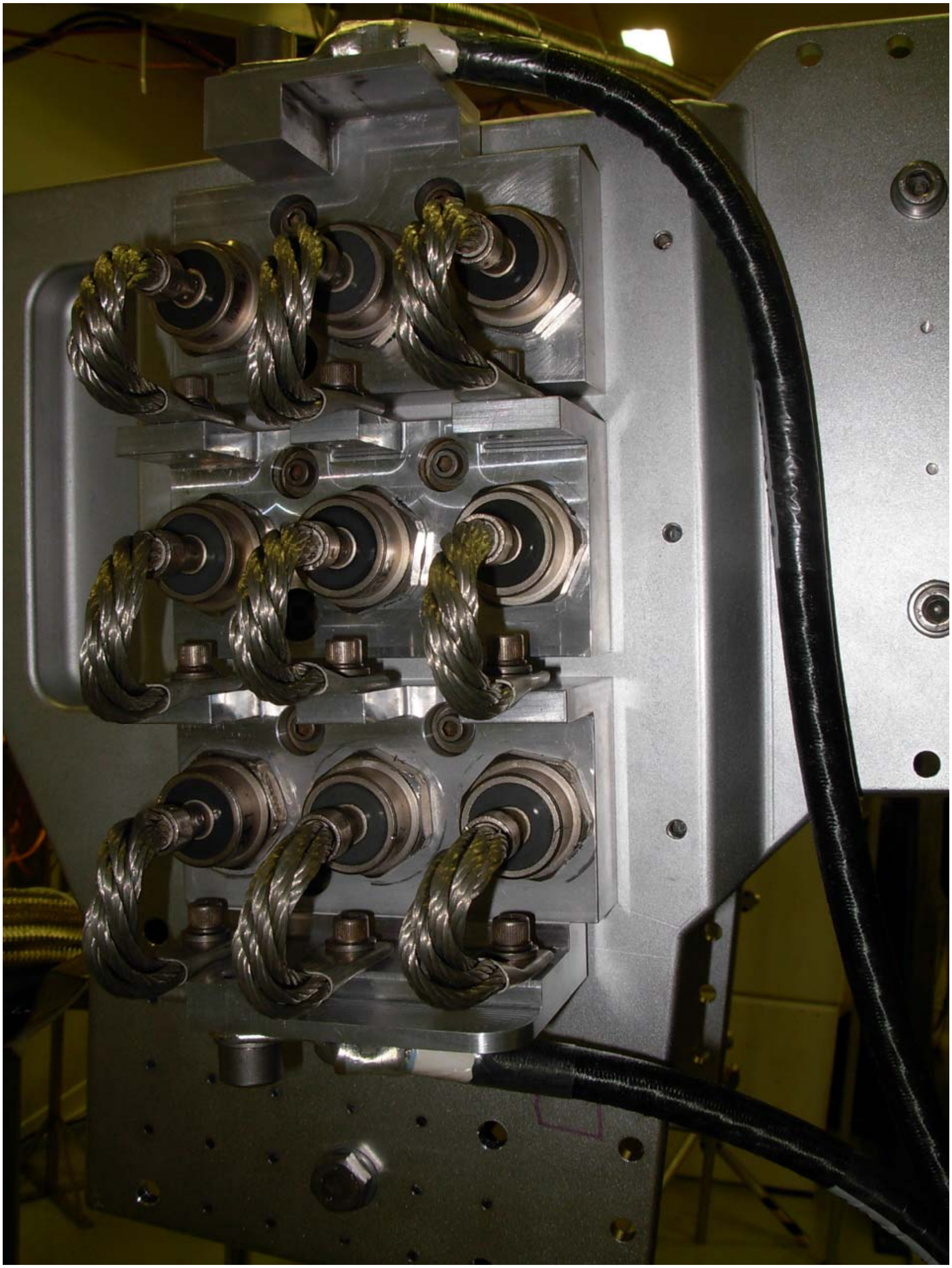


Figure 4.12-2: CDDs (Test Model) Mounted on Sill Trunnion Joint

Figure 4.12-3: CDDs (Test Model) Mounted on the Sill Trunnion Joint with Cover Installed

4.13 HIGH VOLTAGE SOURCES

The Cryo magnet is a potential high-voltage source in the event of a quench. Other than the path to the CAB, the Cryo magnet generated high voltage would be contained within the VC, which is grounded to the USS.

Table 4.13-1 lists the remaining high voltage and current sources on the AMS-02.

Table 4.13-1: AMS-02 High Voltage or Current Sources

High Voltages (and Currents) in AMS-02						
Item	**Subsystem**	**Source**	**Load**	**Voltage**	**Current**	**AWG**
1	Cryo cooler	CCEB	Cryo cooler	<120Vpwm	<5A	3x22
2	Cryo magnet	CCS in CAB	Cryo magnet	<10VDC	<460A	3x00
3	Cryo magnet	Cryo magnet	CDD-P	<10VDC	<460A	00
4	Cryo magnet	UPS	CSP in CAB	<32VDC	<90A	3x12
5	Cryo magnet	CSP in CAB	Quench Heaters	<32VDC	<90A	3x12
6	Cryo magnet	Cryo magnet	Quench Detectors	<1000VDC	<1A	HV 24
7	ECAL	EHV	55 ECAL PMT's	<1000VDC	<250uA	HV 36
8	Interface	ISS	AMS	120VDC	<25A	8
9	Interface	ISS/PVGF	AMS	120VDC	<15A	12
10	Interface	STS/T0, APCU	AMS	120VDC	<25A	8
11	Power	PDS	CCS in CAB	120VDC	<17A	2x12
12	Power	PDS	CCEB	120VDC	<7.5A	2x12
13	RICH	RHV	40 RICH PMT's	<1000VDC	<80uA	HV 36
14	S:TOF+ACC	SHV	20 TOF+4 ACC PMT's	<2300VDC	<25uA	HV 36
15	Thermal	PDS	ECAL Heaters	120VDC	<3A	20
16	Thermal	PDS	Ram Heaters	120VDC	<7.5A	3x20
17	Thermal	PDS	TRD Heaters	120VDC	<3A	20
18	Thermal	PDS	Tracker Wake Heaters	120VDC	<3A	20
19	Thermal	PDS	Wake Heaters	120VDC	<5A	2x20
20	Thermal	PDS	LUSS Boxes	120VDC	<3A	20
21	Thermal	PDS	RICH Heaters	120VDC	<3A	20
22	Thermal	PDS	LTOF Heaters	120VDC	<3A	20
23	Thermal	PDS	CC1&2 Heaters	120VDC	<3A	20
24	Thermal	PDS	Tracker Ram Heaters	120VDC	<3A	20
25	Thermal	PDS	CC3&4 Heaters	120VDC	<3A	20
26	Tracker	TPD	2 TBS in T-Crate	<120VDC	<10mA	2x22

High Voltages (and Currents) in AMS-02						
Item	**Subsystem**	**Source**	**Load**	**Voltage**	**Current**	**AWG**
27	Tracker	2 TBS in T-Crate	24 Tracker Ladders	<80VDC	<10mA	26
28	TRD	UPD	6 UHVG in U-Crate	<120VDC	<35mA	22
29	TRD	6 UHVG in U-Crate	2624 TRD Straw Tubes and 2 Monitor Tubes	<1800VDC	<100uA	HV 36

WIRE: AWG 00=M22759/41-02-5D, AWG 12 – 24=M22759/44-*, AWG 26=GORE PTFE ribbon Cable, HV 24= REYNOLDS 178-8066, HV-36=REYNOLDS 167-2869 coaxial

4.14 THERMAL CONTROL SYSTEM (TCS)

The AMS-02 TCS has been developed and designed by the AMS experiment team. Passive thermal design options are utilized as much as possible, but more complex thermal control hardware is required for some subdetector components to assure mission success. TCS specific hardware includes radiators, heaters, thermal blankets, heat pipes, loop heat pipes, optical coatings and a dedicated CO_2 pumped loop system for Tracker cooling. The heat pipes and two of the loop heat pipes use ammonia that has been sealed in the pipes by the manufacturer. The other eight loop heat pipes use propylene that has also been seal by the manufacturer.

4.15 MICRO-METEOROID AND ORBITAL DEBRIS (MMOD) SHIELDING

The MMOD shielding (Figure 4.14-1) is designed to protect the pressure systems on the AMS-02 experiment from the MMOD environments specified in SSP 30425, Paragraph 8.0. These systems include the Main Helium Tank (MHT), Warm Helium Supply, and the TRD Gas Supply. The MMOD shielding for TRD consists of two shields mounted to the upper USS-02. Each shield consists of 0.1” outer and inner aluminum sheets with a layer of 0.1” Kevlar/Nextel. Standoffs are used to separate the outer aluminum sheet from the inner aluminum sheet. The proposed shield design is shown in Figure 4.14-1. Both of these MMOD shields have the same general design. A third MMOD shield consisting of a lozenge shaped shield of 0.5” thick aluminum foam covers the inboard side of the TRD tanks to provide an additional layer of protection. The Warm Helium Tank is surrounded by a 0.5” thick box of metallic foam of a similar design to the inner TRD shield. These shields also serve a secondary purpose of protecting the Composite Overwrapped Pressure Vessels (COPV) from accidental contact damage. The VC itself provides sufficient protection for the MHT.

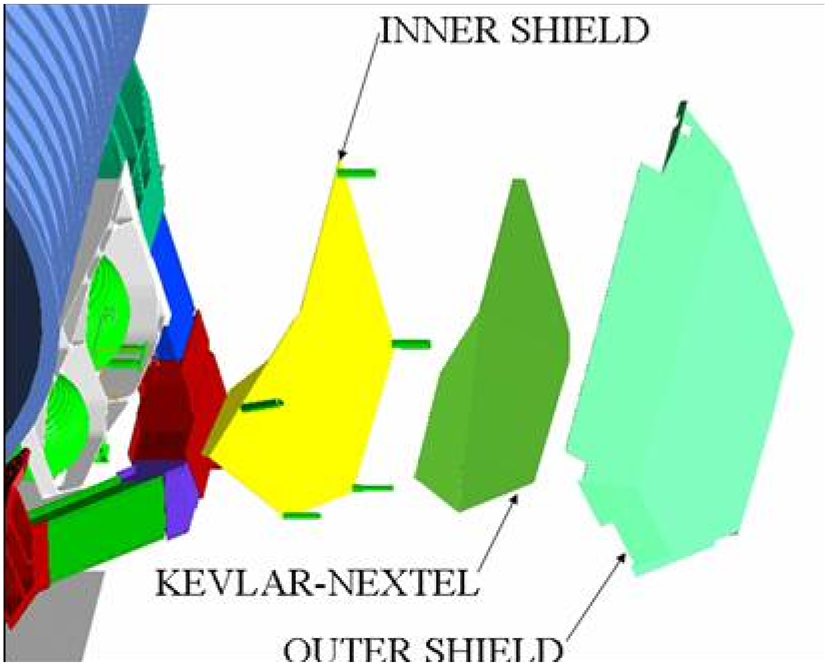


Figure 4.15-1: MMOD Shield Design

4.16 GLOBAL POSITIONING SYSTEM (GPS)

The AMS-02 utilizes an ALCATEL TOPSTAR 3000D which will be integrated into AMS by IN2P3-Montpellier. A single Sextant Avionique model 3407-79 will be mounted on the TRD M-Structure. A signal from the GPS unit is used for precision time correlation with other experiments in the investigation of astrophysical phenomena.

5 GROUND SUPPORT EQUIPMENT (GSE) SUBSYSTEMS

Section five will describe the ground support equipment for AMS-02.

5.1 CRYOGENIC GROUND SUPPORT EQUIPMENT (CGSE)

The CGSE is used to prepare AMS-02 for cryogenic operations (precooling), fill the Superfluid Helium Tank with liquid helium, cool the liquid helium to superfluid helium temperatures and then maintain the flight cryo system at that temperature during pre-launch operations. The integrated CGSE has a number of subsystems. Some of these systems will only be used for contingency operations because the AMS-02 will arrive cold and partially filled and should not need to be recooled from ambient temperature to its nominal operating temperature. The subsystems and elements of the CGSE include:

- Liquid Helium (LHe) Transfer Dewar
- LHe Master Dewar
- Gas Valve Box
- Large GSE (Leybold) Pumps

- Turbomolecular Vacuum Pumps
- Pilot Valve Vacuum Vessel (PVVV) Scroll Pump
- Heat Exchanger
- Flight Helium Tank Fill Bayonet and Lines
- CGSE Electrical System

The proposed layout of the CGSE in the Space Station Processing Facility (SSPF) and Launch Pad 1, as well as a schematic, are found in Figures 5.1-1 through 5.1-4.

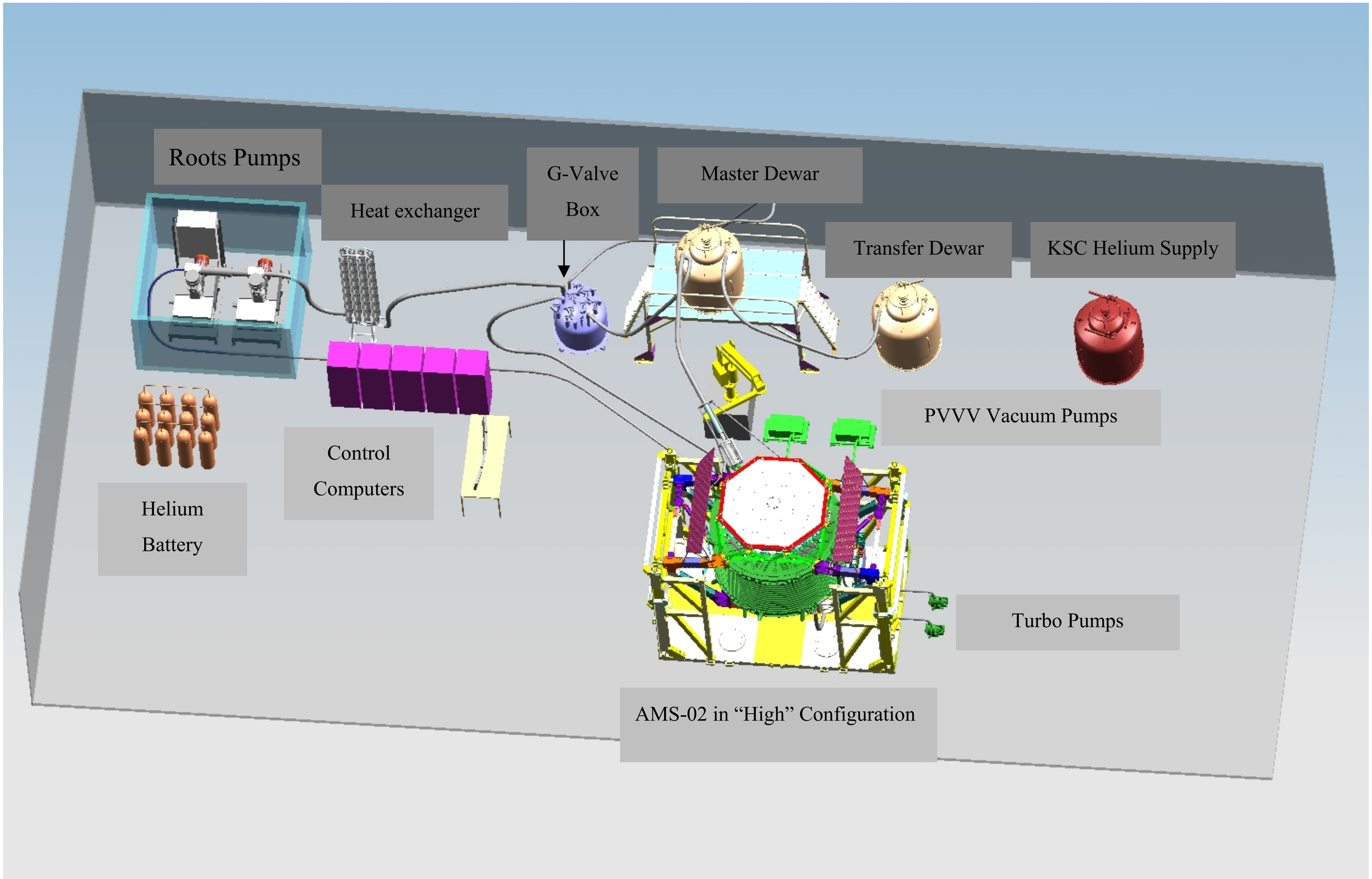


Figure 5.1-1: Proposed Layout of AMS-02 and CGSE Hardware in the SSPF

Figure 5.1-2: Proposed CGSE Layout at Launch Pad 1 (To be provided by KSC as soon as it becomes available)

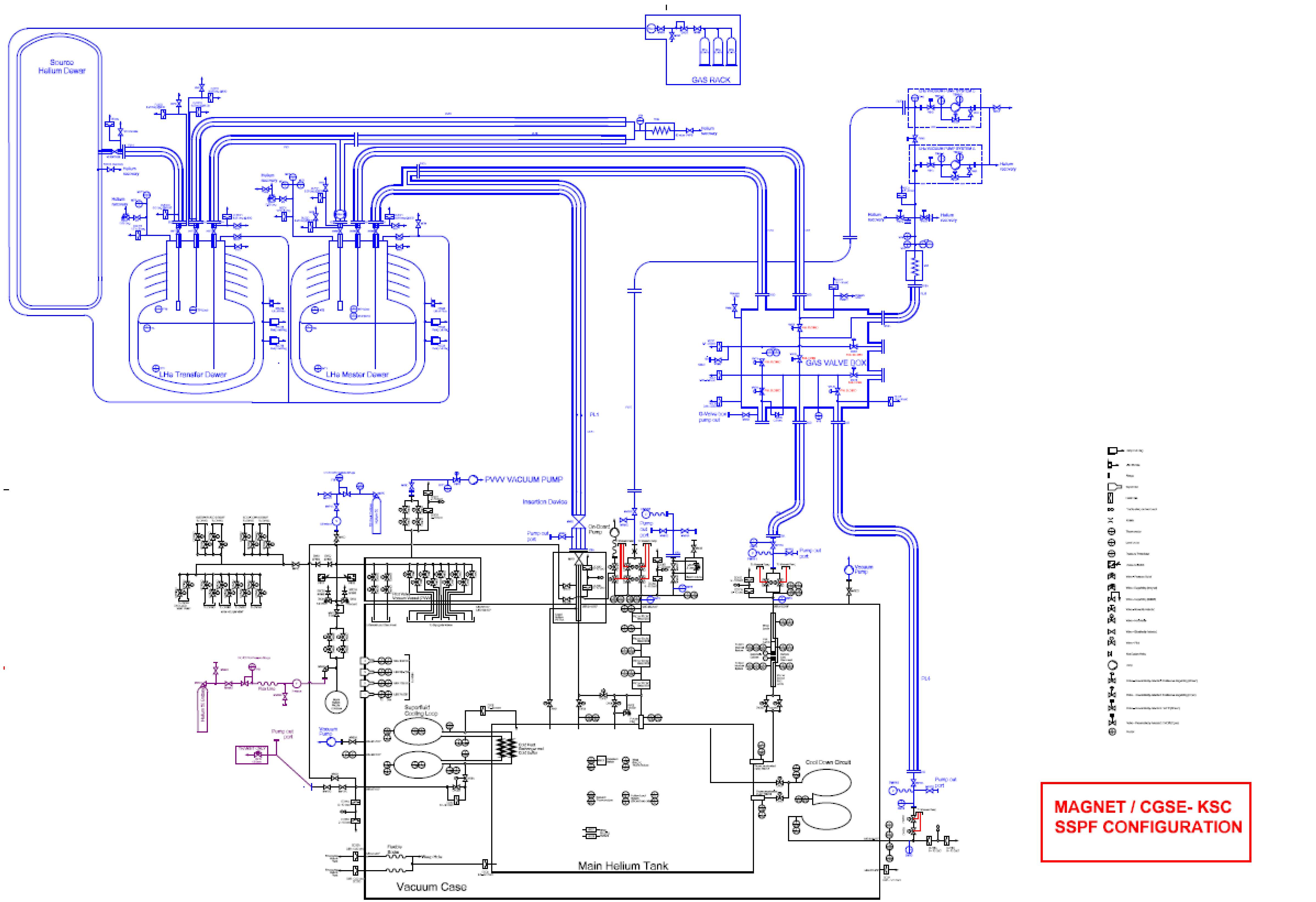


Figure 5.1-3: AMS-02 Cryogenic Ground Support Equipment (CGSE) Schematic with AMS-02 Cryogenic System (SSPF Layout)

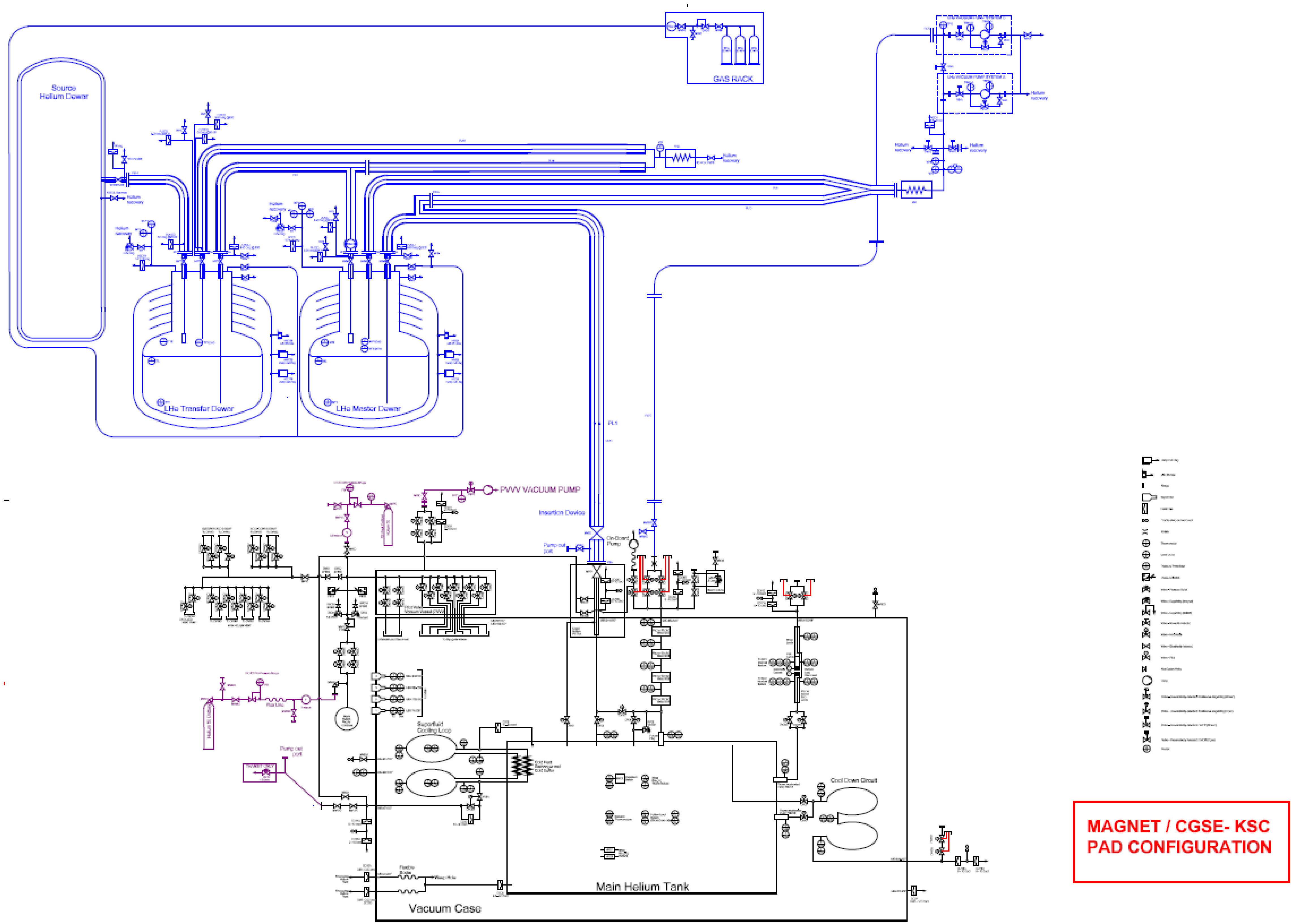


Figure 5.1-4: AMS-02 Cryogenic Ground Support Equipment (CGSE) Schematic with AMS-02 Cryogenic System (Launch Pad Layout)

5.1.1 Liquid Helium (LHe) Transfer Dewar/ Liquid Helium (LHe) Master Dewar

The Transfer and Master dewars are identical. Both are produced by Wessington Cryogenics in England. LHe dewars are high performance storage and transfer devices, capable of holding and delivering 1000 liters of liquid helium in either normal (4.2 K, 1 atmosphere) or near superfluid (2.3 K, 53 Millibar (mbar)) conditions. Each dewar weighs 850.5 kg when full (725.5 kg when empty) and is 1.5 m x 1.5 m x 2 m. They are on lockable casters, are movable by one person, and are capable of being hoisted with permanently welded lifting points. All required pressure gauges, pumping ports, and pressure relief devices are mounted on the dewars. A schematic of the dewar setup and a picture of one of the dewars are found in Figures 5.1.2-1 and 5.1.2-2, respectively.

The LHe dewars are designed to guarantee leak tightness and eliminate any possibility of air leakage into the system. BDs are used instead of relief valves since the latter cannot guarantee tightness when the internal pressure is sub-atmospheric. Pressure relief consists of a 1 bar (14.5 psig) BD and 0.6 bar (10 psig) relief valve on the vent line. The line with the 0.6 bar (10 psig) relief valve can be closed off during pumping of the LHe Dewar to avoid risk of air leakage inside the system. During operations with slightly pressurized helium (fill and storage operations with normal liquid helium) the line is open to allow the tank pressure to rise to 0.6 bar (10 psig). The outer shell has a relief pump-out port set to less than 0.34 bar (5 psig). The MDP of the inner tank is 4.14 bar (60 psig). It is designed to handle a maximum of 16.5 bar (240 psig) and the outer shell a maximum of 2.1 bar (30 psig). The inner tank has been tested to 6.72 bar (97.5 psig).

Both dewars will be used in the SSPF and the Payload Changeout Room (PCR). Both require pressurized helium for flow. The helium is supplied by KSC. The line and regulator are supplied by the project. KSC will also provide LHe grade M-P-27407A purity or better to fill the LHe dewars while at KSC.

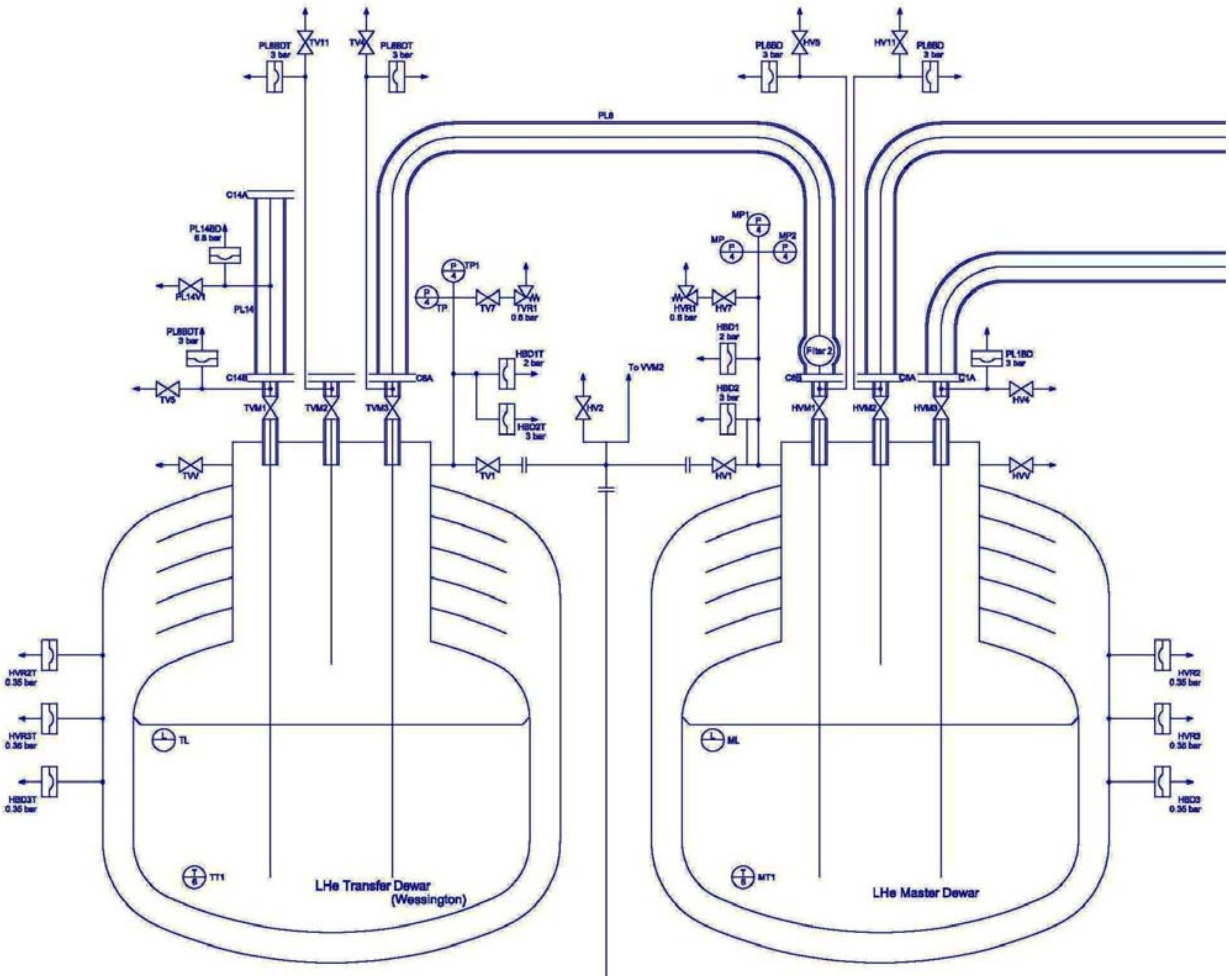


Figure 5.1.1-1: Master and Transfer Dewar Flow Diagram

Figure 5.1.1-2: CGSE Dewar (From Wessington, England)

5.1.2 Gas Valve Boxes

The Gas Valve Box is used for providing vacuum insulation for the CGSE cryogenic valves, filtering solid particles from the LHe, and operating the CGSE in all modes. A schematic can be found in Figure 5.1.2-1. A picture of the Gas Valve Box is found in figures 5.1.3-2. The box was manufactured by Lanzhou Vacuum Company.

The Gas Valve Box is used to collect all gaseous helium flowing from AMS and to provide a flow of gaseous helium that cools the 300-80 K system. It is comprised of valves VVP1, VVP2, VVP3, VVP6, VVP7, CGA1, CVC1, CVP5, and VVM8; relief valve VVR3; valve cold bayonets C3B, C4B, C5B, C6B, C7B, C9B, C10B, and C13B; temperature sensor VT5; pressure sensor VP2; and BDs VBD1, VBD3, VBD6, and VBD7.

The Gas Valve Box is on lockable casters, is movable by one person, and is capable of being hoisted with permanently attached lifting points. Overall dimensions of the Gas Valve Box are 1.50 m x 1.265 mm including castors and weighs 360 kg. It is manufactured by Lanzhou Vacuum Company. It is used in both the SSPF and the PCR.

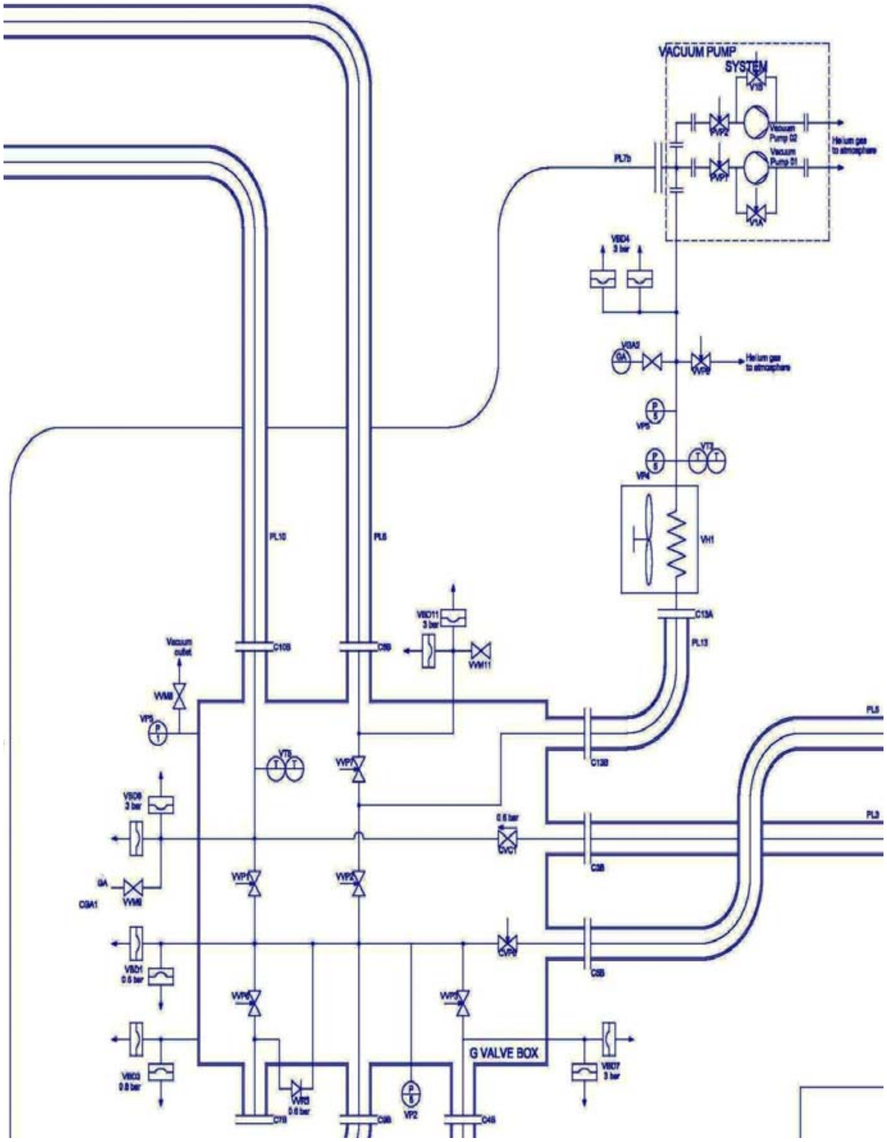


Figure 5.1.2-1: Gas Box Flow Diagram

Figure 5.1.2-2: Gas Valve Box

5.1.3 Vacuum Pump System

The GSE Vacuum Pumps are used to maintain the vapor pressure of liquid helium in both the CGSE dewars and main helium tank to the levels required for ground operations. The two Leybold RUTA WS2001FU/SV630F/A vacuum pumps are connected in parallel for redundancy while AMS is at the SSPF. Both pumps will be used at the Launch Pad as well. The system regulates the throughput of each pump from 0 to 2000 m^3/h. The power requirements for this system are 400V, 50 Hz /460V, 60 Hz. The dimensions of each of the two pumps are 1 m x 2 m x 2 m. Lift points for each of the pumps are located on their frames. Lifting shackles will be provided by KSC. Each pump weighs 1645 kg (+300 kg with the control box). A picture can be found in Figure 5.1.3-1.

Figure 5.1.3-1: Leybold Vacuum Pumps

5.1.3.1 On-Board Pump

A smaller vacuum pump is located on the payload itself, and will be used for prelaunch activities to vent the Helium tank vapor pressure after the payload bay doors are closed and prior to liftoff. The pump is discussed in this document—even though considered flight hardware—because of its implications in ground use and necessary GSE. A remotely controlled and monitored GSE 110 Volts Alternating Current (VAC) power supply will power this pump during payload canister transportation. While in the payload bay, power will be provided through the T-0 connections and the Remotely Operated Electrical Umbilical (ROEU).

5.1.3.2 Turbomolecular Vacuum Pump

Two Turbomolecular Vacuum Pumps will be used to pump down CGSE vacuum spaces. They will be used at the SSPF during payload testing and at the PCR during filling operations. The lines and regulators are provided by the project. It has a 230 V, 50/60 Hz power requirement. The pumps are manufactured by Varian.

5.1.4 Pilot Valve Vacuum Vessel (PVVV) Pump

The PVVV pump is used to create a vacuum in the PVVV, which is part of the AMS-02 flight hardware. It is an Edwards XDS5 Scroll vacuum pump with overall dimensions of .4 m x .25 m x .3 m and a weight of 30 kg. It has a power requirement of 220 V, 50 Hz.

5.1.5 VH1 Heat Exchanger

Heater-fan VH1 is used to warm up cold helium vapor back flow to room temperature before it enters the vacuum pump system or is released into the atmosphere. The input He temperature is anywhere from 1.8-80 K and the output temperature has a range of 278-300K. The nominal flow pressure is between .01 to 1.2 bar absolute. The exchanger's MDP is 16 bar gauge. Its overall dimensions are 2 m x 1 m x 1.8 m and weighs 300 kg. The VH1 has wheels so that it can be rolled along the floor. It also has lifting points permanently welded to the frame. A picture of the VH1 is found in figure 5.1.5-1.

Figure 5.1.5-1: CGSE Heat Exchanger

5.1.6 Flight Helium Tank Fill Bayonet and Lines

The LHe fill lines PL1 connects the LHe Master Dewar the fill port on the AMS-02 VC. Lines PL14 and PL8 are used to fill the CGSE dewars. PL14 and PL8 have fine filters for providing high grade LHe filtration. Line PL1 has an inner pipe for LHe filling and shrouds cooled by helium back flow to reduce heat leakage into the LHe. BDs are installed at the ports to which these lines are connected to relieve pressure in case helium is trapped between valves. The Maximum Dynamic Pressure (MDP) of the lines is 4.5 bar (65.3 psig). Maximum working pressure is 0.6 bar and is limited by the maximum pressure in the LHe dewar. The burst pressure is 18 bar (261.1 psig). The cryogenic lines were made by the Chengdu Holy Vacuum company. At the end of PL1 there is a LHe fill port insertion device, the tank fill bayonet, which is used to connect the line with the AMS LHe fill port.

Other cryogenic lines are used to provide gas helium circulation between CGSE and AMS. Lines that will be used in the PCR include PL4, PL6, PL9, PL10, PL15 and PL16.

A schematic and picture of the bayonet are found in Figures 5.1.6-1 and 5.1.6-2, respectively.

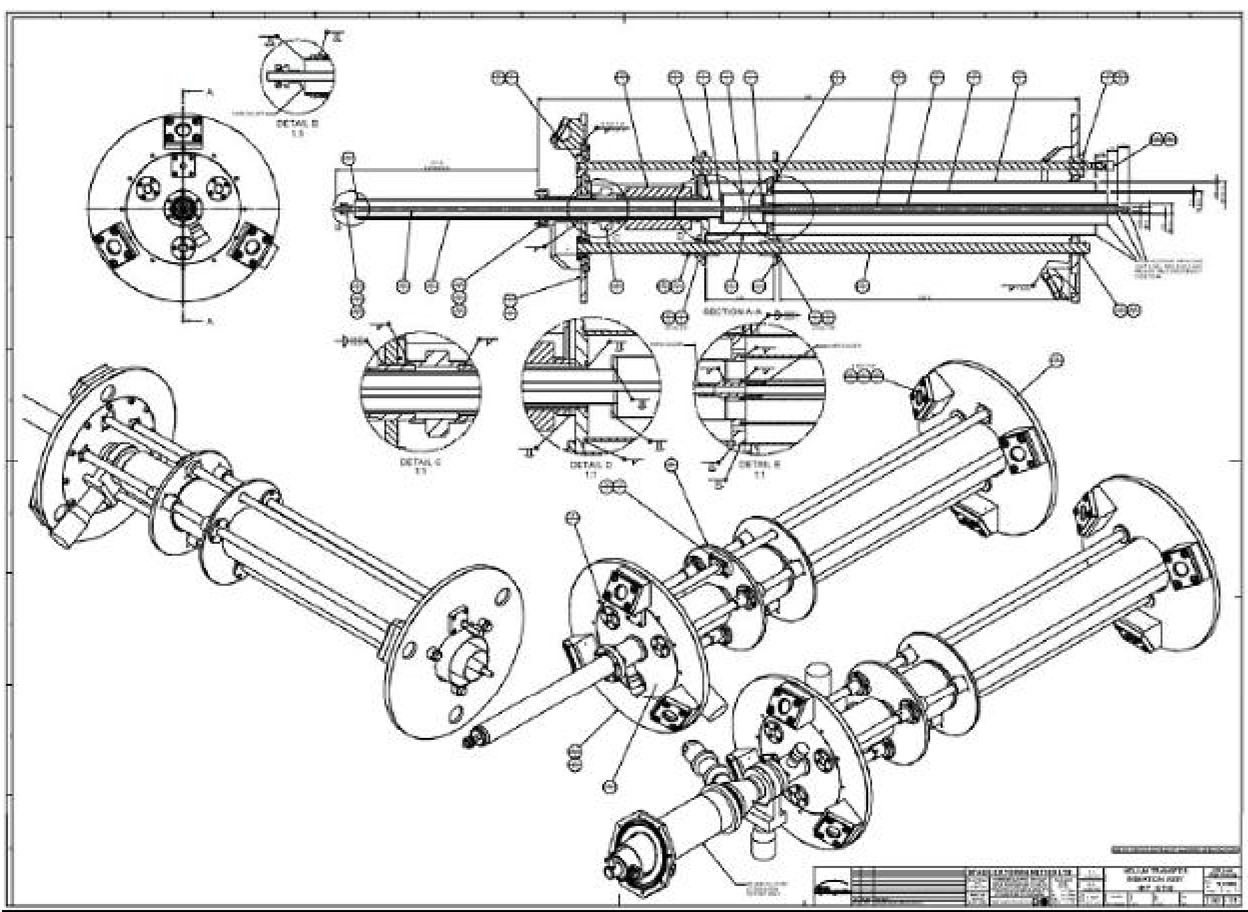


Figure 5.1.6-1: PL1 Insertion Device that Connects to AMS-02 Fill Port

Figure 5.1.6-2: Insertion Device Connected to AMS-02 Simulator

5.1.7 Pneumatic System

The pneumatic system is used to control the CGSE pneumatic valves. It consists of pneumatic pipes which distribute the pressurized air between the Weka pneumatic valves. The system can be connected to a central pneumatic air system if available. The system will use SSPF shop air.

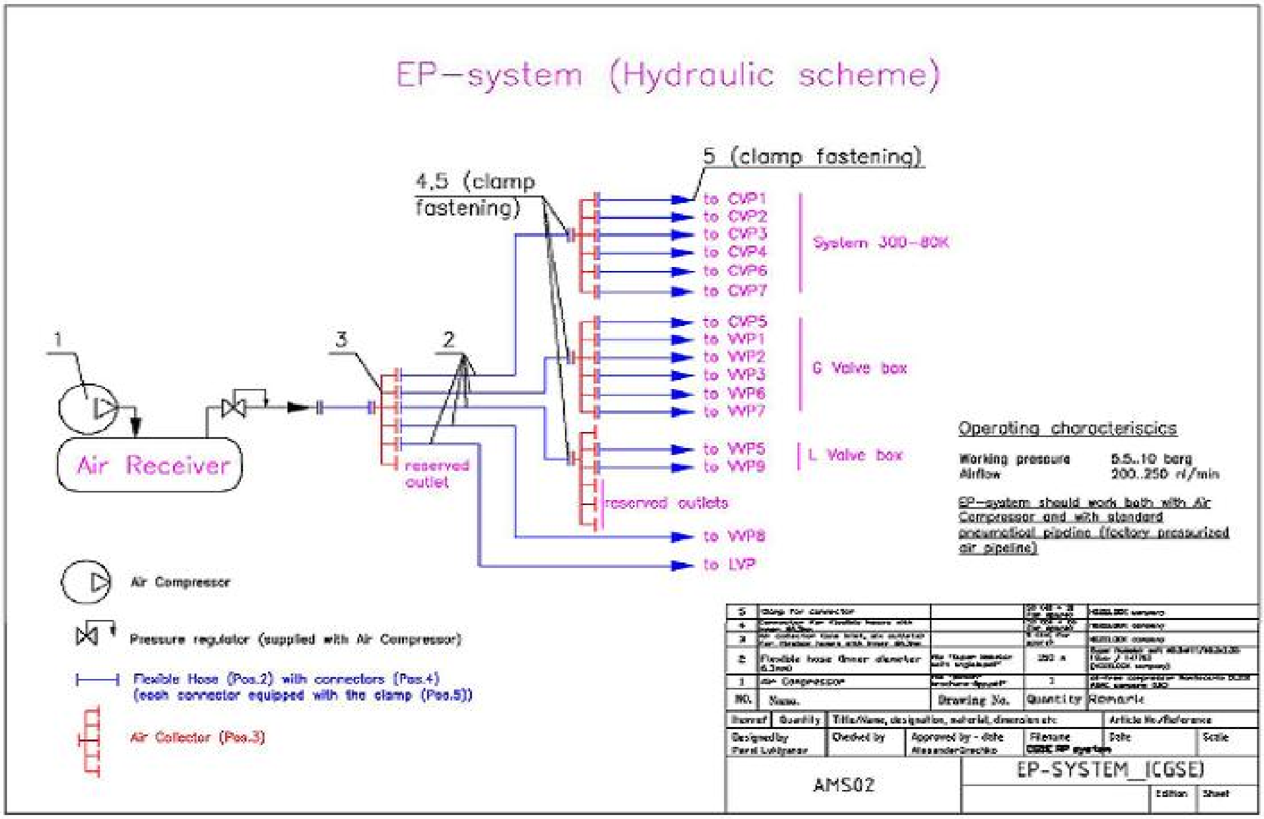


Figure 5.1.7-1: Pneumatic System Diagram

5.1.8 Support Stands for CGSE Cryogenic and Vent Lines

In order to prevent loading on AMS-02 flanges, support stands will be used to support the CGSE cryogenic and support lines. There are 35 stands that are adjustable between 1.6 and 2.5 m. Their maximum load capacity is 150 kg. The maximum load any of the stands will carry is 100kg. A schematic of a typical support stand is found in Figure 5.1.8-1.

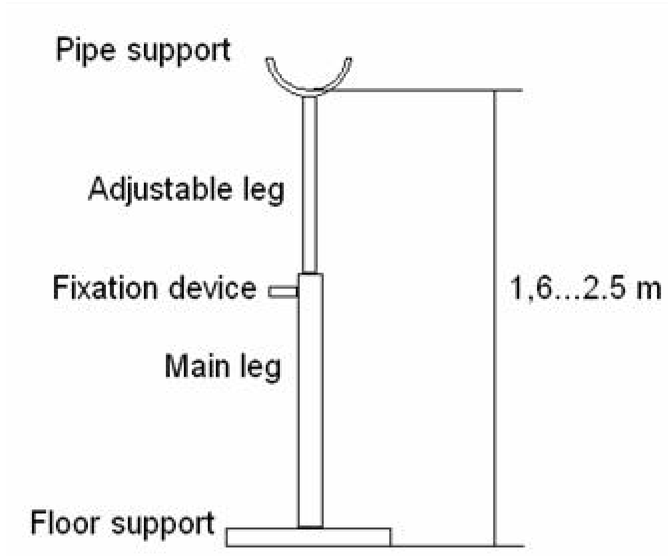


Figure 5.1.8-1: Cryogenic and Vent Line Support Stand

5.1.9 CGSE Electrical System

The CGSE Electrical System (CGSE-ES, Figure 5.1.9-1—5.1.9-2) consists of a Siemens Programmable Logic Controller (PLC) and six computers (two of which are redundant). Computers 1A and 1B provide redundant measuring and control of the CGSE Mechanical System (CGSE-MS). Computers 3 (Controller Area Network (CAN) Slave) and 4 (CAN Master) are connected to the AMS CAN Bus and provide data exchange between AMS and the CGSE control systems during tests (not in the PCR). PC Computer 8 and 10 will connect to the Ethernet and provide data exchange between AMS and CGSE control systems at the launch pad.

The CGSE-MS is interfaced to the CGSE-ES by a direct connection to the PLC. The operator interface is provided by the redundant computers 1A and 1B. The operator interface is also a graphical user interface (GUI) which displays monitoring data and formats control commands to the CGSE-MS. Computers 1A and 1B are also used as a web server which allow any networked computers connected to CGSE-Ethernet (Computers 8 and 11), both locally and remotely, to access the CGSE operator interface in computers 1A and 1B. When the CGSE is operating during tests of AMS-02, computers 3 and 4 are used as a communication interface. They are connected to the AMS CAN bus using the EPP-CAN box. Computer 3 is used as a CAN-bus slave and connects to computers 1A and B, which allows any CAN-bus master (computers 6 and 7), both locally and remotely, to access the CGSE operator interface in 1 (1A and 1B). Computer 4 is used as a CAN-bus master, which allows CGSE-ES access to the CAB, if necessary. Any networked computers connected to Ethernet (9 and 11), both locally and remotely, can access the CGSE Operator Interface in 1 (1A and 1B). When the CGSE is on the launch pad, computer 1 (1A and 1B) is connected to the JMDC via KSC-Ethernet.

The CGSE-ES will be installed in five electronics racks with overall dimensions .6 m x 1.6 m x .6 m. The weight of the electronics racks is less than 200 kg. They have lockable wheels and they will be forklifted while at KSC. At the launch pad, they will be placed on a KSC-supplied platform which will be lifted by crane. The power supply is less than 2 kW, 220 V, 50 Hz. The CGSE-ES will be used in the SSPF and on the launch pad.

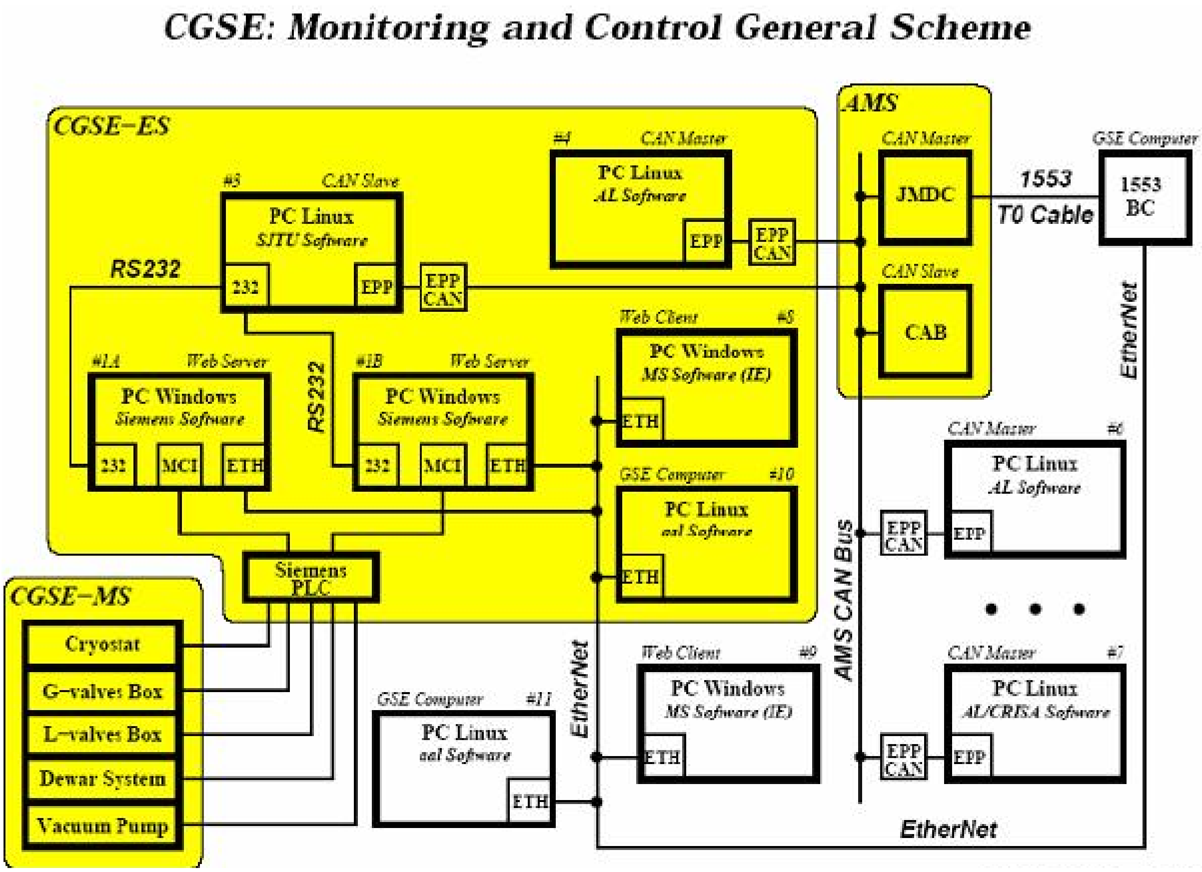


Figure 5.1.9-1: CGSE Monitoring and Control General Scheme

Figure 5.1.9-2: CGSE Control System

5.2 TRD GSE

The TRD GSE includes two separate systems. The first is a passive TRD pressure stabilization system and the second is the xenon and carbon dioxide supply filling system.

5.2.1 Passive TRD Pressure Stabilization System

The passive TRD pressure stabilization system (Figure 5.2.1-1) consists of:

- A small (10 l) commercial bottle rated at 200 bar with a proof pressure of 300 bar manufactured by Luxfer. It is filled with Xe/CO_2 at a pressure of 70 bar, sufficient for resupplying gas losses through one ruptured straw for 20 weeks.
- A pressure reducer with an output range of 0 to 2 bar overpressure (reducer may be reduced to 0-1 bar overpressure).
- A GMH 3150 battery operated pressure sensor display and logging device (for data keeping purposes only).

The system is used to keep the straws inside the TRD from collapsing by keeping them 100 mbar above the atmospheric pressure. It will be connected to the TRD system before arriving at KSC and remain connected during ground processing. Pressure from the CO_2 tank is regulated by the pressure reducer, which is set to 1140 mbar abs. When TRD internal pressure falls below the pressure reducer setting, CO_2 from the supply bottle will increase the pressure so that it maintains the 100 mbar overpressure requirement. This system will be removed before AMS leaves the SSPF when it will allow sufficient time to check the integrity of the cap that seals the TRD GSE connector. In case of a launch abort, the system would have to be reinstalled to stabilize TRD pressure if AMS were to remain without power and access for a significant amount of time (e.g. in case of hurricane).

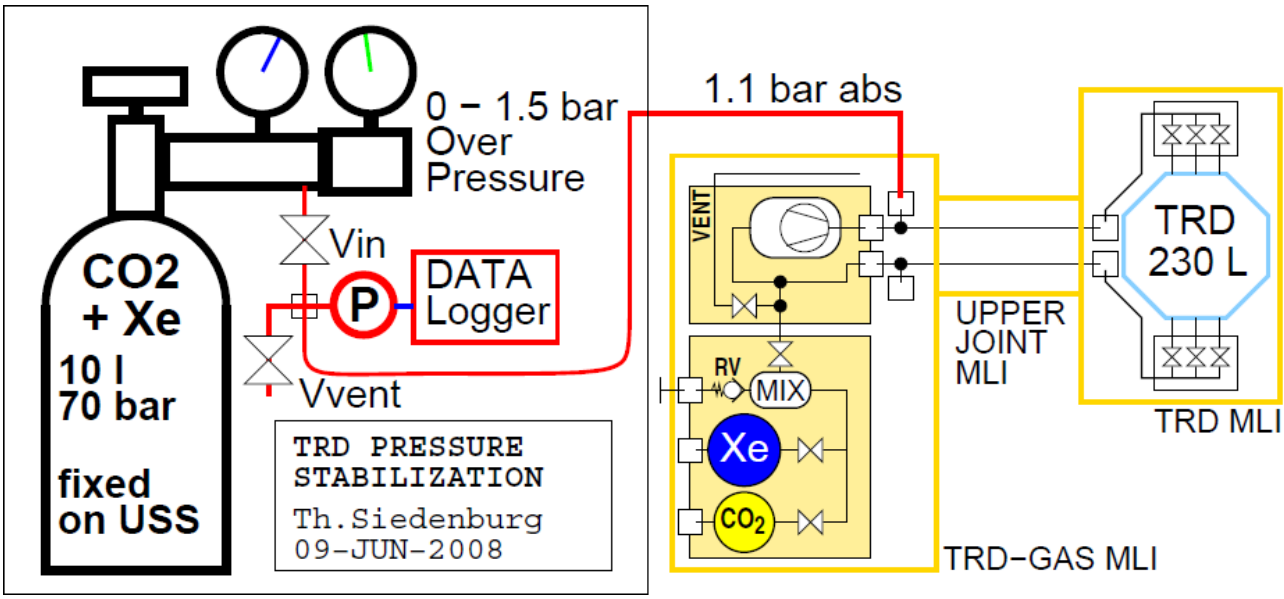


Figure 5.2.1-1: Schematic of TRD Pressure Stabilization System

5.2.2 Xenon and Carbon Dioxide Supply Filling System

The xenon and carbon dioxide supply filling system (Figure 5.2.2-1) consist of the following components:

- One 50 L CO_2 bottle (supplied by KSC)
- One 50 L Xe bottle (supplied by KSC)
- One temperature controller (Horst HT31 controller) with heating tape (Horst 020204, length-2m, 500W at 230V) and a temperature sensor
- A pressure reducer with an output range of 10-100 bar
- A scale for weighing the tanks

The system will be used at KSC only if contingency recovery is necessary. The method of transfer of Xe and CO_2 from the storage tanks to the Box-S supply vessel will be by boiling off some of the gas from the supply tank and letting it condense in the supply vessel. The power requirement for the system is approximately 500W at 220V for the heater tape (AMS will supply a 110V-220V converter).

Maximum fill of the flight tanks is controlled by the molar fill quantity of the source tanks and the need for thermal loading of the source tank to get the pressure curves necessary to affect transfer.

All valves are operated manually by a team of two operator's cross-checking each other. They are present the whole time the system is connected to the supply vessels or when the heaters are powered.

The source bottle temperature is measured three times: 1) by the heater control unit (with display) that is used to switch on power to the heater tape; 2) by a thermometer with display; and 3) by a thermo-sensor read by the PC monitor. The line pressure is measured six times: 1) with manual gauges at the pressure reducer; 2) with P_{man}, P_i; and P_o which are read by the monitor and 3) the two supply vessel pressure sensors from the TRD gas system.

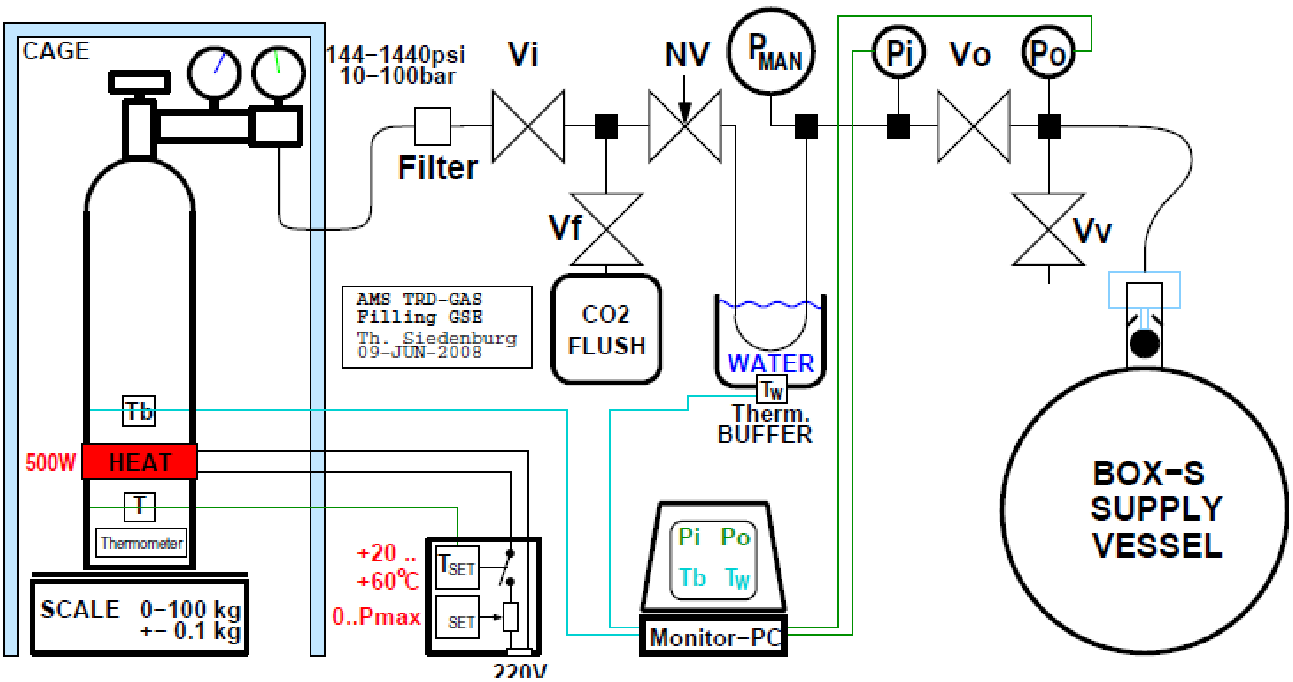


Figure 5.2.2-1: Xenon C02 Supply Filling System (CO2 and Xenon System the Same)

5.3 RICH GSE

The purpose of the RICH GSE (Figure 5.3-1) is to prevent moisture from contaminating the experiment's Aerogel®. The system will occasionally pressurize the RICH to just over one atmosphere with a slow, even supply of nitrogen. This will provide the RICH subsystem with a slight positive pressure to keep humid air out (The RICH is not a sealed container). The nitrogen will also provide a clean environment for the RICH during ground processing at the launch pad. The GSE will monitor the humidity of the air in the RICH and flow level of nitrogen as it leaves the experiment. The GSE consists of the following:

- K-Bottle (from KSC) filled with 99.9999% nitrogen;
- Bottle regulator;

- A CIEMAT monitoring and control box. This is used to adjust the flow of nitrogen to the RICH based on the exiting flow rate;
- Teflon tubes with stainless steel Swagelok fittings on the AMS-02 that runs along the Lower Time of Flight (LTOF), Lower Unique Support Structure (LUSS), and the Upper USS;
- Teflon piping that connects to the monitoring box and K-bottle;
- Swagelok quick disconnects that allow personnel to connect the GSE to the tubing routed along the AMS-02.
- Two bellows that allow for the expansion of nitrogen. One is located on the inlet side and the other on the outlet side of the payload.

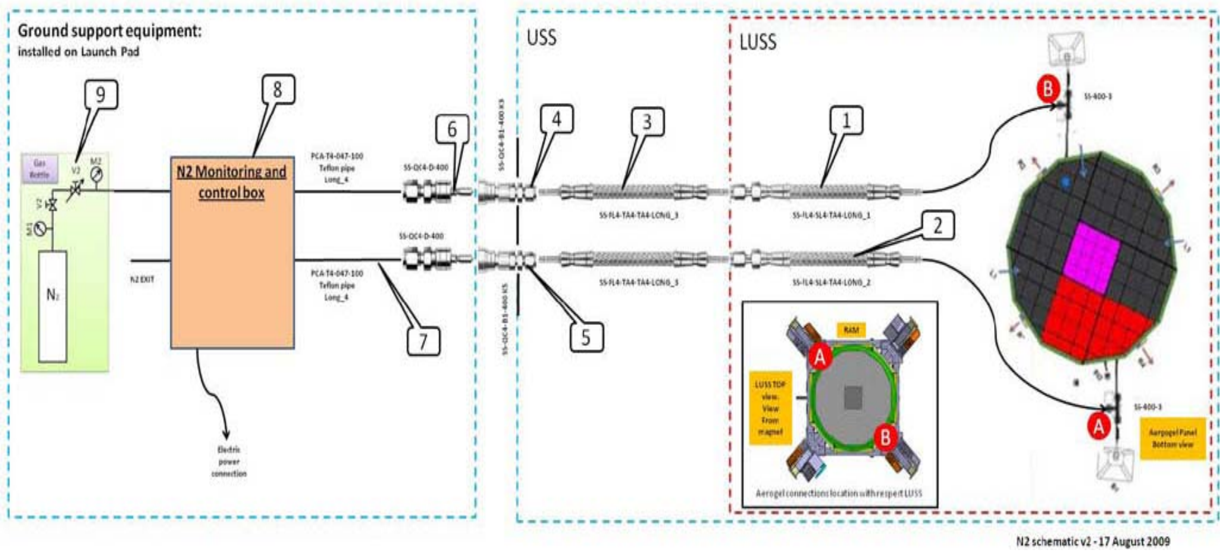


Figure 5.3-1: Layout of RICH GSE

5.4 WARM HELIUM GAS SYSTEM GSE

The warm He gas system GSE consists of a regulator valve, a 300 bar pressure relief valve, a 2 μm filter, a pressure gage, and a vacuum pump. Figure 5.4-1 is a preliminary design. The system will hook up to a KSC supplied helium source (MIL-P-27407 grade) and transfer gaseous helium to the AMS-02 warm helium gas supply bottle. A final design, system specifications, and criteria for refilling are TBD.

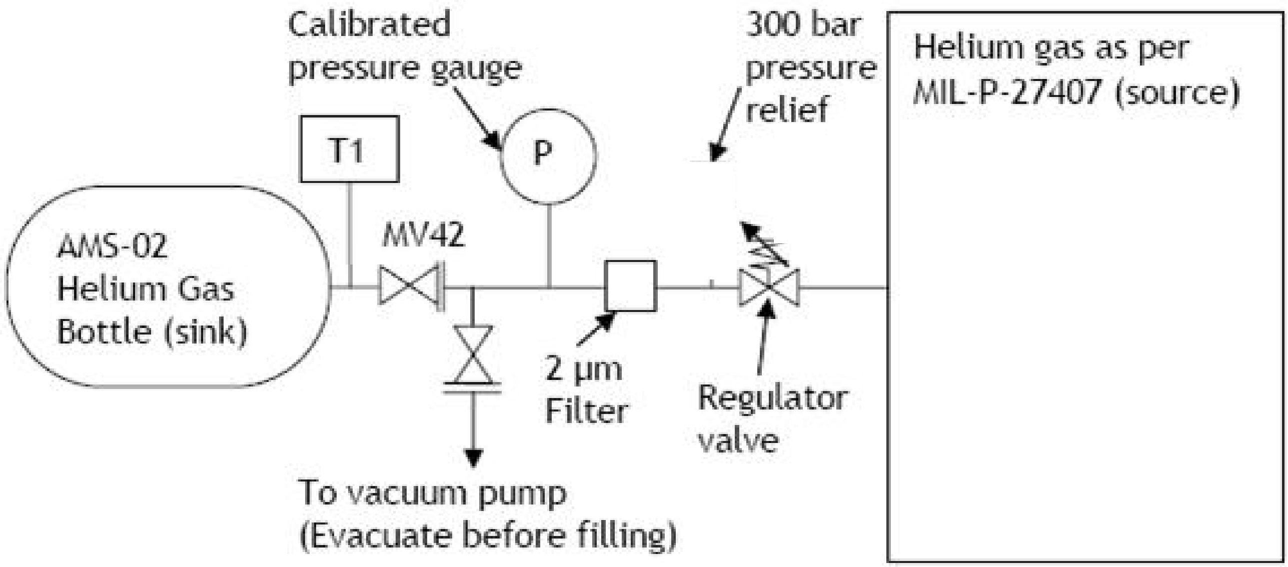


Figure 5.4-1: Warm He Gas System GSE Schematic

(KSC filling system will likely be similar)

5.5 TCS GSE

The TCS GSE consists of 12 type A fans and three type B fans. They are Commerical-Off-The-Shelf (COTS), made by Honeywell, and have the "CE" designation. The following are the specifications for each type of fan:

- Type A Fans
  - Diameter: >.45 m
  - Flow Rate: 5200 m3/hr
  - Power: 135 W
  - Voltage: 230 V
  - Frequency: 50 Hz
- Type B Fans
  - Diameter: >.18 m
  - Flow Rate: >740 m3/hr
  - Power: 50 W
  - Voltage: 230 V
  - Frequency: 50 Hz

The first set of four type A fans will provide ventilation to the electronic units mounted on the Ram radiator. The second set of type A fans will provide ventilation to the electronic units mounted on the Wake radiator. The third set of four fans will provide ventilation to the Zenith radiator.

One type B fan will be dedicated to the PDS. The other two type B fans will be used to provide ventilation to the CAB.

5.6 TRACKER THERMAL CONTROL SYSTEM (TTCS) GSE

The TTCS is a CO_2 loop that transfers heat from the magnet to a condenser where thermal energy is released. The GSE for this system consists of two A/C units with an approximate thermal transfer capability of 2200 W each. Ducting will be used to direct the cold air from them to the condenser.

The units will be supplied by KSC and are in the Payload Data Library (PDL) found in Appendix F.

5.7 CAB COOLING GSE

The CAB cooling GSE will consist of A/C unit with 2200 W capability. Ducting will be used to direct air onto the avionics box to keep it cool when it is operating.

As with the TTCS, the A/C unit will be KSC supplied and is in the PDL found in Appendix F.

5.8 AMS-02 GPS GROUND SYSTEM TEST EQUIPMENT

The GPS Ground System Test Equipment (Figures 5.8-1—5.8-3) is used to test the AMS-02 GPS. It consists of a Spirent STR4500 GPS signal simulator, a Dell D620 Notebook computer, a GPS passive antenna, an attenuator, a radio frequency (RF) coaxial cable and a universal serial bus (USB) cable.

The equipment will be used in two configurations. The first will be with the simulator hooked up directly to the AMS-GPS receiver via a coaxial cable with the Notebook connected to the simulator via a USB cable. The second configuration uses a GPS passive antenna hooked up to the simulator via an RF coaxial cable, with the simulator hooked up to the Notebook via a USB cable. A GPS signal is sent through the passive antenna to the AMS GPS antenna. The distance between the antennas is less than 1 m. Testing will only occur in the SSPF.

Figure 5.8-1: GPS Simulator and Dell Notebook Computer

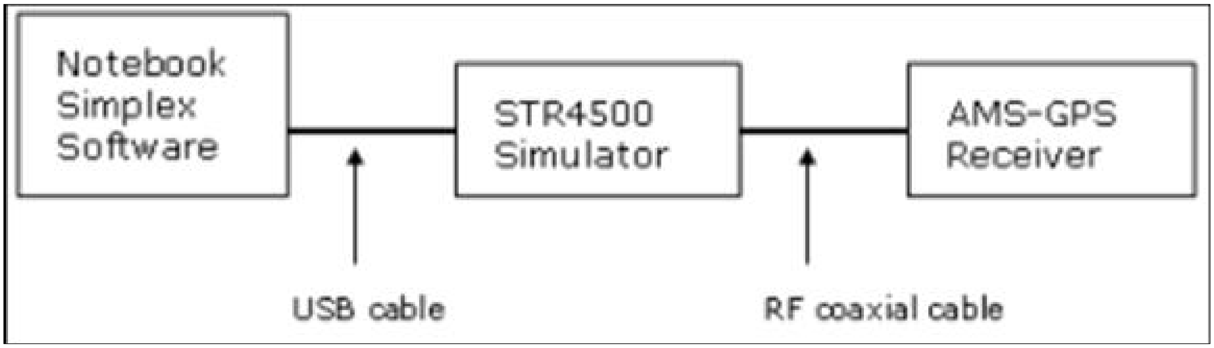


Figure 5.8-2: First Test Configuration

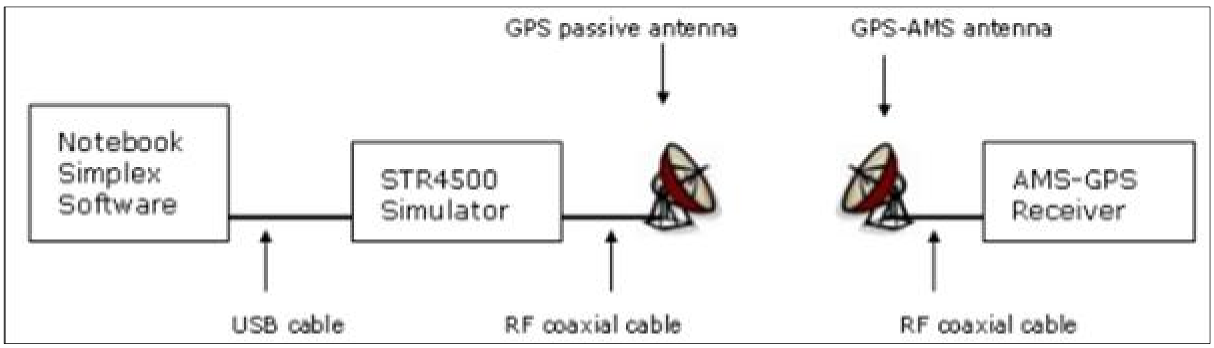


Figure 5.8-3: Second Test Configuration

The output frequency for the STR4500 simulator is 1575.42 MHz. The antenna has a frequency range of 157542 GHz + 1,023 MHz. Its amplification is 26 Db + 3Db. The attenuator has an attenuation of 0-60 Db with 10 Db step.

5.9 STAR TRACKER GSE

The Star Tracker GSE consists of two COTS PC computers (one with Windows 98 and the other with Linux), an emulator, and an illumination source to check the tracker cameras. The emulator will not be used during integration at KSC.

For ASTC reprogramming, the Linux PC is connected to the USCM. New firmware is then downloaded to the AST and a functional check is performed.

The functional check is accomplished by connecting the Linux PC to the USCM and checking the main components and functions of the AST. Checks include the following:

- ASTC Board-Serial communication, PM, DATA, and IMAGE memories, time counter, housekeeping acquisition and data, and powering of the camera.
- Cameras-Power, data acquisition and transfer, and temperatures.

Camera calibration is achieved by covering the star tracker baffles with a lid that contains an LED source. It is powered through a wall adapter (120, 220V to 12V, 0-20 mA). The light flux from the LED is then measured by the camera.

5.10 GROUND HANDLING EQUIPMENT (GHE)

The AMS-02 GHE that will be used at KSC consists of the Primary Support Stand (PSS), the Lower USS Shipping Assembly, the Primary Lifting Fixture (PLF), the Multi-Purpose Lifting Fixture (MPLF), and four Intermediate Support Fixtures (ISF's) (contingency use only).

5.10.1 Primary Support Stand (PSS)

The AMS-02 PSS has three functions. It will be used as a transportation fixture for the AMS-02 payload for airplane travel from Europe to KSC and travel/relocation at KSC. Second, it is a support stand for the AMS-02 payload during assembly, testing and integration. Third, it can support the AMS-02 payload during required lifting operations. The PSS is made of 6061 aluminum and measures 195.0"x 135.7" x 125.0" in its "mid" and "high" configurations. The difference between the mid and high configurations is internal to the overall dimensions of the PSS. The PSS will be in two different configurations while at KSC. It will arrive supporting the AMS-02 payload (both upper and lower sections already assembled), in the "mid" configuration. It will have a cover assembly and shipping panels attached to it that keeps AMS-02 safe from the elements. The cover assembly and 23 panels are of various sizes and are made of Alumalite—an aluminum composite panel with a high density, Corrugated Polyallomer (CPA) core.

Sometime after arrival, the PSS will be converted from its "mid" configuration to its "high" configuration. The upper cover and all of the panels will be removed and then the PLF is used to raise the sliding frames, along with the AMS-02 to the "high" configuration. Ground personnel will then be able to integrate the keel and the Payload Attach System (PAS). Any further transport of the PSS while at KSC will be done in the "high" configuration. Figures 5.10.1-1 through 5.10.1-8 illustrates the PSS conversion process.

There are no plans to lift the PSS with the fully assembled AMS-02 payload. However, it is capable of being lifted in this configuration with the PLF. The PSS and fully assembled AMS-02 will not be lifted by any other means while at KSC.

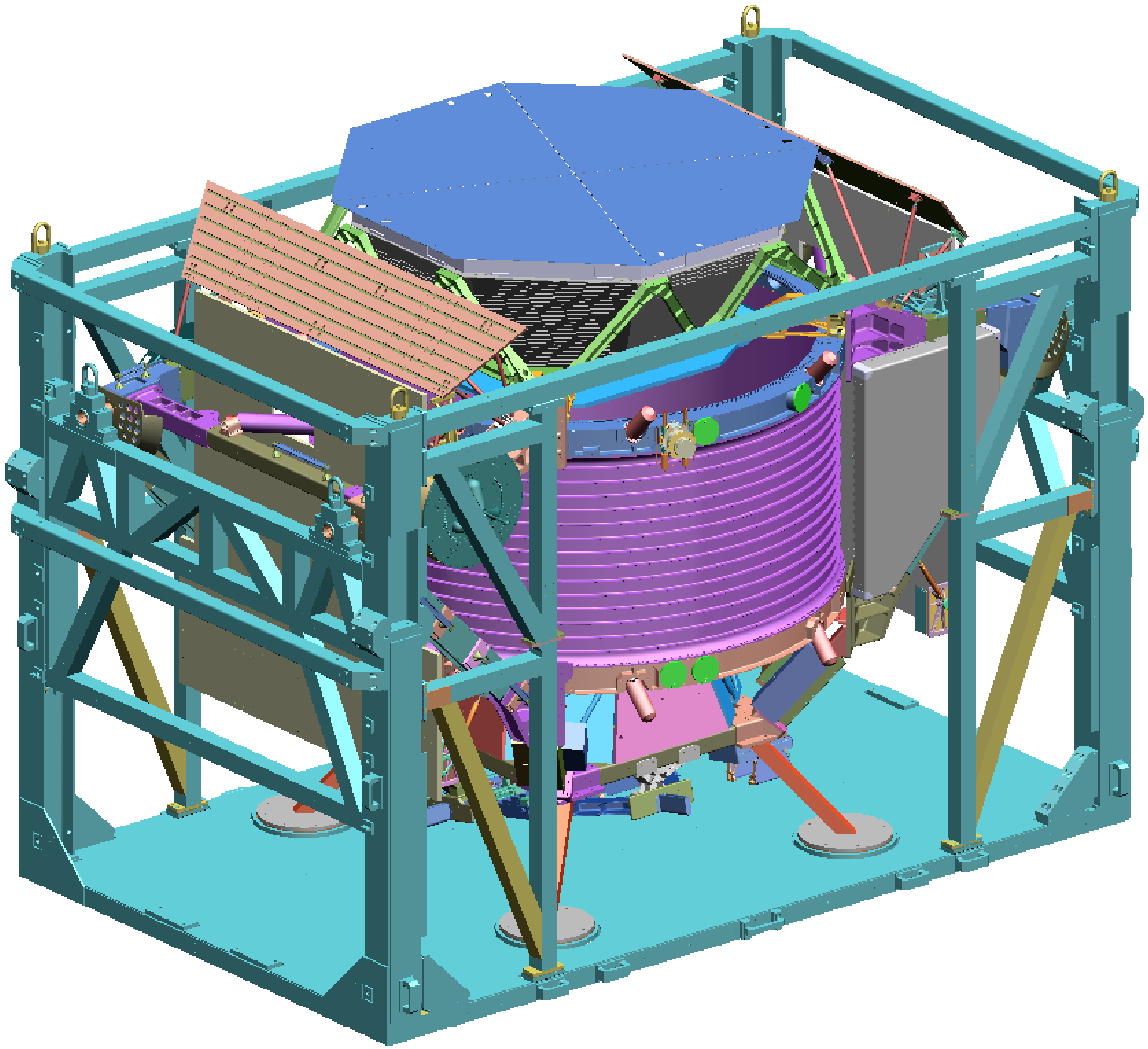


Figure 5.10.1-1: PSS in "Mid" Configuration with AMS-02

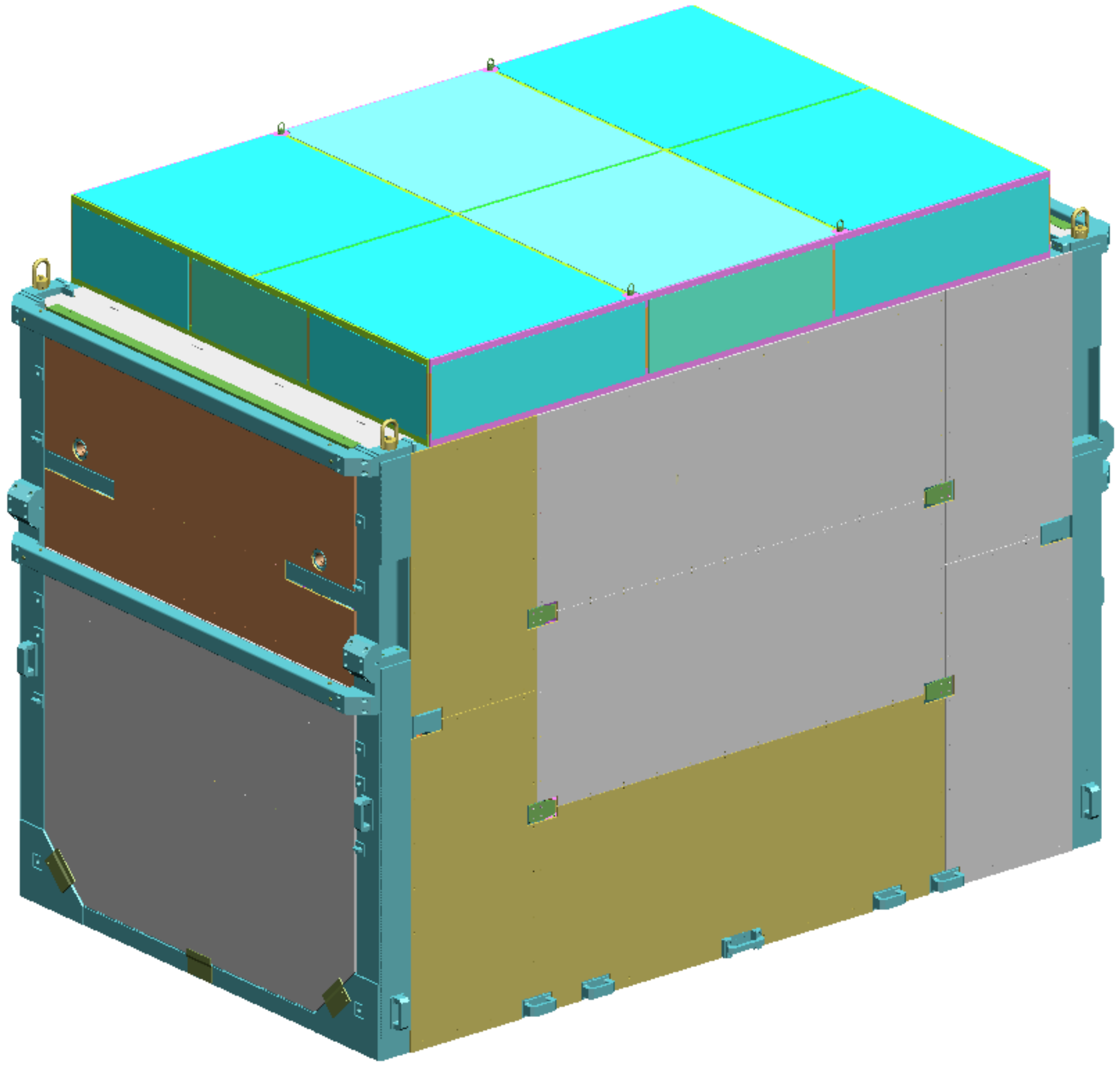


Figure 5.10.1-2: PSS in Mid Configuration with Panel and Top Cover

Figure 5.10.1-3: The PSS in “Mid” Configuration

Figure 5.10.1-4: PSS in the Mid Configuration (Rail Assemblies Being Installed)

Figure 5.10.1-5: Raising the Sliding Frames and the USS-02 (with AMS-02 attached) to the "High" Configuration

(Note: Although the Lower USS is attached for this operation at KSC, it is not shown in this figure.)

Figure 5.10.1-6: Installing 1 of 4 Internal Diagonal Assemblies

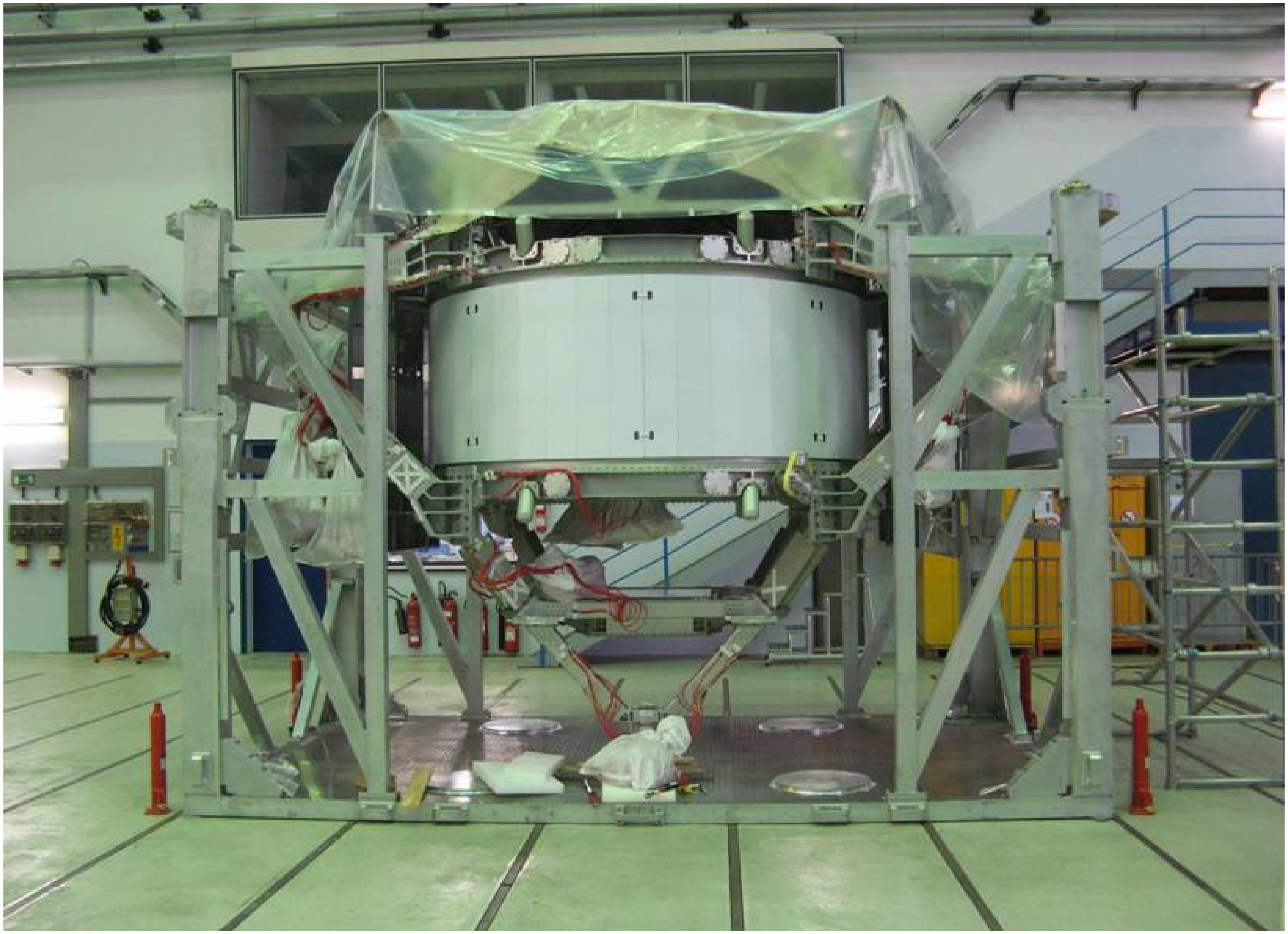


Figure 5.10.1-7: Lower USS and Keel Attached to Upper USS-02

(PAS not shown)

5.10.2 PSS Top Cover

The PSS has a top cover that shelters AMS-02 while it is being transported. It is 166.75” x 118” x 31.32” and is made of 6061 aluminum. The panels of the top cover are made from Alumalite. The top cover will be taken off the PSS shortly after its arrival at KSC. It has four detachable lifting points by which it is lifted from the PSS using the MPLF. Ground personnel confirm proper engagement of the lifting points by torquing them to specified measurements.

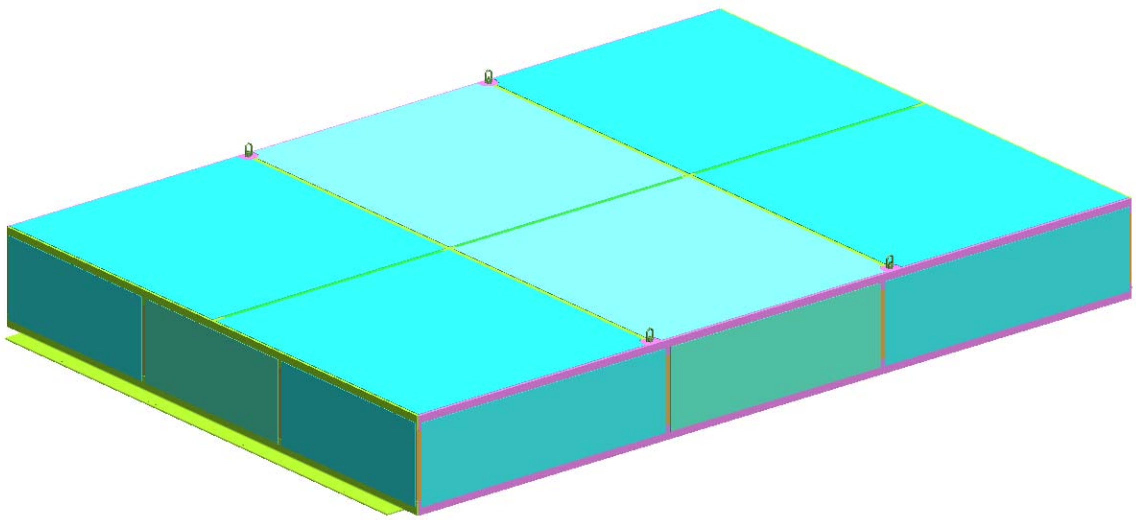


Figure 5.10.2-1: PSS Top Cover

5.10.3 Lower USS (LUSS) Shipping Assembly

The LUSS (Figure 5.10.3-1) will arrive at KSC already attached to the Upper USS-02 but its shipping fixture will arrive empty. The main structure of the LUSS shipping fixture will be to install the PAS on the payload.

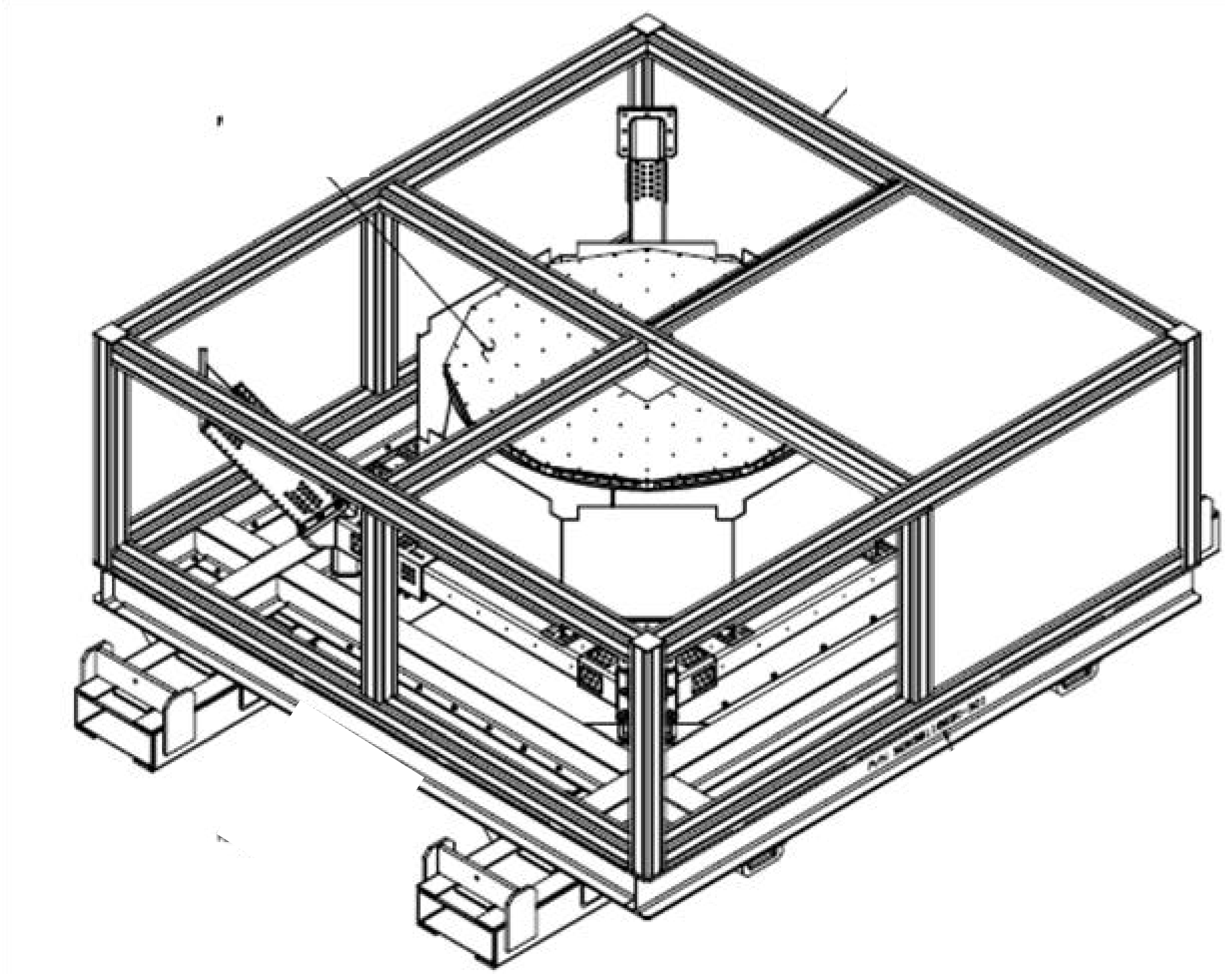


Figure 5.10.3-1: LUSS Shipping Assembly with LUSS and Shipping Panels

5.10.4 Primary Lifting Fixture (PLF)

The PLF (Figure 5.10.4-1) is a hoisting assembly made of A-36 steel/carbon steel with maximum dimensions of 190.8” x 123.8” x 187.4”. It will be used in three ways: 1) it will lift the PSS after its arrival at KSC; 2) it will lift the PSS into the two different heights needed for the assembly of the AMS-02 payload at KSC and; 3) it will lift the entire payload out of the PSS and into the KSC stands.

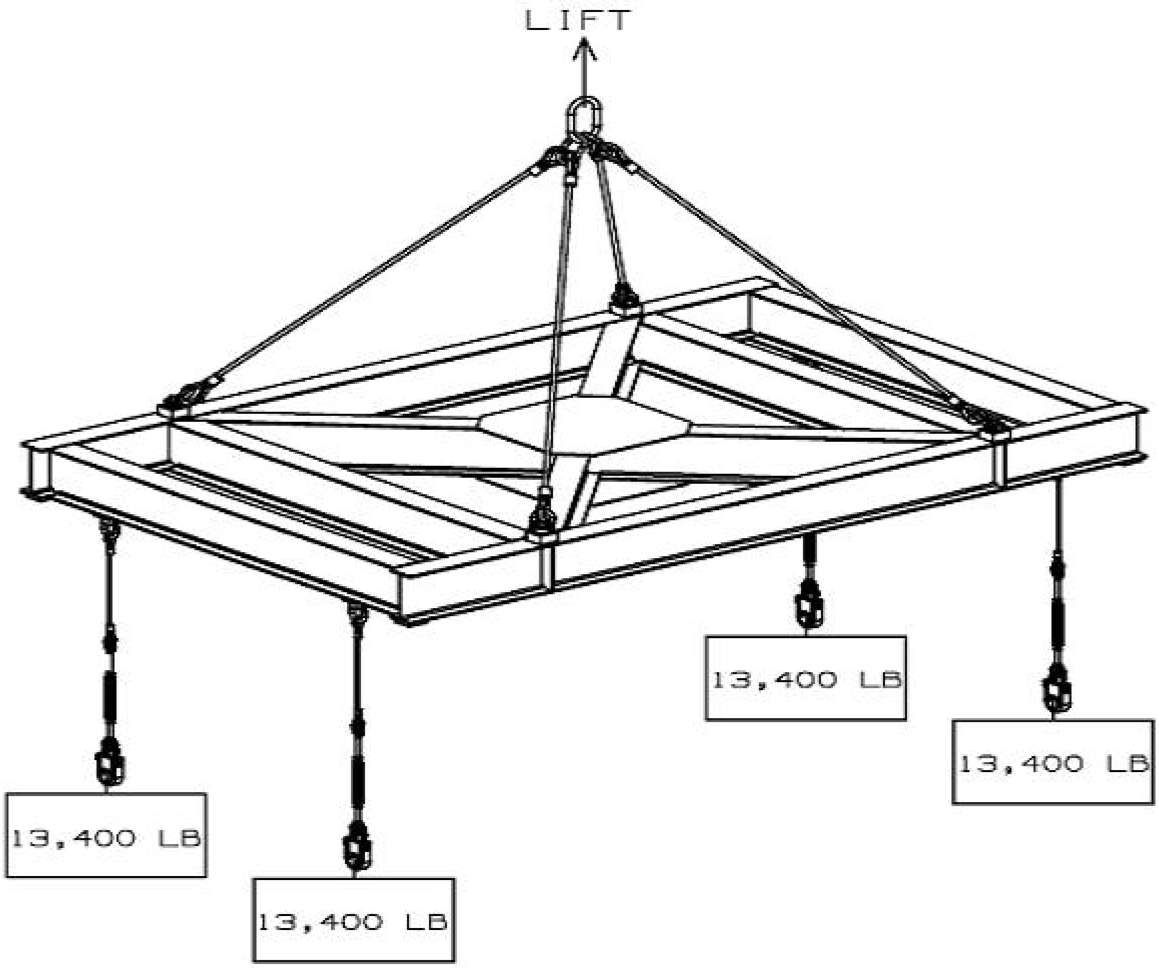


Figure 5.10.4-1: Primary Lifting Fixture (PLF)

5.10.5 Multi-Purpose Lifting Fixture (MPLF)

The MPLF (Figure 5.10.5-1) is a hoist assembly made of A-36 and carbon steel and measures 125.3" x 109.0" x 242.3". It has four functions: 1) it lifts the lower USS shipping assembly during the removal and integration of the lower USS to the upper USS; 2) it lifts the PSS top frame before and after it is transported; 3) it lifts the VC for removal and integration into the upper USS (this function is not anticipated to occur during KSC operations); and 4) it will be used to install the PAS onto the payload.

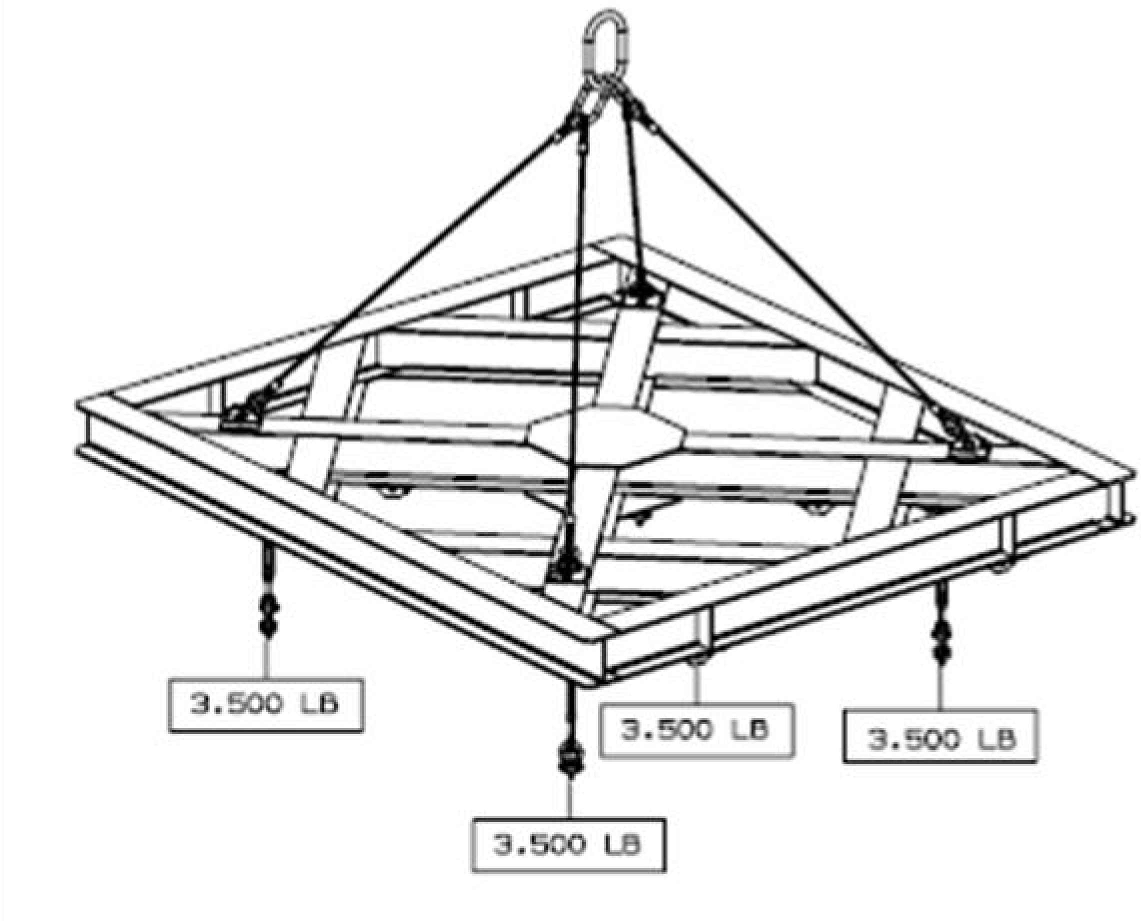


Figure 5.10.5-1: Multi-Purpose Lifting Fixture (MPLF)

5.11 ELECTRICAL GSE (EGSE)

The EGSE for AMS-02 is COTS. A detailed list of the AMS-provided EGSE is in Table 5.11-1.

Table 5.11-1: AMS-Provided Electrical Equipment

Location	Item	Manufacturer	Model Number	Commercial Yes/No	Electrical Code	3-Phase Yes/No	Batteries Yes/No Commercial/Custom	Functions	Quantity
Diagnostic (used wherever needed)									
	1	Tektronix	TDS 7054	Yes	UL	No	No	Oscilloscope	1
	2	Tektronix	TDS 11402	Yes	UL	No	No	Oscilloscope	1
	3	Fluke, etc,	Multimeters	Yes	N/A	N/A	Yes, Commercial	Multimeters	5
EGSE (mounted near or on payload during ground operatrions in SSPF, not used in PCR (TBC))									
TBC	4	Honeywell	HV180	Yes	UL	No	No	Fan for main radiator cooling	8
TBC	5	Honeywell	HV180	Yes	UL	No	No	Fan for Zenith radiator cooling	4
TBC	6	Honeywell	HT800-E	Yes	CE/GS	No	No	Fan for PDS and CAB cooling	3
	7	Texas Instruments	UNK	Yes	CE	No	No	AST LED	1
	8	Spirent	STR4500	Yes	CE	No	No	GPS simulator	1
	9	MIDWEST MICROWAVE	STA-1043-04-NNN-79	Yes	CE	No	No	GPS Attenuator	1
	10	planTec	UNK	Yes	CE	No	No	GPS simulator transmitter	1
GSC (located near payload during ground operations, e.g., on tables in SSPF High Bay or in MLP)									
	11	Hewlett-Packard	DC7700-CMT	Yes	UL	No	No	Personal computer (POC/GSC)	2
	12	Hewlett-Packard	DC7800-CMT	Yes	UL	No	No	Personal computer (POC)	2
	13	Hoojum Design	Cubit3	Yes	UL	No	No	Personal computer (GSC)	4
	14	Agilent Technologies	N5770A	Yes	UL	No	No	DC power supply (120V)	4
	15	D-Link	DGS-1016D	Yes	UL	No	No	Gigabit network switch	1
	16	3Com	4400 24PT	Yes	UL	No	No	10/1000 network switch	1
	17	NEC	Multisync LCD2170NX	Yes	UL	No	No	LCD Monitors	2
	18	Dataprobe	iBB-2N20	Yes	UL	No	No	Remote reboot power outlets	2
	19	AMS	EPPCAN	No		No	No	EEPCAN interface, 5V (Below 30V)	2
	20	AMS	USB422 (Flight Hardware)	No		No	No	RS422-USB interface (DDRS) (Flight Hardware)	2
POCC (located in "user area" for controlling the payload during ground operations)									
	21	Hewlett-Packard	DC7700-CMT	Yes	UL	No	No	Personal computer (POC/GSC)	4
	22	Hewlett-Packard	DC7800-CMT	Yes	UL	No	No	Personal computer (POC)	2
	23	D-Link	DGS-1016D	Yes	UL	No	No	Gigabit network switch	1
	24	3Com	4400 24PT	Yes	UL	No	No	10/1000 network switch	1
	25	NEC	Multisync LCD2170NX	Yes	UL	No	No	LCD Monitors	13
	26	Dell	PowerEdge 2900 III	Yes	UL	No	No	Personal computer (SOC)	2
	27	Dell	Dell Power Vault DP 600	Yes	UL	No	No	Disk server (POC)	1
	28		UPS	Yes	UL	No	Yes, Commercial	UPS for disk server	1
	29	Hewlett-Packard	Laserjet printer	Yes	UL	No	No	Network printer	1
CGSE (CGSE that uses electricity directly, all needed at SSPF and in PCR)									
	30	Leybold Vacuum	RUTA 2001	Yes	CE	YES	No	Main Vacuum Pump	2
	31	BOC Edwards	XDS5	Yes	CE	No	No	PVVV Vacuum Pump	1
	32	Infincon	UL 1000	Yes	CE	No	No	He leak detector	1
	33	DAIKIN EUROPE NV	EUWAB8KAZW1 - - G	Yes	CE	Yes	No	Chiller for PCR??	1
E-CGSE (electronics associated with CGSE, located nearby in 5 enclosed 19" racks, ~2ftx2ftx5ft, e.g. on floor of SSPF or in PCR)									
	34	APC	2200UX Smart UPS	Yes	UL	No	Yes, Commercial	UPS for CGSE	2
	35*	Le Guan	Lead-Acid Battery Pack	Yes	UNK	No	Yes, Commercial	UPS for CGSE	2
	36	ADVANTECH	610H	Yes	CE	No	Yes, Commercial	Industrial PC for CGSE	3
	37	ADVANTECH	AWS-8259TP-T	Yes	CE	No	Yes, Commercial	Industrial PC Display	3
	38	SIEMENS	PanelPC 557	Yes	CE	No	Yes, Commercial	Industrial PC for CGSE	1
	39	SIEMENS	FieldBus Modules	Yes	UL	No	No	PLC crates for CGSE	10
	40	Scientific Insturements	9350-1	Yes	UL	No	No	Temperature Indicator	1
	41	Yudain	UNK	Yes	CE	No	No	Alarm MUX?	1
	42	TPLink	UNK	Yes	CCC	No	No	Ethernet hub	1
	43	AMI	135-2K	Yes	CE	No	No	Liquid He level probe	1
	44	Shanghai YunJie Vacuum Equip	2DF-1B	Yes	UNK	No	No	"Complex Vacuum Meter"	1
	45	TBD	Transformer	Yes	UL	No	No	110-220V transformer	3
	46	AMS	EPPCAN	No		No	No	EEPCAN interface, 5V (Below 30V)	2
E-CGSE (electronics associated with CGSE, mounted onto the CGSE elements themselves)									
	47	SIEMENS	FieldBus IO Modules	Yes	UL	No	No	CGSE Monitoring & Control	~30
	48	TBD	FieldBus IO Modules	Yes	UL	No	No	CGSE Monitoring & Control	~20
Offices/POCC (wherever people can find to sit and work)									
	49	Various	Laptop computers	Yes	UL	No	Yes, Commercial	Laptop computer	40
	50	Hewlett-Packard	Laserjet printer	Yes	UL	No	No	Network printer	1

* Not used at KSC

5.12 KSC Supplied GSE

AMS-02 has requested a variety of KSC supplied GSE. A list can be found in Appendix F, "KSC Supplied GSE."

6 OPERATIONS SUMMARY

The following represents a summary of AMS-02 operations at KSC. It is a top level description describing the flow of operations from the time GSE and AMS-02 arrives at KSC through L-9 minutes. There are also sections covering launch scrubs and contingency landing operations.

6.1 Pre-Payload Arrivals

There will be two shipments prior to the arrival of AMS-02. One shipment will be a helium dewar for filling operations testing. The other will be various GSE from CERN. Payload Arrival

AMS-02 and its GSE will arrive at KSC in March 2010. It will be delivered at approximately L-4.5 months. The majority of AMS will likely arrive by airplane at the shuttle landing facility. Other components will arrive by truck. The payload will arrive loaded in the PSS which will be in the "mid" configuration.

6.1.1 Operational Description

The following is an operational description for the AMS-02 payload from the time it arrives at the SSPF through pad operations. Contingency operations at the pad and for abortive landings are also covered.

6.1.2 SSPF

Before arriving in the SSPF, AMS and its GSE will be unpacked in the SSPF airlock. AMS arrives in the PSS and will be transferred into the SSPF in this stand. The PSS will have its external protective covers removed in the airlock and the stand will be thoroughly cleaned. Two oxygen sensors will be set up around AMS in order to monitor the work area. A third sensor will serve as a backup, with mobile units on standby.

6.1.3 Work in PSS

Shortly after arriving in the SSPF, the PSS will be reconfigured to the "high" position in order to accommodate the integration of the LUSS, the PAS, and the keel. The EGSE will be connected to the payload. Various intra-payload electrical connections will be completed. The warm helium supply will be refilled. If necessary, the TRD gas supply will be refilled. Shuttle interfaces that will be installed include handrails, brackets, and the Worksite Interface Fixture (WIF). ISS interfaces to be installed include the EVA interface panel, the Universal Mating Assembly (UMA), and the External Berthing Camera System (EBCS). The CGSE will be attached to the payload and cooling of the Cryo magnet from 4.2K to 1.2K will commence. The non-flight UPSs will be replaced with ones for flight. There will be Payload Rack Checkout Unit (PRCU) testing through the Test Connector Panel (TCP), as well as with the Medusa Cable and the UMA. There will also be time set aside for KSC PRCU test support.

6.1.4 Work in Express Logistics Carrier (ELC) Stand

Once processing is complete in the PSS, AMS-02 will be lifted into the ELC Stand after the CGSE is disconnected. Once in the stand, the Power and Video Grapple Fixture (PVGF) will be installed and EBCS alignment will be performed. On-line processing includes Active Common Attach System (ACAS) testing and the UMA mechanical and electrical check. While the payload is in the ELC, personnel will take the PSS out of footprint 7 and replace it with the Cargo Element Workstand (CEWS).

6.1.5 Work in the Cargo Element Workstand (CEWS)

After the scheduled work in the ELC Stand, AMS-02 will be lifted into the CEWS. On line processing will include the PRCU test. Once this is completed, off-line processing will commence which will include installing the Flight Releasable Grapple Fixture (FRGF), ROEU arm, and ROEU Payload Disconnect Assembly (PDA). The payload organization will also perform several tests including power quality, UPS power isolation, and Orbiter Disconnect Assembly (ODA) simulation off-line testing. After final MLI installation, the CGSE will be disconnected from AMS and the payload on-board pump (OBP) will be powered down and energized in order to draw a vacuum on the payload. The payload will be unpowered after the OBP completes its pump-down. There will be a weight and center of gravity test and then the AMS will be lifted into the canister for transport to the Canister Rotation Facility (CRF).

6.1.6 Canister Operations

Both AMS-02 and its required GSE will be placed inside the canister during this phase of ground operations. GSE include a router, an I-boot bar, and Resistance Temperature Detector (RTD) reader, and a 120VDC power supply. A GSE computer will be placed on the canister's back porch so that AMS avionics and on cryo coolers can be commanded. The cable connecting the GSE computer to AMS will be long enough to provide communication even if the canister is delayed in its hoisting operations at the pad. Monitoring and control capabilities will be lost during hoisting and convoy operations. The GSE will operate on internal canister 120 VAC power, converting it to 120 VDC power for the AMS avionics and cryo coolers. The onboard pump will be powered directly from the canister's internal AC power supply.

Once AMS arrives at the CRF, it will be temporarily powered down in order to shift from canister to facility power. The canister will then be rotated to the vertical position in preparation for its trip to the launch pad after SOO24.

For cooling the zenith radiator, there are currently two options being discussed. The first option utilizes a fan on the aft bulkhead. The second involves using deflectors on the duct heads. A decision will be reached soon.

6.1.7 Pad Operations

After SOO24, AMS-02 is rolled out to the Pad. Once there, AMS will be transferred to the Payload Ground Handling Mechanism (PGHM). The EGSE will then be reconnected to the payload, followed by payload electrical mates, with AMS-02 being powered up. Interface Verification Tests (IVTs) will begin shortly after this. Additionally, the CGSE will be reconnected to the payload after the Rotating Service Structure (RSS)has been rotated to the orbiter and AMS has been installed into the orbiter payload bay. The layout of the CGSE is in Figure 5.1-1. Both Leybold pumps will be connected to AMS during Pad operations. After these installations are complete, the Terminal Countdown Test (TCDT) and the payload end-to-end test will be performed.

Topping off AMS-02 with superfluid He will begin shortly after the CGSE has been reconnected to the payload. There are two additional pad clears while at the Pad: S5009 (ordinance installation) and S0071 (hypergol/MPS press/and closeouts). The Pad will be cleared of personnel during these operations and AMS-02 will be shut down.

At L-88 hours, personnel will disconnect the CGSE from AMS-02 and the payload doors will be closed. The payload will go through another checkout and power will be reduced to minimum. At L-9 minutes, power at T0 will be switched off.

6.1.8 Contingency Operations

In case of a launch scrub, AMS-02 will need to be reconnected with its CGSE by scrub+120 hours. This will allow helium replenishment and cooling down of the liquid helium tank.

6.1.9 Contingency Return

If the shuttle needs to make a contingency return (Return to Launch Site (RLS), Trans-Atlantic Landing (TAL), or some other contingency return from orbit), the most immediate concern for AMS is to prevent overpressure of the helium system to keep the BDs from opening and introducing air into the system. To preclude this scenario after landing, the payload would need both AC and DC electrical power at the T0 umbilical connection. AC power would operate the AMS on-board pump which vents out gaseous helium. DC power would operate the payload’s cryo coolers which remove heat from the cryo system, thus reducing pressure build-up and loss of helium as well as allow operation of AMS-02 cryo valves.

6.2 Operational Outline

The following is an outline of the flow of operations for the AMS-02. It is intended to provide a brief flow of events of the payload’s ground processing.

6.2.1 SSPF Activities

SSPF activities will begin with the arrival of hardware into the SSPF airlock and proceed to footprint 7 where AMS-02 is to be processed. The activities within the SSPF include the following:

- Hardware unpacking, setup, and cleaning
- GSE assembly
- CGSE integrated with AMS-02
- Attach LUSS to USS
- Hardware Installation
    - Grapple Fixtures
    - Wiring Panels
- Remove AMS-02 from PSS
- Lift AMS-02 to ELC Rotation Stand
    - EBCS alignment
    - ACAS fit check
- ISS Interface Verification Testing (IVT) [Power and Data]
- Remove AMS-02 from ELC—install back into PSS
- Reconnect CGSE to AMS-02
- Functional testing while AMS-02 magnet is charging* (TBR)
- Continue to fill/cool AMS-02 with CGSE
- Word comes to take AMS-02 to the launch pad
    - CGSE transferred to PCR
    - AMS-02 placed in Canister and taken to CRF

6.2.2 CRF Activities

- Canister Operations (possibly including operation of on-board vacuum pump)

6.2.3 PCR Activities

- Install CGSE

6.2.4 Orbiter/Pad Activities

- STS IVT [Power and Data]
- SOO24
- Payload arrives at Pad/PCR after SOO24
- Connect CGSE to AMS-02 after AMS-02 is placed in the Orbiter
- Filling operation of AMS-02 with liquid until L-88 hours (**<u>May</u>** require top-off immediately after payload arrival to troubleshoot technique)
- CGSE/EGSE tear down and payload close out operations
- Clear Pad by L-80
- On-board pump (OBP) turned on
- Payload bay doors closed

---

* To charge the Cryomagnet, the semiconductor switch on the charging circuit is closed, and power is supplied to the transformer input. The current is slowly ramped up over a period of approximately 1.5 hours to 459 amps. Current during charging operations is monitored using a 500 amp shunt. The connection from the CCS to the Cryomagnet is made via three pairs of ASG 2/0 wires. Once full operating current is reached, the Persistent Switch is closed (The switch consists of a pair of super-conducting wires. They are closed by cooling them down to superconducting temperatures.). Once the Persistent Switch is closed, there will be 459 amps running through both sides of the circuit (the Cryomagnet side and the charger side). To avoid ripple currents through the Persistent Switch, the current on the charger side is slowly reduced to zero. Once the current on the charger side is depleted, the semiconductor switch is opened, and the charging system is disconnected from the magnet circuit.

- Ground operations/maintenance
- OBP off at L-30 minutes
- Monitor AMS-02 until L-9 minutes

6.2.5 Contingency Operations

- Scrub +120 hours
  - Reconnect CGSE to AMS-02
  - Cool down Lhe tank
  - Top off for next launch
- Rollback (for hurricane or other contingency in which AMS-02 must go without services.)
  - Disconnect CGSE from AMS-02
- Orbiter is rolled back from the pad

7 SAFETY DISCUSSION

A safety analysis was performed for the AMS-02 GSE, GHE, and KSC ground operations using KHB 1700.7C to identify potential hazards. The analysis covered all identified ground operations at KSC including payload handling, payload assembly, payload servicing payload checkout, and contingency scenarios. The analysis for the AMS-02 ground safety package has resulted in the production of 16 unique hazard reports. What follows is a summary of the hazard analysis by category.

7.1 FIRE

Hazard causes that could lead to a fire either from AMS-02 flight or ground hardware include improper use of flammable material, electrical causes, and mechanical failures.

In order to control these hazards, flammable material use has been kept to a minimum. Any flammable materials that will be used by the AMS-02 project will be submitted to the Customer Integration Manager. In addition, any plastics, adhesive tapes, or foams will be used only with the concurrence of KSC.

Any potential ignition sources on either the payload or its GSE will be labeled or shielded. In the case of electrical ignition sources, all electrical circuits will be designed with proper wire sizes and overload protection devices. Electrical connectors will be designed to make it physically impossible to mismate. In addition, proper mating/demating procedures will be performed to prevent any arcing and sparking. Mechanically, rotating equipment will be properly cooled, either with air or water cooling systems. Rotating parts will be properly lubricated to minimize heat build-up. In addition, components will be sized for the appropriate function they are to perform.

The hazard causes and controls for fire have been addressed in GHR-AMS-02-001.

7.2 Toxicity

The only toxic materials used by AMS-02 are ammonia and propylene in the TCS and isopropyl alcohol and acetone used for cleaning. The thermal control fluids are in sealed tubes buried within the radiator panels or mounted underneath MLI and will not have any personnel interaction while at KSC. Cleaning solvents will be controlled either through proper containment and/or procedure. Any solvents or adhesive materials will be contained in National Fire Protection Agency (NFPA) —approved containers. Toxic materials will only be handled by trained personnel using procedures approved by the KSC Biomedical Office and the Launch Site Safety Office (LSSO). AMS-02 does not have plans to bring any of its own solvents or adhesives to KSC. Instead, the project will request them from KSC.

The hazard cause and controls for toxicity have been addressed in GHR-AMS-02-002.

7.3 Liquefaction of Atmospheric Gases

AMS-02 uses a cryogenic system to super-cool its magnet. While on the ground, superfluid helium will be pumped into the AMS-02 via the CGSE. With the use of a cryogenic system comes the hazard of the liquefaction of surrounding atmospheric gases. These liquefied gases then have the potential of coming into contact with incompatible materials causing injury to personnel and damage to the payload, its GSE and surrounding GFE.

There will be three approaches to controlling this hazard. First, the cryogenic systems will be properly insulated in order to prevent contact with the surrounding atmosphere and ground-based heat guns will be used to warm selected areas during cryogenic operations. Second, for those areas that cannot be sufficiently insulated, containment in the form of catch pans and absorbent “diapers” will be used to prevent liquefied gases from coming into contact with incompatible materials. Third, materials that will be used close to cryogenic systems will be selected only if they are compatible with liquefied atmospheric gases.

The hazard causes and controls for liquefaction of atmospheric gases have been addressed in GHR-AMS-02-003.

7.4 Pressure Systems

There are a variety of different pressure systems on the AMS-02 payload and its associated GSE. Hazard causes covered for these systems include personnel error, freezing of the cryogenic vents and lines, puncture of the VC or GSE vacuum shrouds, materials incompatibility, and COPV damage.

Personnel error includes such causes as over-pressurization/overfilling and mishandling of the pressure vessels as well as improper workmanship or assembly. Controls will include observance of proper filling procedures, correct handling of the pressure vessels, and the use of pressure relief devices to prevent over-pressurization. The systems will be built to controlled drawings and quality assurance procedures to ensure proper operation.

Freezing of the vents and freezing/thawing of the cryogenic pressure system could either cause over-pressurization or breaches in the system. Controls include using the vacuum pumps to keep atmosphere out of the cryogenics lines. The helium used will meet or exceed purity standards of MIL-P-27407 and will be filtered to remove particles.

Puncture of either the VC or GSE vacuum shrouds could cause over-pressurization of the cryogenic system. Both shrouds are designed to preclude puncture from falling objects.

Materials incompatibility could lead to deterioration of a pressure system. The design of each system precludes such deterioration by ensuring the system's materials are compatible with what it will hold.

COPV damage through accidental handling or falling objects raises uncertainty as to its structural integrity. The COPVs on AMS-02 will have temporary shields during ground handling as well as permanent MMOD shielding. The project will also implement procedural controls to prevent damage from falling objects or incidental contact. Details for protecting the COPVs are found in the *AMS-02 COPV Damage Control Plan*.

The hazard causes and controls for pressure systems have been addressed in GHR-AMS-02-004.

7.5 HIGH PRESSURE GAS

With the variety of pressure systems associated with AMS-02, there is the hazard of personnel being exposed to gas plumes. Such a hazard could lead to asphyxiation, high velocity gas, projectiles, and/or touch temperature hazards. The hazard could come about due to equipment or personnel error, normal fill/transfer operations, or due to improper handling or assembly.

In order to control equipment failure or operator error, a variety of controls will be used. Vents and relief devices will direct vented gas out of the AMS-02 work area. Shields and deflectors will be put placed to prevent personnel from being fully exposed to plumes. Labels will warn personnel of potential gas plume locations.

During normal operations, personnel will wear Personal Protective Equipment (PPE) to prevent full exposure to gas. Training will be provided on proper filling procedures. Labels will warn of potential vent areas. There will also be clear indications of when filling operations are taking place. To avoid mishandling or assembly of gas or cryogenic systems, proper assembly and operating procedures will be followed.

The hazard causes and controls for pressure systems have been addressed in GHR-AMS-02-005.

7.6 TOUCH TEMPERATURES

Either excessively low (below 32ºF or 0ºC) or excessively high (above 113º F or 45º C) surface temperatures on certain components of AMS-02 will create a touch temperature hazard for ground personnel. Cold touch temperatures are associated with the cryogenic systems and their

GSE. The hazard is controlled primarily through insulation of the cryogenic system. For those areas that cannot be insulated, atmospheric gases might liquefy and come into contact with payload or GSE surfaces. Diapers and catch pans will be used in such instances to prevent contact. In the case of released cryogenic materials, vents are positioned to preclude cryogenic gas contact with payload or GSE surfaces. To preclude the formation of ice, heaters/fans will be used to keep exposed areas warm. Warning signs will be placed where ice might accumulate to alert personnel to stay clear of the affected areas. The cryogenic systems will also be monitored by trained personnel to detect leaks and apply corrective measures.

The hazard causes and controls for cold touch temperatures have been addressed in GHR-AMS-02-006.

Hot touch temperatures are associated with various pumps (the vacuum pumps being the biggest concern), dump diodes, and heaters on the TRD K-bottle (cf. Figure 5.2.2-1). The large vacuum pumps will be cooled via a water coolant system while the others will be air cooled. The dump diodes, which convert electrical energy to heat during a nominal discharge of the magnet, are located in an area out of reach of personnel. They are also shielded in an enclosure and are insulated. When the magnet is charged, personnel are not allowed in the immediate area, thus further reducing the likelihood of a hazard. The TRD heating tape has the capability of heating the surface temperature of the K-bottle above 113º F when the bottle is near empty. Controls for the tape include proper setting of the temperature controller, a temperature sensor, and the use of a frame to keep personnel away from the bottle.

The hazard causes and controls for hot touch temperatures have been addressed in GHR-AMS-02-015.

7.7 LOSS OF BREATHABLE ATMOSPHERE

Due to the presence of oxygen displacing gases in the AMS-02 and GSE, a loss of breathable atmosphere could occur either in the immediate vicinity of the payload, the building, or the container in which it is housed.

In the event of oxygen displacing gases being released from the AMS-02 or its GSE, ventilation will be used to aerate the surrounding volume. Oxygen sensors will monitor any areas where these gases may accumulate. Personnel will be trained regarding evacuation procedures in the event of a significant gaseous release by the AMS-02 and/or its GSE.

Injury due to prolonged activity close to venting gases will be controlled by requiring a minimum of two people working in the payload area at one time (the buddy system). Labels will indicate where gases may vent. Nominal operations will not occur near venting areas.

There is particular concern of an oxygen displacing gas venting in the canister that takes AMS-02 to the pad. This will be precluded by venting and inspection of the canister atmosphere for adequate oxygen levels prior to allowing personnel into the canister.

An analysis of oxygen depletion during failure scenarios has been made for operations at the SSPF, the launch pad, and during moves. The flight helium tank/vacuum case was the focus of the analysis due to it being the container with the greatest volume of superfluid He (2500 liters). The following were assumptions made in the analysis:

- Helium exiting the vent in the VC has already expanded to ambient temperature and pressure. Density is therefore at its minimum possible value and volume displacement is maximized.
- The exiting helium instantaneously and completely mixes with the air in the room. It is not assumed to stratify and rise to the ceiling.
- Overall change in air pressure and density from the vented helium is assumed to be negligible.

The potential failure used for the analysis was termed the Maximum Credible Leak. The scenario chosen was adjacent 3" wide pinches in the double O-ring seals surrounding the main dewar. If the fastener closest to the pinches was to fail, a gap of .001" could open up, creating a .003 in^2 hole in the VC. For conservatism, it was assumed that the hole was circular, minimizing boundary layer effects on the airflow into the VC. The air leaking into the hole would then heat up the liquid helium dewar, causing the helium to warm up past the superfluid helium stage (i.e. past the lambda point). The helium would continue to expand, fill the tank, resulting in a BD through which helium would vent into the atmosphere. Although originally developed for flight, the Maximum Credible Leak is equally reasonable for ground operations.

The analysis for the SSPF interior volume concluded that oxygen levels will not fall below 19.5% (Oxygen percentage required by the Occupational Safety and Health Association (OSHA)) in the facility, thus no general asphyxiation hazard. Discussions amongst the payload organization have concluded that—based on these results—no emergency vent lines will be necessary during any AMS-02 ground operations in the SSPF. Since helium rises, however, caution needs to be exercised by personnel who go up into the upper bay of the SSPF so that they will not walk into an oxygen deficient atmosphere. Two oxygen sensors will be placed near the AMS-02 hardware to detect leakage of helium while it is in the SSPF. They are Servomex Oxygen Analyzers, Model 571, which are paramagnetic sensors that have been proven to be accurate and dependable in a helium environment.

After checkout in the SSPF, the AMS-02 is disconnected from its GSE and is placed in the canister for delivery to the CRF. While being transported in the canister, flight hardware will be in the transport configuration and will require nominal venting/evacuation of the helium tank. Any helium gas from the tank is not anticipated to build up to an appreciable level under nominal operations. If the AMS-02 is required to stay in the canister longer than planned, a pressure relief ("burp") valve has been provided for in the flight system to preclude the pressure of the tank from exceeding MDP. The AMS-02 Project will have monitoring capabilities and may request the vehicle to stop if it detects a large scale release of helium.

The nominal venting of helium gas will not displace breathable atmosphere within the canister. Venting due to fault conditions that result in a BD could in theory displace the breathable atmosphere within the canister, however. The potential build up is controlled by the environmental system that exchanges air within the canister. If AMS-02 has to be left dormant or unattended in the vehicle, oxygen sensors will be used prior to entry into the canister.

Once in the canister, AMS-02 is transported from the SSPF to the CRF for further processing before proceeding to the Pad. The analysis for the CRF interior concluded that oxygen levels will not fall below 19.5%. As with the SSPF, the volume of the CRF is large enough to allow the helium to dissipate. Caution should be taken by personnel going into the upper levels of the CRF. Since helium rises, the risk of an oxygen deficient atmosphere is greater for personnel who work in the upper levels of the building.

During operations at the pad, GSE will be installed and connected to AMS-02. Emergency vents will not be required. Vent paths available at the pad will be used to plumb exhaust gases from the vacuum pump outside the work areas, primarily to limit the possible oil vapor that the pumps generate. Furthermore, vent pumps and CGSE will be in place to pump the cryo system pressure down to keep the superfluid helium temperature at 1.2K, thus eliminating the need for emergency venting. Three oxygen sensors will be placed near the AMS-02 hardware while it is at the launch pad.

During its time in the payload bay at the pad, venting by the AMS-02 will not present a hazard to the shuttle. Refer to the flight safety data package for more details.

The hazards and controls for the loss of breathable atmosphere have been addressed in GHR-AMS-02-007. More detailed information of the venting analysis is found in the ESCG memo “Helium Venting Analysis” prepared for review by the KSC GSRP.

7.8 RF RADIATION

The GPS ground testing equipment has been reviewed by the KSC Health Physics office to find out if it poses an RF radiation hazard. The conclusion is that the GSE is exempt from the requirements of KNPR 1860.2 and 45-201 as per IEEE C-95.1 (2005) and therefore does not present a hazard to ground personnel (E-mail from Ennis Shelton to Tom Tinsler dated April 8, 2008).

7.9 STRUCTURES

Structural failure was divided up into static and dynamic operations. Static structural hazards are concerned with the structural stand hardware. The causes for structural failure while static include inadequate structural design and improper assembly of the PSS vertical corner supports, as well as structural failure of the CGSE cryogenic/vent line support stands. These will be controlled by ensuring proper procedures are followed during assembly and that support hardware meets the requirements of KHB 1700.7C. The PSS is designed to support the load of AMS-02 during all planned and contingency ground operations in the SSPF.

The hazards and controls for structural failure during static operations have been addressed in GHR-AMS-02-010.

The dynamic structural hazards are concerned with the lifting equipment. The causes for structural failure include inadequate structural design, structural deterioration, the improper attachment of swivel hoist rings, overloading of the lifting equipment, improper assembly, and personnel error.

Inadequate structural design is controlled through designing the lifting equipment with safety factors for crane, forklift, and dolly operations. Structural aging will be controlled through daily inspections of the lifting equipment and annual structural inspections. Swivel hoist rings will have specific torque values that determine proper engagement and will be visually inspected before use. Detachable eyebolts will have a positive means to ensure complete engagement. Permanent lifting points on GSE will be designed to a minimum ultimate factor of safety of 5. To prevent overload, lifting equipment will have pertinent load information located on it. The lifting equipment will only lift AMS-02 flight hardware and GSE. Procedures will preclude the improper assembly of the lifting equipment. Personnel error will be controlled by using only KSC certified personnel to perform heavy lifting operations.

The hazards and controls for structural failure during static operations have been addressed in GHR-AMS-02-009.

7.10 Electrical Systems

There are a variety of electrical systems that could be hazardous to ground personnel. Typical causes of electric shock include over voltage/current, contact with high voltage sources, mismating of power connectors, leakage the presence of water, ungrounded components of AMS-02 or its GSE, and shorting an energized circuit during connector mating/demating.

Circuit protection devices are designed to National Electric Code (NEC) or equivalent standards, which will control over-voltage/current hazards. To preclude contact with high voltage/current sources, socket connectors will be used on the power side of GSE. High voltage/current sources will be labeled for those circuits accessible to personnel, and lock-out/tag-out procedures will be implemented during maintenance operations. Mismating of powered connectors will be precluded through use of connector keying. Water leakage will be precluded by proper assembly of the vacuum pump cooling system and ensuring hoses and connectors can handle the water pressure. Proper grounding and bonding between AMS-02 hardware and KSC facilities, including power cords using non-current carrying ground conductors, will prevent conductive external parts from shocking personnel. Mating de-energized electrical circuits will prevent shorting payload or GSE electrical circuits.

The hazards and controls for electrical shock have been addressed in GHR-AMS-02-011.

7.11 Acoustics

Excessive noise levels (above 80 dB constant, 140 dB impulse) could cause hearing damage or loss to personnel. Hearing protection will be required for personnel to protect them from constant high level noise, if required. The vacuum pumps will be enclosed in sound absorbing housing. Monitoring AMS-02 systems for pressure and temperature increases will warn personnel of impending BDs.

The hazards and controls for hearing loss have been addressed in GHR-AMS-02-012.

7.12 Magnetic Fields

The AMS-02 utilizes a superconducting magnet and can create strong magnetic fields when charged. This could result in equipment malfunction and excessive loads. To control this hazard, the design of the coils of the magnet limits the strength of the fields outside of the core. The magnet's avionics box limits the maximum current that the magnet can receive, thus limiting magnetic field strength. Procedural controls, such as using non-magnetic tools and placement of warning signs, will be used to keep vulnerable equipment outside of magnetic field range.

The hazards and controls for excessive magnetic fields have been addressed in GHR-AMS-02-013.

7.13 Sharp Edges

Sharp edges on either GSE or flight hardware could cause personnel injury or equipment damage. GSE will be designed to meet the requirements of MIL-STD-1472 and NASA-STD-3000. For items such as lock wire, procedures will be in place to ensure that sharp edges are controlled. For flight hardware, it will be designed to NSTS 07700, Vol. XIV, Appendix 7 (specifically, the star tracker baffles). For sharp edges that cannot be controlled, keep-out zones will be established to prevent personnel contact.

The hazards and controls for sharp edges have been addressed in GHR-AMS-02-014.

7.14 Lasers

Lasers are located in the interior of the AMS-02. Exposure to lasers could cause personnel injury. Control of this hazard includes the inherent design of AMS-02 in which the lasers are inside closed boxes and are conducted to the interior of the tracker via shielded optic cables. The connectors and cables are under thermal blankets, adding another layer of optical protection. In addition there are no nominal or contingency operations requiring access to the lasers or the laser beam path.

The hazards and controls for lasers have been addressed in GHR-AMS-02-016.

7.15 Biomedical Subsystems

There are no biomedical subsystems on AMS-02 flight or ground hardware.

7.16 Ordnance

There is no ordnance on AMS-02 flight or ground hardware.

7.17 MECHANICAL AND/OR ELECTROMECHANICAL DEVICES

There are no mechanical or electromechanical devices on the AMS-02 flight or ground hardware.

7.18 PROPELLANTS

There are no propellants on AMS-02 flight or ground hardware.

7.19 OXYGEN

There will be no stored liquid or gaseous oxygen on AMS-02 flight or ground hardware.

7.20 BATTERIES

All batteries associated with AMS-02 and its GSE are COTS. The exceptions are two Uninterruptible Power Supply (UPS) boxes that contain an eight cell lithium ion battery per box. They are located on the USS in battery boxes. They are used to assist in shutting down AMS-02 in case of power or communication loss with the ISS. During the operation of AMS-02 at KSC, it will be trickle charged, which is standard operating procedure. There are no charging operations conducted by ground personnel.

For more information regarding the UPS batteries, please refer to Flight Hazard Report AMS-02-F13, “Battery Failure “and the AMS-02 EP-5 “Battery Design Evaluation Form”, tracking number EP-06-19, found in Appendix E of the flight safety data package.

7.21 SAFETY RELATED FAILURES AND MISHAPS

There have been no safety related failures or mishaps with the AMS-02 GSE to date. A list of flight related failures and mishaps are documented in Appendix B, “Flight/Ground Safety Anomalies.”

7.22 USE OF SIGNS DURING GROUND PROCESSING

AMS-02 will be using a variety of signs to warn ground personnel of hazardous situations during ground processing. Below are the types of signs the project will require along with the wording needed on each type:

- Signs that will warn personnel to stay out of certain areas, such as during magnet charging. They will need to have the words “Keep Out” printed on them.
- Signs that will be used to warn personnel of those areas that have cryogenic operations. These signs will need to have the word “Warning: Cryogenics” printed on them. Signs that will warn personnel of those areas that have a high touch temperature hazard. The signs will need to have the words, “Warning: High temperature” printed on them.

APPENDIX A: GROUND SAFETY HAZARD REPORTS

PAYLOAD HAZARD REPORT		a. NO: GHR-AMS02-001
b. PAYLOAD: Alpha Magnetic Spectrometer-02 (AMS-02) GSE		c. PHASE: III
d. SUBSYSTEM: Materials, Rotating Equipment, Electrical	e. HAZARD GROUP: Fire	f. DATE: January 2010
g. HAZARD TITLE: Fire hazard due to flammable materials and/or equipment failure.		i. HAZARD CATEGORY ☒ CATASTROPHIC ☐ CRITICAL

h. APPLICABLE SAFETY REQUIREMENTS:

KHB 1700.7C, Sections: 4.3.2 Electrical; 4.3.9 GSE Materials

j. DESCRIPTION OF HAZARD:

AMS-02 GSE flammable materials (including solvents, chemicals etc), and/or ignition sources could cause a fire.

(For Materials of Flight Hardware, see AMS-02-F10)

k. HAZARD CAUSES:

1. Improper use of flammable materials.
2. Exposure of flammable materials to ignition sources.
3. AMS-02 GSE electrical circuits overheat due to overloads or short circuits.
4. Mating/demating of energized AMS-02 electrical circuits causes arcing.
5. Mismating of AMS-02 connectors.
6. Runaway AMS-02 heaters.
7. Damaged hardware causes fire.
8. Mechanical failure of rotating equipment.
9. Static buildup from rotating equipment or GSE power equipment.
   (Note: Contact with liquefied air as an ignition source is addressed under GHR-AMS02-003, Liquefaction of Atmospheric Gases)

l. HAZARD CONTROLS:

(See continuation sheet)

m. SAFETY VERIFICATION METHODS:

(See continuation sheet)

n. STATUS OF VERIFICATION:

(See continuation sheet)

o. APPROVAL	PAYLOAD ORGANIZATION	SSP/ISS
PHASE I		
PHASE II		
PHASE III	[signature] 1/14/10	

PAYLOAD HAZARD REPORT CONTINUATION SHEET	a. NO: GHR-AMS02-001
b. PAYLOAD: Alpha Magnetic Spectrometer-02 (AMS-02) GSE	c. Phase III

k. HAZARD CAUSES:

1. Improper use of flammable materials.

l. HAZARD CONTROLS:

1.1 Use of flammable AMS-02 GSE materials will be avoided wherever possible in all payload processing areas. A list of any flammable materials used will be submitted to the Customer Integration Manager (CIM).

1.2 All plastic films, adhesive tape and foams will be used per MUA based on material rating, application, and quantity used.

1.3 KSC-provided cleaning solvents will be used when possible. Cleaning solvents and adhesives not provided by KSC will be submitted to KSC for review and approval (Including application quantities, amount, and storage methods).

1.4 Flammable liquids and gases will be stored in properly sealed containers and in a hazardous materials storage cabinet as required or will be vented outside of KSC facilities in a controlled manner.

1.5 Potentially hazardous byproducts (dirty rags, dirty used solvents etc) will be disposed of in accordance with KSC health and safety protocols. (Note: Includes disposal of toxic and flammable materials.)

m. SAFETY VERIFICATION METHODS:

1.1.1 Review of AMS-02 flight and GSE materials lists including Material Safety Data Sheets (MSDSs) that will be submitted for all material/solvents/chemicals not provided by NASA/KSC.

1.1.2 Review of AMS-02 procedures for location of materials usage.

1.2.1 Review of AMS-02 flight and GSE materials lists against KSC-approved lists.

1.2.2 Review of AMS-02 materials usage agreements.

1.3.1 Material usage agreement from KSC for all solvents not provided by KSC.

1.3.2 Review of AMS-02 flight and GSE solvents and adhesives for location of materials usage. MSDSs will be submitted for all materials not on the NASA/KSC approved lists.

1.4.1 Review of design of sealed containers with flammable liquids to verify positive margins against rupture or leakage.

1.4.2 Review of containment venting to ensure that flammable gases are not allowed to accumulate.

1.5.1 Approval of the Process Waste Questionnaire.

n. STATUS OF VERIFICATION:

1.1.1 Closed 11/25/09. ESCG-4470-09-TEAN-DOC-0121, *AMS-02 Heat Pipes and Loop Heat Pipes Fluid Fill* Quantities, 09/09/09; Form P-4562-E, *Praxair Material Safety Data Sheet*, Ammonia, Anhydrous; *Lenox Material Safety Data Sheet*, Propylene.*Open*

1.1.2 Closed 11/25/09.E-mail from Chris Tutt to Tom Tinsler, PSE of GSRP, Paul Kirkpatrick, GSRP Chair, and Joe Delai, STS-134/ULF6 Mission Manager entitled “Flammable Materials on AMS-02”, 11/23/09.Open

1.2.1 Open

1.2.2 Open

1.3.1 OpenClosed 11/09/09. AMS-02 will not bring any of their own solvents to KSC.

1.3.2 Closed 11/09/09. AMS-02 will not bring any of their own solvents to KSC.Open

1.4.1 Open

1.4.2 OpenClosed 11/09/09. All flammable materials associated with AMS-02 will be sealed in heat pipes and loop heat pipes, which are located on the flight hardware.

1.5.1 Open

PAYLOAD HAZARD REPORT CONTINUATION SHEET	a. NO: GHR-AMS02-001
b. PAYLOAD: Alpha Magnetic Spectrometer-02 (AMS-02) GSE	c. Phase III

k. HAZARD CAUSES:

2. Exposure of flammable materials to ignition sources.

l. HAZARD CONTROLS:

2.1 Label all ignition sources that can't be eliminated which are found on flight hardware and GSE.

2.2 Prohibit use of flammable material near ignition sources.

2.3 Proper control/shielding of ignition sources on flight hardware and GSE.

m. SAFETY VERIFICATION METHODS:

2.1.1 Inspect flight hardware and GSE for proper identification of potential ignition sources and correct warning labels.

2.2.1 Review proper use of flammable material per MSDS.

2.3.1 Review of flight hardware and GSE design drawings for proper controls/shielding.

n. STATUS OF VERIFICATION:

2.1.1. Open

2.2.1 ~~Open~~Closed 11/25/09. Form P-4562-E, *Praxair Material Safety Data Sheet*, Ammonia, Anhydrous; *Lenox Material Safety Data Sheet*, Propylene.

2.3.1 Open

PAYLOAD HAZARD REPORT CONTINUATION SHEET	a. NO: GHR-AMS02-001
b. PAYLOAD: Alpha Magnetic Spectrometer-02 (AMS-02) GSE	c. Phase III

k. HAZARD CAUSES:

3. AMS-02 GSE electrical circuits overheat due to overloads or short circuits.

l. HAZARD CONTROLS:

3.1 AMS-02 GSE electrical circuits are selected (COTS) or designed (custom) using proper wire sizes and overload protection devices (such as fuses and circuit breakers) to prevent overheating.

(Note: All ground cabling will be built to the same/equivalent rating as the flight hardware)

m. SAFETY VERIFICATION METHODS:

3.1.1 Review of AMS-02 electrical GSE to verify it meets the requirements of KHB 1700.7C, Section 4.3.2 (Electrical) and the National Electric Code (NEC), National Fire Protection Association 70 (NFPA 70), or equivalent.

n. STATUS OF VERIFICATION:

3.1.1 Open

PAYLOAD HAZARD REPORT CONTINUATION SHEET	a. NO: GHR-AMS02-001
b. PAYLOAD: Alpha Magnetic Spectrometer-02 (AMS-02) GSE	c. Phase III

k. HAZARD CAUSES:

4. Mating/demating of energized AMS-02 electrical circuits causes arcing.

l. HAZARD CONTROLS:

4.1 All mating/demating of connectors will be performed on de-energized electrical circuits.

m. SAFETY VERIFICATION METHODS:

4.1.1 Review of AMS-02 mating/demating procedures to ensure personnel de-energize electrical circuits prior to mating/demating.

n. STATUS OF VERIFICATION:

4.1.1 Open

PAYLOAD HAZARD REPORT CONTINUATION SHEET	a. NO: GHR-AMS02-001
b. PAYLOAD: Alpha Magnetic Spectrometer-02 (AMS-02) GSE	c. Phase III

k. HAZARD CAUSES

5. Mismating of AMS-02 connectors.

l. HAZARD CONTROLS

5.1 AMS-02 connectors carrying electrical power will be selected which make it physically impossible to mismate.

5.2 For those connectors that cannot conform to ~~c~~Control 5.1, procedures will be put into place to prevent mis~~-~~mating.

5.3 Warning labels indicating not to mis~~-~~mate will be placed on connectors that cannot conform to ~~c~~Control 5.1.~~-~~

m. SAFETY VERIFICATION METHODS

5.1.1 Review of AMS-02 drawings.

5.1.2 QA inspections of as-built hardware to approved drawings.

5.2.1 Review of procedures to ensure there are warnings to preclude mismating.

5.3.1 Review of affected connectors to ensure label placement.

n. STATUS OF VERIFICATION:

5.1.1 ~~Open~~Closed 12/22/09. ESCG-4390-08-SP-MEMO-0022, *Mate/Demate of Connectors*, 06/11/08. This closes the verification for all flight related electrical connectors. GSE is either COTS or KSC-supplied and will be used as designed.

5.1.2 Open

5.2.1 Open

5.3.1 Open

PAYLOAD HAZARD REPORT CONTINUATION SHEET	a. NO: GHR-AMS02-001
b. PAYLOAD: Alpha Magnetic Spectrometer-02 (AMS-02) GSE	c. Phase III

k. HAZARD CAUSES:

6. Runaway AMS-02 heaters.

l. HAZARD CONTROLS:

6.1 The AMS-02 heater circuits will be monitored via computer and kept below a potential ignition temperature.

6.2 Heating tape on the fill-gas K-bottles is set to 40°C (TRD Gas System).

6.3 Heaters on flight hardware are controlled by thermostats.

m. SAFETY VERIFICATION METHODS:

6.1.1 Review of AMS-02 procedures to verify monitoring of heater circuit temperatures.

6.2.1 Review of AMS-02 procedures to verify K-bottle heater tape controller is set to 40C.

6.3.1 Review of AMS-02 heater parameters.

n. STATUS OF VERIFICATION:

6.1.1 Open

6.2.1 Closed 06/29/09. AMS-02 Task Sheet (ATS) TRD-090522-1, *TRD Gas Supply System Xenon Vessel Filling for Flight* and TRD-090131-1, *TRD Gas Supply System CO2 Vessel Filling for Flight.* ~~Open~~

6.3.1 Open. AMSTR-NLR-TN-043, Issue 4.0, *AMS Tracker Thermal Control Subsystem TTCS Heater Specifications*, 08/2009.

PAYLOAD HAZARD REPORT CONTINUATION SHEET	a. NO: GHR-AMS02-001
b. PAYLOAD: Alpha Magnetic Spectrometer-02 (AMS-02) GSE	c. Phase III

k. HAZARD CAUSES:

7. Damaged hardware causes fire.

l. HAZARD CONTROLS:

7.1 Components will be selected to ensure design lifetime will exceed operational lifetime.

7.2 Components will be selected to ensure that they can withstand the thermal cycling associated with the AMS-02 Cryogenic Systems.

m. SAFETY VERIFICATION METHODS:

7.1.1 Review of component specifications to ensure design lifetime exceeds operational lifetime.

7.2.1 Review of component specifications to ensure they can withstand thermal cycling.

n. STATUS OF VERIFICATION:

7.1.1 Open
7.2.1 Open

PAYLOAD HAZARD REPORT CONTINUATION SHEET	a. NO: GHR-AMS02-001
b. PAYLOAD: Alpha Magnetic Spectrometer-02 (AMS-02) GSE	c. Phase III

k. HAZARD CAUSES

8. Mechanical failure of rotating equipment.

l. HAZARD CONTROLS:

8.1 Proper selection of components to minimize heat buildup.

8.2 Proper lubrication of rotating equipment to minimize heat buildup.

8.3 Adequate cooling of rotating equipment (i.e. vacuum pumps) to ensure rotating equipment won't heat up beyond design parameters. Large vacuum (Roots) pumps are equipped with auto-shutoff sensors for over temperature conditions.

m. SAFETY VERIFICATION METHODS:

8.1.1 Review of design drawings to ensure proper components are being used.

8.2.1 Review preventative maintenance schedule to ensure rotating parts are being lubricated.

8.3.1 ~~Monitoring of rotating via computer equipment cooling system.~~Review of design to ensure there are proper cooling features in place.

8.3.2 Review of manufacturer's specifications for auto-shutoff feature.

8.3.3 Review of ground procedures to ensure cooling water temperature is monitored.

n. STATUS OF VERIFICATION:

8.1.1 ~~Open~~Closed 11/09/09. ESCG-4295-09-CPAS-MEMO-0012, *AMS-02 Ground Pump Requirements*, dated 11/06/09.
8.2.1 Closed 11/09/09. ESCG-4295-09-CPAS-MEMO-0012, *AMS-02 Ground Pump Requirements*, dated 11/06/09.~~Open~~
8.3.1 Closed 11/09/09. ESCG-4295-09-CPAS-MEMO-0012, *AMS-02 Ground Pump Requirements*, dated 11/06/09.~~Open~~
8.3.2 Closed 11/09/09. ESCG-4295-09-CPAS-MEMO-0012, *AMS-02 Ground Pump Requirements*, dated 11/06/09.
8.3.3 Open

PAYLOAD HAZARD REPORT CONTINUATION SHEET	a. NO: GHR-AMS02-001
b. PAYLOAD: Alpha Magnetic Spectrometer-02 (AMS-02) GSE	c. Phase III

k. HAZARD CAUSES:

9. Static buildup from rotating equipment or GSE power equipment.

l. HAZARD CONTROLS:

9.1 Bond and ground rotating equipment and GSE power equipment to ensure there is no static buildup per KSC bonding/grounding requirements.

m. SAFETY VERIFICATION METHODS:

9.1.1 Review of GSE electrical schematics for proper bonding/grounding.

n. STATUS OF VERIFICATION:

9.1.1. Open

PAYLOAD HAZARD REPORT		a. NO: GHR-AMS02-002
b. PAYLOAD: Alpha Magnetic Spectrometer-02 (AMS-02) GSE		c. PHASE: III
d. SUBSYSTEM: Materials	e. HAZARD GROUP: Toxicity	f. DATE: January 2010
g. HAZARD TITLE: Exposure to Toxic Materials. ~~in Flight Hardware~~		i. HAZARD CATEGORY ☒ CATASTROPHIC ☐ CRITICAL

h. APPLICABLE SAFETY REQUIREMENTS:

KHB 1700.7C, Sections: 4.3.9 GSE Materials
For Materials of Flight Hardware, see AMS-02-F10

j. DESCRIPTION OF HAZARD:

Toxic materials in AMS-02 flight hardware/GSE, or used on AMS-02 flight hardware/GSE (i.e. cleaning solvents) causes injury/death to personnel.

k. HAZARD CAUSES:

1. Improper use of toxic materials.
2. Improper containment of toxic materials.

l. HAZARD CONTROLS:

(See continuation sheet)

m. SAFETY VERIFICATION METHODS:

(See continuation sheet)

n. STATUS OF VERIFICATION:

(See continuation sheet)

o. APPROVAL	PAYLOAD ORGANIZATION	SSP/ISS
PHASE I		
PHASE II		
PHASE III	[signature] 1/14/10	

JSC Form 542B (Rev November 22, 1999) (MS Word September 1997)

PAYLOAD HAZARD REPORT CONTINUATION SHEET	a. NO: GHR AMS02-002
b. PAYLOAD: Alpha Magnetic Spectrometer-02 (AMS-02) GSE	c. Phase III

k. HAZARD CAUSES:
1. Improper use of toxic materials.

l. HAZARD CONTROLS:

1.1 Toxic materials will be handled by trained personnel.

1.2 Toxic materials will be used according to written procedures approved by the KSC Biomedical Office and LSSO.

1.3 Use of toxic materials will be minimized when possible (non-toxic alternatives will be substituted for toxic materials when possible).

m. SAFETY VERIFICATION METHODS:

1.1.1 Review of list of certified personnel.

1.2.1 Review and approval of written procedures to ensure proper handling of toxic materials.

1.3.1 Review of toxic material applications for acceptable alternatives.

n. STATUS OF VERIFICATION:

1.1.1 Open

1.2.1 ~~Open~~Closed 12/04/09. ESCG-4295-09-CPAS-MEMO-0016, Toxic Materials Usage within AMS-02, dated 12/03/09.

1.3.1 ~~Open~~Closed 12/04/09. ESCG-4295-09-CPAS-MEMO-0016, Toxic Materials Usage within AMS-02, dated 12/03/09.

PAYLOAD HAZARD REPORT CONTINUATION SHEET	a. NO: GHR AMS02-002
b. PAYLOAD: Alpha Magnetic Spectrometer-02 (AMS-02) GSE	c. Phase III

k. HAZARD CAUSES:

2. Improper containment of toxic materials.

l. HAZARD CONTROLS:

2.1 Cleaning solvents and adhesive materials will be contained in NFPA-approved containers.

2.2 Toxic ~~cleaning~~ materials for flight hardware and GSE will be in suitable containment for its toxicity level.

m. SAFETY VERIFICATION METHODS:

2.1.1 Inspection of cleaning solvent/adhesive material containers to ensure it meets standards.

2.2.1 Inspection of containment of flight/GSE toxic material to ensure it is suitable for the material it holds.~~containment.~~

n. STATUS OF VERIFICATION:

2.1.1 Open

2.2.1 Closed 12/04/09. ESCG-4295-09-CPAS-MEMO-0016, Toxic Materials Usage within AMS-02, dated 12/03/09.~~Open~~

GSE MATERIALS LIST

BRAND NAME / MANUFACTURER	SUBSTANCE (SOLVENT, EXPOXY, PLASTIC FILM, ETC)	QUANTITY	PROCESSING LOCATION AT KSC	USE	**MSDS** FORWARDED TO KSC? (YES/NO)
All Toxic materials for AMS-02 operations will be provided by KSC					

PAYLOAD HAZARD REPORT

PAYLOAD HAZARD REPORT		a. NO: GHR-AMS02-003
b. PAYLOAD: Alpha Magnetic Spectrometer-02 (AMS-02) GSE		c. PHASE: III
d. SUBSYSTEM: Materials	e. HAZARD GROUP: Materials	f. DATE: January 2010
g. HAZARD TITLE: Liquefaction of Atmospheric Gases		i. HAZARD CATEGORY ☒ CATASTROPHIC ☐ CRITICAL

h. APPLICABLE SAFETY REQUIREMENTS:

KHB 1700.7C, Sections: 4.3.9 GSE Materials

For Materials of Flight Hardware, see AMS-02-F10

j. DESCRIPTION OF HAZARD:

The liquefaction of atmospheric gases—due to coming in contact with cryogenic hardware—reacts with incompatible materials causing damage to hardware or injury to personnel.

k. HAZARD CAUSES:

1. Improper insulation of cryogenic hardware (tanks, piping, etc.).
2. Lack of containment of liquefied atmospheric gases.
3. Materials that are incompatible with liquefied atmospheric gases are located near exposed cryogenic systems.

l. HAZARD CONTROLS:

(See continuation sheet)

m. SAFETY VERIFICATION METHODS:

(See continuation sheet)

n. STATUS OF VERIFICATION:

(See continuation sheet)

o. APPROVAL	PAYLOAD ORGANIZATION	SSP/ISS
PHASE I		
PHASE II		
PHASE III	[signature] 1/19/10	

PAYLOAD HAZARD REPORT CONTINUATION SHEET	a. NO: GHR-AMS02-003
b. PAYLOAD: Alpha Magnetic Spectrometer-02 (AMS-02) GSE	c. Phase III

k. HAZARD CAUSES:

1. Improper insulation of cryogenic hardware (tanks, piping, etc.).

l. HAZARD CONTROLS:

1.1 Insulate cryogenic hardware to preclude contact of cryogenic temperature surfaces with the atmosphere.

1.2 Insulation installation will be designed to preclude contact of cryogenic temperature surfaces with the atmosphere.

1.3 Insulation will be installed as per design drawings.

m. SAFETY VERIFICATION METHODS:

1.1.1 Review of system drawings to ensure insulation of cryogenic systems.

1.2.1 Review of system drawing to ensure insulation ~~design drawings~~is adequate to prevent contact with cryogenic temperature surfaces.

1.3.1 Inspection to ensure insulation is installed per design drawings.

n. STATUS OF VERIFICATION:

1.1.1 ~~Open~~Closed, 08/07/2009~~-~~. ESCG-4175-09-REENTES-MEMO-0054, *AMS-02 CGSE Design Review*, 08/07/2009.
1.2.1 Closed, 08/07/2009~~-~~. ESCG-4175-09-REENTES-MEMO-0054, *AMS-02 CGSE Design Review*, 08/07/2009.
1.3.1 Open

JSC Form 542B (Rev November 22, 1999) (MS Word September 1997)

PAYLOAD HAZARD REPORT CONTINUATION SHEET	a. NO: GHR-AMS02-003
b. PAYLOAD: Alpha Magnetic Spectrometer-02 (AMS-02) GSE	c. Phase III

k. HAZARD CAUSES:

2. Lack of containment of liquefied atmospheric gases.

(Note: The cause and control are dealing with a contingency, not day-to-day operations.)

l. HAZARD CONTROLS:

2.1 Use catch pans and "diapers" to contain liquefied atmospheric gases, preventing them from coming in contact with incompatible materials or electrical components.

2.2 Use of warning signs to prevent personnel from coming into contact with liquefied atmospheric gases.

2.3 Use of keep out zones to prevent personnel from coming into contact with liquefied atmospheric gases.

m. SAFETY VERIFICATION METHODS:

2.1.1 Review of AMS-02 flight and GSE layout to ensure adequate containment is provided.–

2.1.2 Inspection of containment to ensure proper functioning.—

2.2.1 Review of AMS-02 safety procedures to ensure warning sign placement.

2.3.1 Review of AMS-02 safety procedures to ensure there are directions to set up keep out zones.

n. STATUS OF VERIFICATION:

2.1.1 Open
2.1.2 Open
2.2.1 Open
2.1.23.1 Open

PAYLOAD HAZARD REPORT CONTINUATION SHEET	a. NO: GHR-AMS02--003
b. PAYLOAD: Alpha Magnetic Spectrometer-02 (AMS-02) GSE	c. Phase III

k. HAZARD CAUSES:

3. Materials that are incompatible with liquefied atmospheric gases are located near exposed cryogenic systems.

l. HAZARD CONTROLS:

3.1 Use only those materials that are compatible with liquefied atmospheric gases.

3.2 Shield materials from liquefied atmospheric gases.

m. SAFETY VERIFICATION METHODS:

3.1.1 Review of flight hardware/GSE layout for proper material usage.

3.2.1 Review of flight hardware/GSE design and layout to ensure proper protection.

n. STATUS OF VERIFICATION:

3.1.1. Open

3.2.1. Open

PAYLOAD HAZARD REPORT		a. NO: GHR-AMS02-004
b. PAYLOAD: Alpha Magnetic Spectrometer-02 (AMS-02) GSE		c. PHASE: III
d. SUBSYSTEM: Pressure Vessels, Pressurized Lines, Vacuum Shroud	e. HAZARD GROUP: Pressure Systems	f. DATE: January 2010
g. HAZARD TITLE: Rupture of the AMS-02 Pressurized Components.		i. HAZARD CATEGORY ☒ CATASTROPHIC ☐ CRITICAL

h. APPLICABLE SAFETY REQUIREMENTS:

KHB 1700.7C, Sections: 4.3.3 Pressure/Vacuum Systems and 4.3.8 Cryogenics.

j. DESCRIPTION OF HAZARD

The rupture of GSE/Flight pressure systems presents a hazard to personnel, KSC facilities, or the orbiter during pad operations.

NOTE: For pressure systems hazard reports for flight hardware see AMS-02-F03, and AMS-02-F05.

(cf. attached GSE pressure systems components tables.)

k. HAZARD CAUSES:

1 Structural failure of pressure vessel(s)/systems.
2. Structural failure of the flight cryosystem while mated to the GSE.
3. Puncture of the flight dewar vacuum case.
4. Puncture of GSE vacuum shrouds.
5. Improper handling during operation, transportation, lifting, filling or securing of pressure vessels.
6. Blockage of vent line due to frozen impurities in He liquid or gas.
7. Materials incompatibility.
8. Improper workmanship and/or assembly.
9. Overfilling/overpressure of pressure vessel/system during ground operations.
10. Liquid freezing/thawing.
11. Damage to COPV.

l. HAZARD CONTROLS:

(See continuation sheet)

m. SAFETY VERIFICATION METHODS:

(See continuation sheet)

n. STATUS OF VERIFICATION:

(See continuation sheet)

o. APPROVAL	PAYLOAD ORGANIZATION	SSP/ISS
PHASE I		
PHASE II		
PHASE III	[signature] 1/14/10	

JSC Form 542B (Rev November 22, 1999) (MS Word September 1997)

PAYLOAD HAZARD REPORT CONTINUATION SHEET

a. NO: GHR-AMS02-004

b. PAYLOAD: Alpha Magnetic Spectrometer-02 (AMS-02) GSE

c. PHASE III

k. HAZARD CAUSES:

1. Structural failure of pressure vessels/systems.

l. HAZARD CONTROLS:

1.1 LHe supply dewars have an MDP of 4.14 bar (60 psig). The inner tank is designed to handle a maximum of 16.5 bar (240 psig). The outer shell is designed to handle a maximum of 2.1 bar (30 psig). The inner tank has been tested to 6.72 bar (97.5 psig).

1.2 GSE LHe supply dewar internal pressures will be limited to 10 psig ± 5% through the use of redundant relief valves (4) set at 10 psig ± 5% and through use of approved procedures. (Note: Relief pressure on the outer shell will be limited to 3-5 psig ± 5% by a pressure relief valve and pump-out port.)

1.3 The TRD GSE pressure systems will be designed to have a design burst pressure of 4 x MOP.

1.4 The Warm Helium Supply pressure system will be designed to have a design burst pressure of 4 x MOP.

~~1.4~~1.5 The RICH GSE will be designed to have a design burst pressure of 4 x MOP.

m. SAFETY VERIFICATION METHODS:

1.1.1 Review of manufacturer's data.

1.1.2 Proof tests will be performed on the GSE inner dewars at ~~TBD~~ 6.7 ~~psid~~ bar (> 1.5 x MAWP).

1.2.1. Review of design analysis of LHe supply dewars pressure relief system to ensure proper pressure relief valve setting was determined and to ensure adequate vent capacity.

1.2.2 QA verification on the relief valve settings.

1.3.1 Demonstration of positive margins of safety. (by means of test, analysis etc.)

1.3.2 Review of TRD design to ensure it has the proper design burst pressure.

1.4.1 Demonstration of positive margins of safety. (by means of test, analysis etc.)

1.4.2 Review of Warm Helium Supply design to ensure it has the proper design burst pressure.

1.5.1 Demonstration of positive margins of safety. (by means of test, analysis, etc.)

1.5.2 Review of RICH GSE design to ensure it has the proper design burst pressure.

n. STATUS OF VERIFICATION:

1.1.1 ~~Open~~Closed 08/07/2009. ESCG-4175-09-REENTES-MEMO-0054, *AMS-02 CGSE Design Review*, 08/07/2009.

1.1.2 ~~Open~~Closed 08/07/2009. ESCG-4175-09-REENTES-MEMO-0054, *AMS-02 CGSE Design Review*, 08/07/2009.

1.2.1 ~~Open~~Closed 08/07/2009. Wessington Cryogenics, Ltd. Design Calculations, *Relief Valve Requirements (Calculations for Helium)*, dated 12/23/2004.

1.2.2 ~~Open~~Closed 08/07/2009. ESCG-4175-09-REENTES-MEMO-0054, *AMS-02 CGSE Design Review*, 08/07/2009.

1.3.1 ~~Open~~Open. Luxfer Gas Cylinders Certificate issued on 04/03/2009.

1.3.2 Open. Luxfer Gas Cylinders Certificate issued on 04/03/2009.~~Open~~

1.4.1 Open

1.4.2 Open

1.5.1 Open

1.5.2 Open

PAYLOAD HAZARD REPORT CONTINUATION SHEET	a. NO: GHR-AMS02-004
b. PAYLOAD: Alpha Magnetic Spectrometer-02 (AMS-02) GSE	c. PHASE III

k. HAZARD CAUSES:

2 Structural failure of the flight cryosystem while mated to the GSE.

l. HAZARD CONTROLS:

2.1 The flight SFHe system incorporates burst disks and pressure relief devices so that the pressure will not exceed the Maximum Design Pressure (MDP) of the system. (See attached Cryogenic Schematic)

2.2 Design (pressure relief devices) and operational procedures of the CGSE will preclude introducing pressures that can exceed the flight system's MDP.

m. SAFETY VERIFICATION METHODS:

2.1.1 Analyses/Tests are being performed to verify the burst disks provide sufficient flow rate to prevent exceeding the MDP of the flight dewar system. (See attached preliminary results of the AMS-02 flight dewar system ground emergency venting analysis.)

2.1.2 Review of AMS-02 drawings showing burst disks and QA inspections of as-built hardware to approved drawings.

2.2.1 Review of CGSE design to ensure adequate pressure relief devices are used.

2.2.2 Review of CGSE operating procedures to ensure they provide steps and cautions to preclude overpressurization.

n. STATUS OF VERIFICATION:

2.1.1 ~~Open~~Closed 11/30/09. ESCG-4390-08-SP-MEMO-0017, *Helium Venting Analysis*, dated 05/15/08 and EA3-09-030, *AMS Burst Disk Vent Duct Redesign and Certification*, dated 11/17/09.
2.1.2 ~~Open~~Closed 12/21/09. ESCG-4295-09-CPAS-MEMO-0018, *Review of the AMS-02 Cryomagnet Acceptance Data Package*, dated 12/21/09.
2.2.1 Open
2.2.2 Open

PAYLOAD HAZARD REPORT CONTINUATION SHEET	a. NO: GHR-AMS02-004
b. PAYLOAD: Alpha Magnetic Spectrometer-02 (AMS-02) GSE	c. PHASE III

k. HAZARD CAUSES:

3. Puncture of the flight vacuum case.

l. HAZARD CONTROLS:

3.1 The flight dewar vacuum case has been designed to preclude puncture by an object falling on it in the Orbiter payload bay with the doors closed.

3.2 Procedural controls prevent hazardous objects from being left in the payload bay prior to launch.

3.~~2~~3 Procedural and area control will preclude operations that could lead to high energy impacts with the flight VC that could result in the rupture of the VC.

m. SAFETY VERIFICATION METHODS:

3.1.1 Structural analysis to verify that falling objects do not penetrate the vacuum case.

3.~~1~~2.~~2~~1 ~~Procedural controls prevent hazardous objects from being left in the payload bay prior to launch~~Review of procedures to ensure there is an inspection for potential hazardous objects.

3.~~2~~3.1 Review of AMS-02 procedures and KSC ~~S~~standard procedures for handling/lifting.

n. STATUS OF VERIFICATION:

3.1.1 ~~Open~~Closed. ESCG-4460-09-LODY-DOC-0050, *Penetration of the Alpha Magnetic Spectrometer (AMS)-02 Vacuum Case by Loose Falling Objects*, dated 4/16~~-April~~/~~-20~~09.

3.~~1~~2.~~2~~1 Open

3.~~2~~3.1 Open

PAYLOAD HAZARD REPORT CONTINUATION SHEET	a. NO: GHR-AMS02-004
b. PAYLOAD: Alpha Magnetic Spectrometer-02 (AMS-02) GSE	c. PHASE III

k. HAZARD CAUSES:

4. Puncture of GSE vacuum shrouds.

l. HAZARD CONTROLS:

4.1 The construction of the GSE dewars is strong enough to preclude puncture within an industrial environment.

m. SAFETY VERIFICATION METHODS:

4.1.1 Review of GSE dewar specifications to ensure adequate shroud strength.

n. STATUS OF VERIFICATION:

4.1.1 ~~Open~~Closed 08/07/2009. ESCG-4175-09-REENTES-MEMO-0054, *AMS-02 CGSE Design Review*, 08/07/2009.

PAYLOAD HAZARD REPORT CONTINUATION SHEET	a. NO: GHR-AMS02-004
b. PAYLOAD: Alpha Magnetic Spectrometer-02 (AMS-02) GSE	c. PHASE III

k. HAZARD CAUSES:

5. Improper handling during operation, transportation, lifting or securing of pressure vessels.

l. HAZARD CONTROLS:

5.1 Approved procedures will be used for operating, transporting, lifting, and securing AMS pressure vessels.

5.2 Handling personnel will be trained regarding the hazards associated with AMS-02 pressure vessels.

5.3 Operational restrictions/procedures for large tool control and machinery operations around pressure vessels.

m. SAFETY VERIFICATION METHODS:

5.1.1 Review and approval of procedures to ensure safe handling of GSE and flight hardware.

5.2.1 Review and approval of training and certification process of personnel.

5.3.1 Review and approval of procedures to restrict access.

n. STATUS OF VERIFICATION:

5.1.1 Open
5.2.1 Open
5.3.1 Open

PAYLOAD HAZARD REPORT CONTINUATION SHEET	a. NO: GHR-AMS02-004
b. PAYLOAD: Alpha Magnetic Spectrometer-02 (AMS-02) GSE	c. PHASE III

k. HAZARD CAUSES:

6. Blockage of vent line due to frozen impurities in He liquid or gas.

l. HAZARD CONTROLS:

6.1 He~~lium~~ will meet or exceed the purity standards of MIL-P-27407A.

6.2 Pressure relief valves operate at ambient pressure (>1ATM) to prevent backflow in cryogenic system.

6.3 LHe will be filtered to remove particles ≥ 2 microns before filling GSE supply dewars.

6.4 He tank is continuously evacuated of atmosphere by vacuum pumps.

6.5 Loss of pump power causes solenoid valves to close, preventing atmosphere from entering system.

m. SAFETY VERIFICATION METHODS:

6.1.1 Certification of purity standards ~~by test of delivered GHe included in procedures~~per certificate of conformance (COC) from the vendor.

6.2.1 Review of as-built hardware to ensure pressure relief devices are built as per design drawings.

6.3.1 Review of procedures which include the use of LHe filters to fill GSE supply dewars and on the line to fill the flight dewar from the GSE dewars.

6.4.1 Review of as-built hardware to ensure pressure relief devices are built as per design drawings.

6.5.1 Review of as-built hardware to ensure pressure relief devices are built as per design drawings.

n. STATUS OF VERIFICATION:

6.1.1 ~~Open~~Closed 11/16/09. ESCG-4295-09-CPAS-MEMO-0013, *Helium Purity Control*, 11/13/09.
6.2.1 ~~Open~~Closed 12/07. Product Certificate, Design Approval Letter TS1210210-2009, dated 09/28/2007, National Board inspection stamp on plates for both main and transfer dewars (CH1000-031 and CH1000-030) dated 2007.
6.3.1 Open
6.4.1 Open
6.5.1 Closed 11/09/09. ESCG-4295-09-CPAS-MEMO-0012, *AMS-02 Ground Pump Requirements*, dated 11/06/09.~~Open~~

PAYLOAD HAZARD REPORT CONTINUATION SHEET	a. NO: GHR-AMS02-004
b. PAYLOAD: Alpha Magnetic Spectrometer-02 (AMS-02) GSE	c. PHASE: III

k. HAZARD CAUSES:

7. Materials incompatibility.

l. HAZARD CONTROLS:

7.1 Design of system to be compatible with the specific material that it will hold.

7.2 All cleaning materials will be compatible with system materials and working fluids.

m. SAFETY VERIFICATION METHODS:

7.1.1 Review and approval by AMS Materials Group.

7.1.2 Review of design and procedures to ensure appropriate materials usage with hardware.

7.2.1 Review and approval by AMS Materials Group.

n. STATUS OF VERIFICATION:

7.1.1 ~~Open~~Closed 12/10/09. E-mail, "GSE Materials", between Chris Tutt (ESCG Project Manager) and Chia Chang (ESCG Materials Analysis), dated 12/07/09.

7.1.2 Open

7.2.1 Closed 12/10/09. E-mail, "GSE Materials", between Chris Tutt (ESCG Project Manager) and Chia Chang (ESCG Materials Analysis), dated 12/07/09.~~Open~~

PAYLOAD HAZARD REPORT CONTINUATION SHEET	a. NO: GHR-AMS02-004
b. PAYLOAD: Alpha Magnetic Spectrometer-02 (AMS-02) GSE	c. PHASE: III

k. HAZARD CAUSES:

8. Improper workmanship and/or assembly.

l. HAZARD CONTROLS:

8.1 System built to design drawings with documented assembly and quality assurance procedures.

8.2 Testing/Operations during operations at CERN and ESTEC validate systems prior to arrival at KSC.

m. SAFETY VERIFICATION METHODS:

8.1.1 QA review to ensure hardware is built per approved drawings.

8.1.2 QA review of as-built hardware to ensure it meets design.

8.2.1 Review of test/operational data from CERN and ESTEC.

n. STATUS OF VERIFICATION:

8.1.1 Closed 12/07. Product Certificate, Design Approval Letter TS1210210-2009, dated 09/28/2007, National Board inspection stamp on plates for both main and transfer dewars (CH1000-031 and CH1000-030) dated 2007. ~~Open~~

8.1.2 Closed 12/07. Product Certificate, Design Approval Letter TS1210210-2009, dated 09/28/2007, National Board inspection stamp on plates for both main and transfer dewars (CH1000-031 and CH1000-030) dated 2007. ~~Open~~

8.2.1 Open

PAYLOAD HAZARD REPORT CONTINUATION SHEET	a. NO: GHR-AMS02-004
b. PAYLOAD: Alpha Magnetic Spectrometer-02 (AMS-02) GSE	c. PHASE: III

k. HAZARD CAUSES:

9. Overfilling/overpressurization of pressure vessel/system during ground operations.

l. HAZARD CONTROLS:

9.1 Pressure relief devices prevent over pressurization (CGSE).

9.2 Filling procedures will preclude overfilling of pressure vessels.

9.3 GSE pressure vessels will meet the design requirements of KHB1700.7C, Section 4.3.3.1.3.a.

9.4 GSE pressure system components will meet the design requirements of KHB 1700.7C, Section 4.3.3.1.3.c.

m. SAFETY VERIFICATION METHODS:

9.1.1 Review and approval of pressure relief devices.

9.1.2 Review of design to confirm no blockages/obstructions for pressure relief valves during filling operations.

9.1.3 Inspection of as-built design to ensure proper valve installation.

9.2.1 Review of filling procedures to ensure there are steps and cautions to prevent overfilling.

9.3.1 Review of design schematics to ensure conformance with KHB1700.7C, Section 4.3.3.1.3.a.

9.4.1 Review of design schematics to ensure conformance with KHB 1700.7C, Section 4.3.3.1.3.c.

Note: Data used for pressure systems certification is located in a separate document. The document will accompany the hardware at KSC.

n. STATUS OF VERIFICATION:

9.1.1 ~~Open~~Closed 10/06/09. ESCG-4175-09-REENTES-MEMO-0054, AMS-02 CGSE Design Review, dated 08/07/09.

9.1.2 Open

9.1.3 Closed 12/07. Product Certificate, Design Approval Letter TS1210210-2009, dated 09/28/2007, National Board inspection stamp on plates for both main and transfer dewars (CH1000-031 and CH1000-030) dated 2007.~~Open~~

9.2.1 Open

9.3.1 Closed 10/06/09. ESCG-4175-09-REENTES-MEMO-0054, AMS-02 CGSE Design Review, dated 08/07/09.~~Open~~

9.4.1 Open. ESCG-4175-09-REENTES-MEMO-0054, AMS-02 CGSE Design Review, dated 08/07/09.~~Open~~

PAYLOAD HAZARD REPORT CONTINUATION SHEET	a. NO: GHR-AMS02-004
b. PAYLOAD: Alpha Magnetic Spectrometer-02 (AMS-02) GSE	c. PHASE: III

k. HAZARD CAUSES:

10. Liquid freezing/thawing within cryosystem pipes/components (excluding vents which are in Cause 6).

l. HAZARD CONTROLS:

10.1 Proper design and venting of dewars and GSE (Adequate insulation and drainage of condensation).

10.2 Proper operation of valves and proper procedures of GSE to eliminate atmosphere entering the system.

m. SAFETY VERIFICATION METHODS:

10.1.1 Thermal and pressure analysis to ensure proper insulation and drainage.

10.1.2 Review of design to ensure proper insulation and drainage.

10.1.3 Inspection of as built hardware to ensure proper insulation and drainage.

10.2.1 Review of design and as built hardware to ensure proper operation of valves.

10.2.2 Review of ground procedures to ensure steps and cautions are written to preclude atmosphere from entering the system.

10.2.3 Functional testing of pump and valves.

Note: Data used for pressure systems certification is located in a separate document. The document will accompany the hardware at KSC.

n. STATUS OF VERIFICATION:

10.1.1 Open

10.1.2 ~~Open~~Closed 08/07/2009. ESCG-4175-09-REENTES-MEMO-0054, *AMS-02 CGSE Design Review*, 08/07/2009.

10.1.3 Closed 12/07. Product Certificate, Design Approval Letter TS1210210-2009, dated 09/28/2007, National Board inspection stamp on plates for both main and transfer dewars (CH1000-031 and CH1000-030) dated 2007.~~Open~~

10.2.1 ~~Open~~Open. ESCG-4175-09-REENTES-MEMO-0061, *AMS-02 Cryomagnet Design Review*, 08/08/31/2009.

10.2.2 Open

10.2.3 Open

PAYLOAD HAZARD REPORT CONTINUATION SHEET	a. NO: GHR-AMS02-004
b. PAYLOAD: Alpha Magnetic Spectrometer-02 (AMS-02) GSE	c. PHASE: III

k. HAZARD CAUSES:

11. Damage to COPV.

l. HAZARD CONTROLS:

11.1 Damage control features will be implemented per the AMS-02 COPV Mechanical Damage Control Plan.

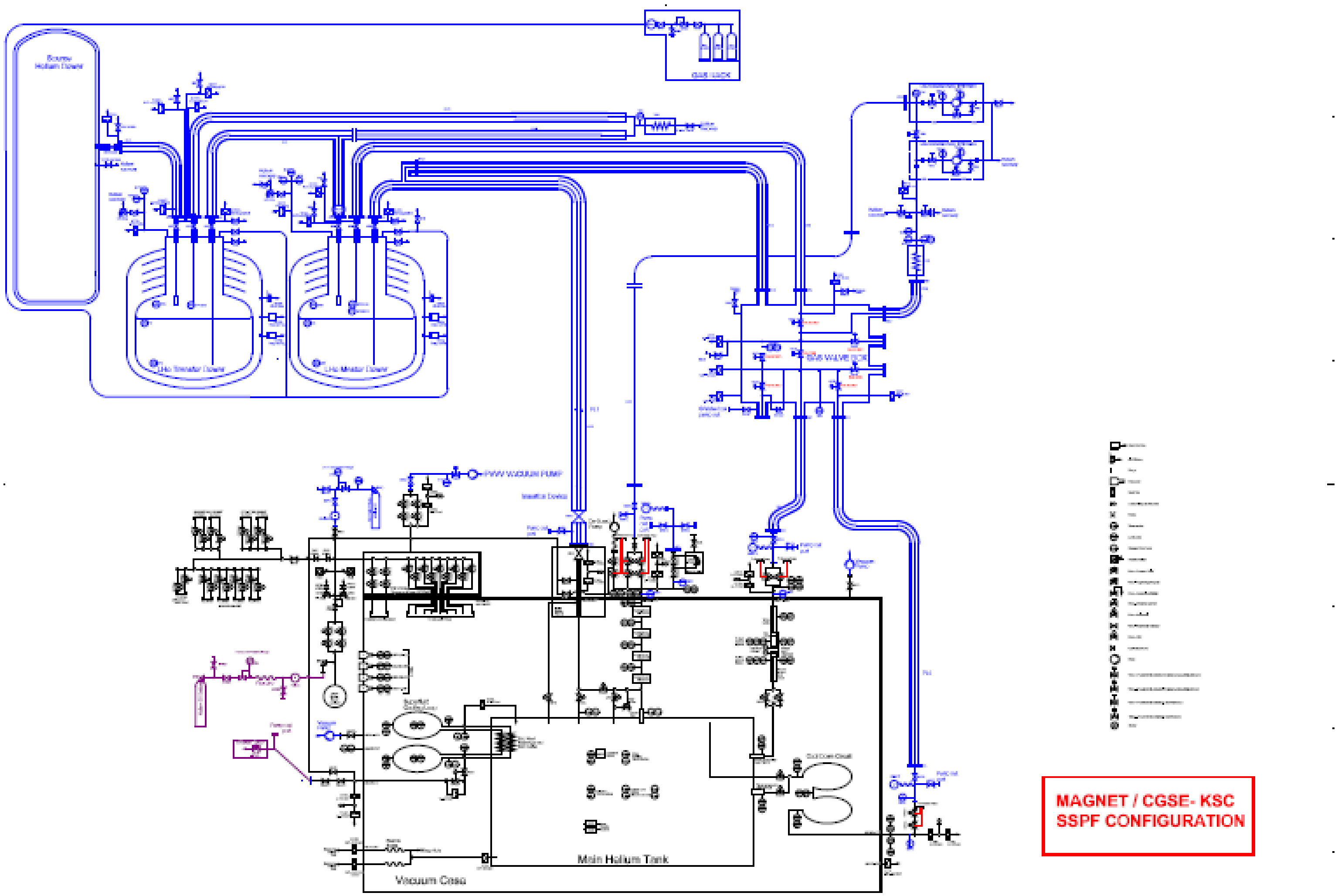
m. SAFETY VERIFICATION METHODS:

11.1.1 PO approval of AMS-02 COPV Mechanical Damage Control Plan with NASA concurrence.

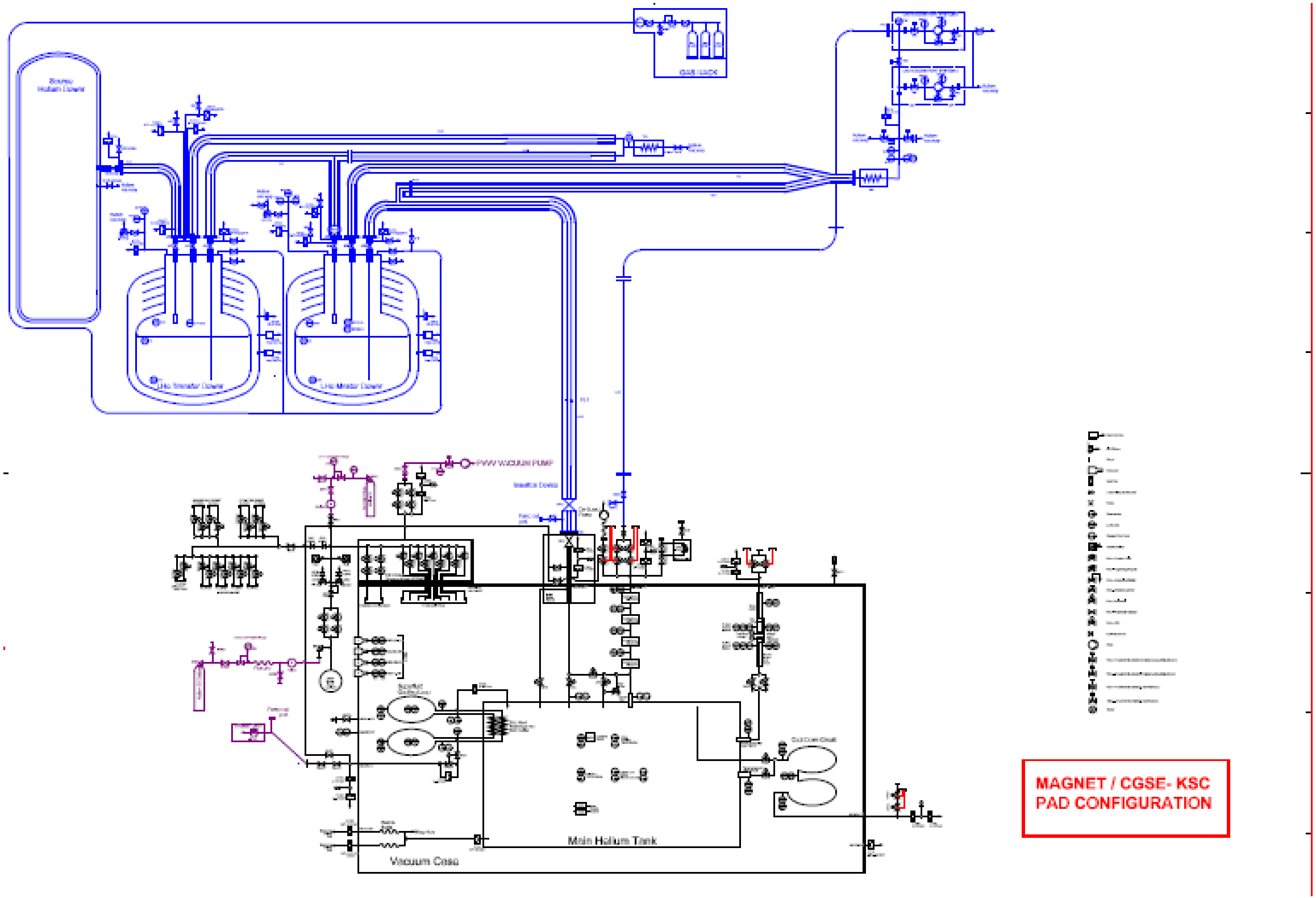
n. STATUS OF VERIFICATION:

11.1.1 ~~Open~~Closed 4/08 ~~April 20~~/09. ESCG-4390-09-SP-MEMO-002, *AMS-02 COPV Damage Control Plan*, dated 1/26/ ~~Jan~~

JSC Form 542B (Rev November 22, 1999) (MS Word September 1997)



AMS-02 Cryogenic Ground Support Equipment (CGSE) Schematic with AMS-02 Cryogenic System (SSPF)



AMS-02 Cryogenic Ground Support Equipment (CGSE) Schematic with AMS-02 Cryogenic System (Launch Pad)

GROUND SUPPORT PRESSURE SYSTEM COMPONENTS

Updated 05.03.2008		OUR APPLICATION		FROM PRODUCER		TESTED TO		FROM CALCULATION		SUPPLIED WITH EQUIPMENT	
Description	**Model Number, Producer**	**MAXIMUM OPERATING PRESSURE (MOP)**		**DESIGN MAXIMUM ALLOWABLE WORKING PRESSURE (MAWP)**		**Proof Pressure**		**Design Burst Pressure**		**Proof test date**	**COMMENTS (GAUGE OR REGULATOR RANGE, RELIEF SETTINGS, ETC.)**
		bar	**psid**	**bar**	**psid**	**bar**	**psid**	**bar**	**psid**		
Wessington LHe Master Dewar Model CH100 Serial No 031											
LHe vessel	CH1000, Wessington, England	0.69	10.00	4.14	60.00	5.70	97.5	16.5	240	05.02.2007	Pressure gauge range -1 to +4 bar, relief setting first burst disc 2 bar, second burst disc 3 bar, relief valve for 0.69 bar
Vacuum case (nominal with vacuum)	CH1000, Wessington, England	-1.00	-14.7	-1.0	-14.7	-1.00	-14.7	0.0	0.0	15.01.2007	relief setting less then 0.5 bar incorporated in self relieving vacuum pumping port
Vacuum case (Contingency with Burst Disk Release)	CH1000, Wessington, England	0.00	0.0	2.1	30.5	0.4	5.0	2.1	30.0		relief setting less then 0.5 bar incorporated in self relieving vacuum pumping port
Valves HVM1, HVM2, HVM3	model C5041-M11, Cryocomp, USA	0.69	10.00	10.3	150.0	15.5	225.0	according ASME MAWPx 4			Cryocomp, USA, stainless steel

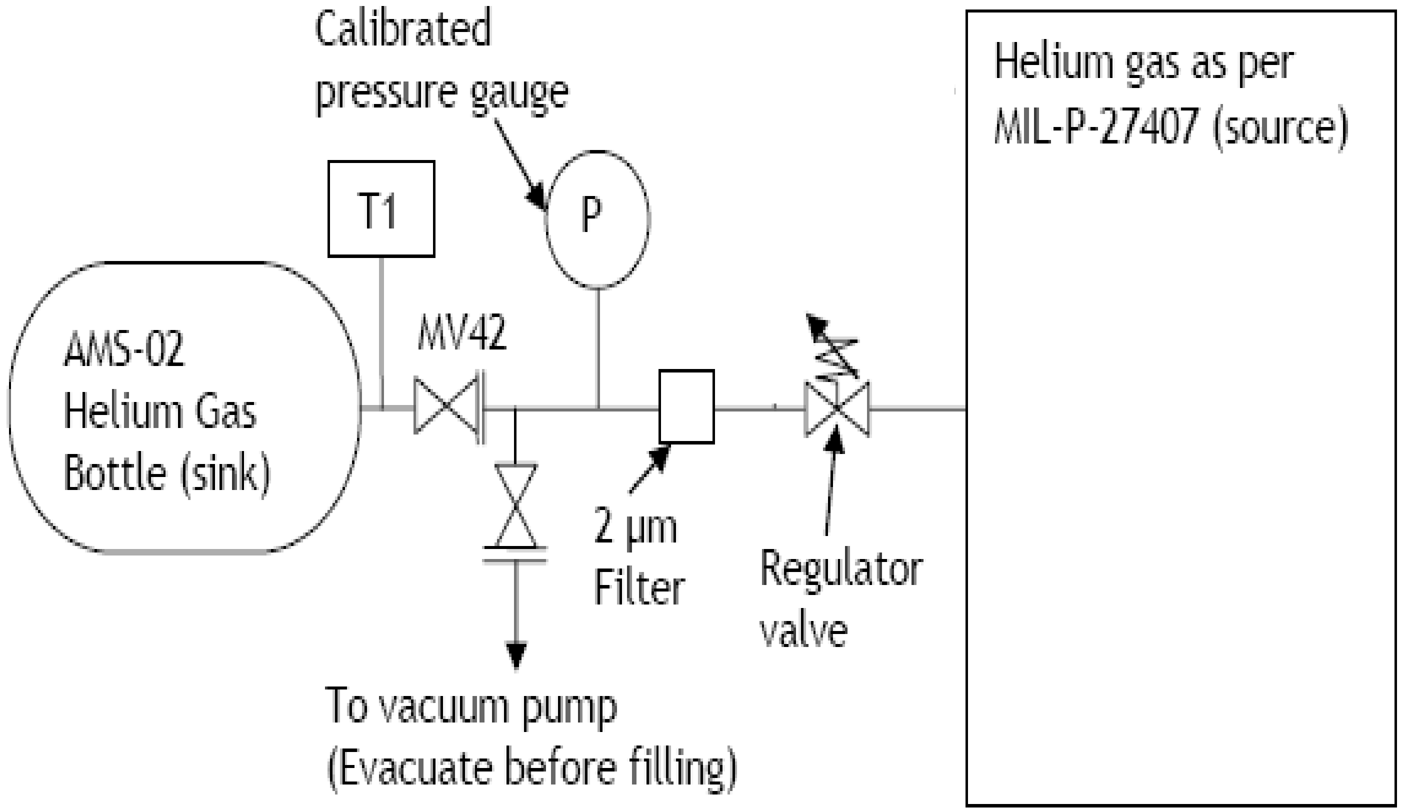
Valves for HV1,HV7,HVV	Kurt J.Lesker, SLO100MVQF	0.69	10.00	20.7	300.0	Accordin g ASME req.		Accordin g ASME req.			Lesker, SLO100MVQF
Valves for HV4, VH5, VH11	Hoke, USA 4551F2B Brass Body, Nickel Disc	0.69	10.00	20.7	300.0	Accordin g ASME req.		Accordin g ASME req.			Hoke, USA 4551F2B Brass Body, Nickel Disc
Low pressure control valve HVR1	CH2041LO	0.69	10.00	0.69	10.00			0.69	10.00		
First Burst disks HBD1	Type: Special 11/16’’LDV-G(FS) LaMOT Rupture Disc	0.69	10.00	2.0	30	N/A	N/A	2.0	30		Fike, USA, Brass body, Nickel disc
Second burst disks HBD2	Type: Special 11/16’’LDV-G(FS) LaMOT Rupture Disc	0.69	10.00	3.0	45	N/A	N/A	3.0	45		Fike, USA, Brass body, Nickel disc
Burst disks PL1BD, PL6BD,PL8BD	Fike	0.69	10.00	4.0	58.0	N/A	N/A	4.0	58.0		Fike, USA, Brass body, Nickel disc
Pressure sensor MP	DIXON ENGENEERING SUPPLIES	0.69	10.00								range -1 to +2 bar
Pressure sensor MP1	GE PTX7517	0.69	10.00								range -1 to +2 bar
Pressure sensor MP2	Micro MPM430	0.69	10.00	4.0	58.0						range 0…10 kPa
Feedthrough	DETORONICS DT02H-14-19PN	0.69	10.00								
Wessington LHe Transfer Dewar Model CH100 Serial No 030											
LHe vessel	CH1000, Wessington, England	0.69	10.00	4.14	60.00	5.70	97.5	16.5	240	05.02.2007	Pressure gauge range -1 to +4 bar, relief setting first burst disc 2 bar, second burst disc 3 bar, relief valve for 0.69 bar

Vacuum case (nominal with vacuum)	CH1000, Wessington, England	-1.00	-14.7	-1.0	-14.7	-1.00	-14.7	0.0	0.0	15.01.2007	relief setting less then 0.5 bar incorporated in self relieving vacuum pumping port
Vacuum case (Contingency with Burst Disk Release)	CH1000, Wessington, England	0.00	0.0	2.1	30.5	0.4	5.0	2.1	30.0		relief setting less then 0.5 bar incorporated in self relieving vacuum pumping port
Valves TVM1, TVM2, TVM3	model C5041-M11, Cryocomp, USA,	0.69	10.00	10.3	150.0	15.5	225.0	according ASME MAWPx 4			Cryocomp, USA, stainless steel
Valves for TV1,TV7,TVV	Kurt J.Lesker, SLO100MVQF	0.69	10.00	20.7	300.0	According ASME req.		According ASME req.			Lesker, SLO100MVQF
Valves for TV4,TV5,TV11	Hoke, USA 4551F2B Brass Body, Nickel Disc	0.69	10.00	20.7	300.0	According ASME req.		According ASME req.			Hoke, USA 4551F2B Brass Body, Nickel Disc
Low pressure control valve TVR1	CH2041LO	0.69	10.00	0.69	10.00			0.69	10.00		
First Burst disks HBD1T	Type: Special 11/16’’LDV-G(FS) LaMOT Rupture Disc	0.69	10.00	2.0	30	N/A	N/A	2.0	30		Fike, USA, Brass body, Nickel disc
Second burst disks HBD2T	Type: Special 11/16’’LDV-G(FS) LaMOT Rupture Disc	0.69	10.00	3.0	45	N/A	N/A	3.0	45		Fike, USA, Brass body, Nickel disc
Burst disks PL1BDT, PL6BDT,PL14BD2	Fike	0.69	10.00	4.0	58.0	N/A	N/A	4.0	58.0		Fike, USA, Brass body, Nickel disc
Pressure sensor TP	DIXON ENGENEERING SUPPLIES	0.69	10.00								range -1 to +2 bar

Pressure sensor TP1	GE PTX7517	0.69	10.00								range -1 to +2 bar
Feedthrough	DETORONICS DT02H-14-19PN	0.69	10.00								
Cryogenic lines											
Line PL1+PL10 made by DeMaCo	DeMaCo, Holland	0.69	10.00	4.50	65.27	6.75	97.90	18.0	261.07	TBD DeMaCo[1]	
Line PL2 made by DeMaCo	DeMaCo, Holland	0.69	10.00	4.50	65.27	6.75	97.90	18.0	261.07	TBD DeMaCo	
Spare Line PL1+PL10 made by Chengdu	Chengdu, China	0.69	10.00	4.50	65.27	6.75	97.90	18.0	261.07	29.01.2007[2]	
Spare Line PL2 made by Chengdu	Chengdu, China	0.69	10.00	4.50	65.27	6.75	97.90	18.0	261.07	29.01.2007	
Line PL3	Chengdu, China	1.30	18.85	16.00	232.06	24.00	348.09	min 96.0[3]	1392.36	29.01.2007	
Line PL4	Chengdu, China	0.60	8.70	16.00	232.06	24.00	348.09	min 96.0	1392.36	29.01.2007	
Line PL5	Chengdu, China	0.60	8.70	16.00	232.06	24.00	348.09	min 96.0	1392.36	29.01.2007	
Line PL6	Chengdu, China	0.69	10.01	16.00	232.06	24.00	348.09	min 96.0	1392.36	29.01.2007	
Line PL7	Chengdu, China	0.60	8.70	16.00	232.06	24.00	348.09	min 96.0	1392.36	29.01.2007	
Line PL8	Chengdu, China	0.69	10.01	16.00	232.06	24.00	348.09	min 96.0	1392.36	29.01.2007	
Line PL9	Chengdu, China	0.60	8.70	16.00	232.06	24.00	348.09	min 96.0	1392.36	29.01.2007	
Line PL11	Chengdu, China	2.00	29.01	16.00	232.06	24.00	348.09	min 96.0	1392.36	29.01.2007	
Line PL12	Chengdu, China	1.00	14.50	16.00	232.06	24.00	348.09	min 96.0	1392.36	29.01.2007	
Line PL13	Chengdu, China	1.00	14.50	16.00	232.06	24.00	348.09	min 96.0	1392.36	29.01.2007	
Line PL14	Chengdu, China	0.69	10.01								
G valve box											
G valve box vacuum case (nominal with vacuum)	Lanzhou, China	-1.00	-14.7	-1.0	-14.7	-1.00	-14.7	0.0	0.0		
G valve box vacuum case (Contingency with Burst Disk Release)	Lanzhou, China	0.00	0.0	0.8	11.6	2.1	30.5	7.95	115.3		
G valve box pipes system	Lanzhou, China	1.00	14.5	16.0	232.1	16.00	232.1	17.42	252.7		

Heat exchanger VH1											
Heat exchanger VH1	Chengdu, China	0.69	10.01	16.00	232.06	24.00	348.09	min 96.0	1392.36		
L valve box											
L valve box vacuum case (nominal with vacuum)	Lanzhou, China	-1.00	-14.7	-1.0	-14.7	-1.00	-14.7			31.08.2007	
L valve box vacuum case (Contingency with Burst Disk Release)	Lanzhou, China	0.00	0.0	0.8	11.6	2.1	30.5	14.5	210.9		
Filter 1 and pipes	Lanzhou, China	2.00	29.01	10.00	145.04	10.00	10.00			02.09.2007	
Valves											
WEKA valves VVP1, VVP2, VVP3, VVP5, VVP6, VVP7, VVP8, VVP9, VVM1, VVM3, VVM4, VVM5, VVM6, CVP5, CVC1, CVP1, CVP2, CVP3, CVP4, CVP6, CVP7, CVR3, LVP	Weka, Switzerland	2.00	29.01	16.00	232.06	24.00	348.09	96.0	1392.36	VVP5, VVM1, VVP9, VVM6: 26.08.05; VVM2,VVM3, VVM4, VVM5: 16.08.05; LVP: 08.08.05; VVP6, VVP2, VVP8, CVP1, CVP3: 28.06.05; VVP1, VVP3, CVP4, CVP5, CVC1: 29.06.05; CVP6: 2005-06-24; CVP2: 30.06.05; CVP7:01.07.05;	
Vacuum valve VVM8 for G valve box		-1.00	-14.50	-1.00		Tested -1.0 and +32					
Pressure relief valve VVR3 in G valve box	8V1-C08L-10-V-SS-C3 2VN, Parker, USA	0.60	8.70	16.00	232.06	24.00	348.09				
Pressure reducer LVC	Parker instrumentation IR4002	200.00	2900.75	276.0	4000.00	414.0	6004.56	828.0	12009.12		
Other Valves											
Valve NV of LN2 tank		2.00	29.01	20.00	290.08						

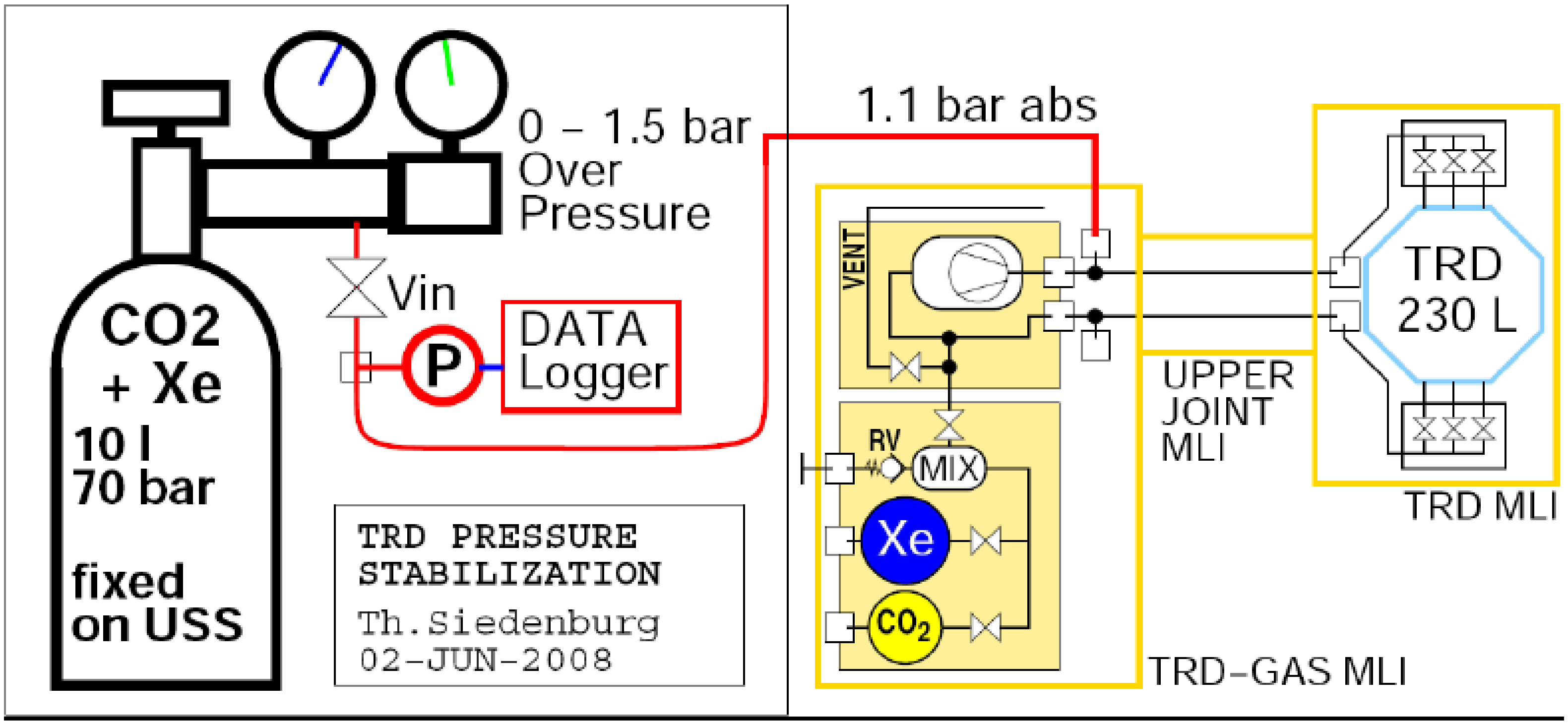
Valves PVP1, PVP2 of vacuum pump system		0.50	7.25	0.50	7.25						
Valves for gas analysis CGA1, CGA2, VGA1, VGA2, LGA	SS-6BRG-MM, Swagelok	1.00	14.50	16.00	232.06						
Pressure Sensors											
PX1005L1 range 0 to 50 psia (all numbers in psia)		2.00	29.01	3.45	50.00	6.90	100	10.34	150		
HP (2pieces)		1.00	14.50	2.00	29.01						
CP1		0.60	8.70	2.00	29.01						
CP2		2.10	30.46	3.00	43.51						
VP1		0.69	10.01	6.00	87.02						
VP2		1.00	14.50	4.50	65.27						
VP3		2.00	29.01	1.00	14.50						
LP		1.00	14.50	9.00	130.53						
Burst disks											
Burst Disk CBD1		3.00	43.51	3.00	43.51	N/A	N/A	3.00	43.51		
Burst Disk CBD2, VBD1		2.30	33.36	2.30	33.36	N/A	N/A	2.30	33.36		
Burst Disk CBD3, VBD3, VBD8		0.80	11.60	0.80	11.60	N/A	N/A	0.80	11.60		
Burst Disk VBD2, VBD4, VBD5, VBD6, VBD7, VBD9, VBD10, LBD, PL8BD2, PL14BD1, HBD3		3.00	43.51	3.00	43.51	N/A	N/A	3.00	43.51		
Air compressor	**Hitachi, 2.2P-9.5V5C**	7.00	101.53	9.30	134.89	10.5	152.29				
Air dryer	**HCA-1.1HC, Han Ye Inc., China**	3.00	43.51	11.00	159.54	16.5	239.31			Apr-14-2007	



Warm Helium Gas System Schematic (Minus the AMS-02 He Gas Bottle and He Source)

GROUND SUPPORT PRESSURE SYSTEM COMPONENTS

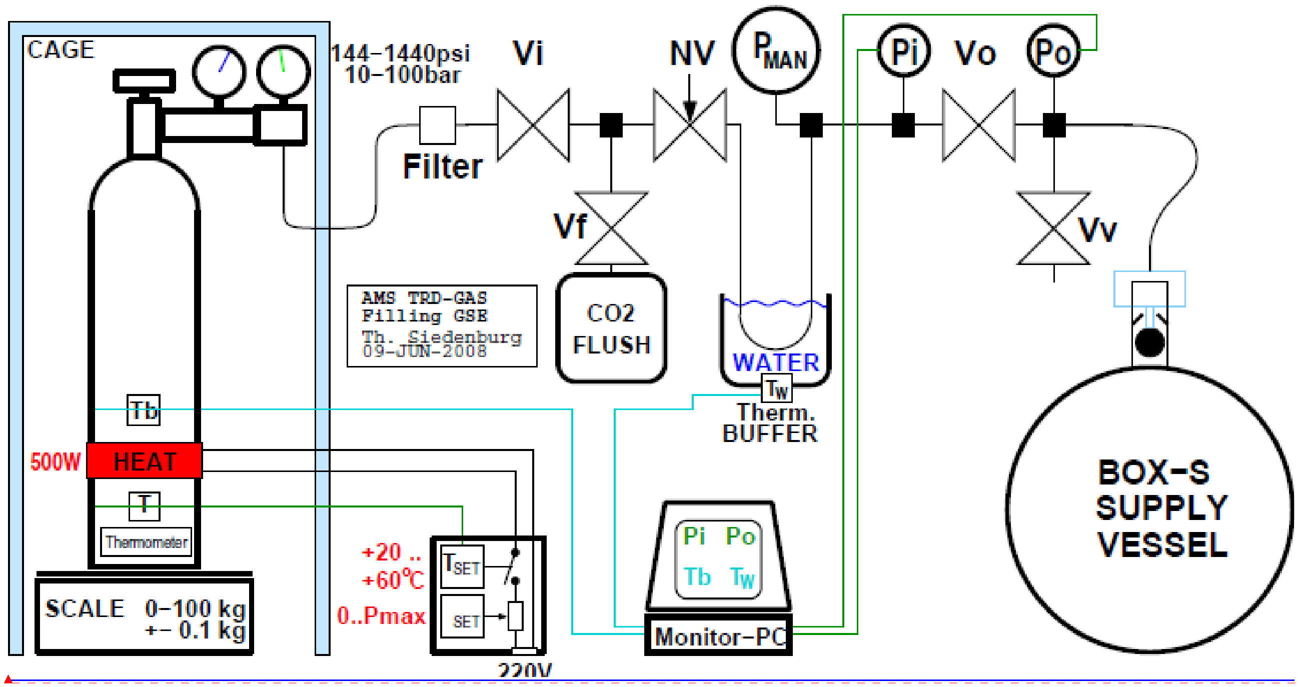
COMPONENT	MAXIMUM OPERATING PRESSURE (MOP)	DESIGN MAXIMUM ALLOWABLE WORKING PRESSURE (MAWP)	PROOF PRESSURE	DESIGN BURST PRESSURE	PROOF TEST DATE	**COMMENTS** (GAUGE OR REGULATOR RANGE, RELIEF SETTINGS, ETC.)
Warm Helium System-TBD						

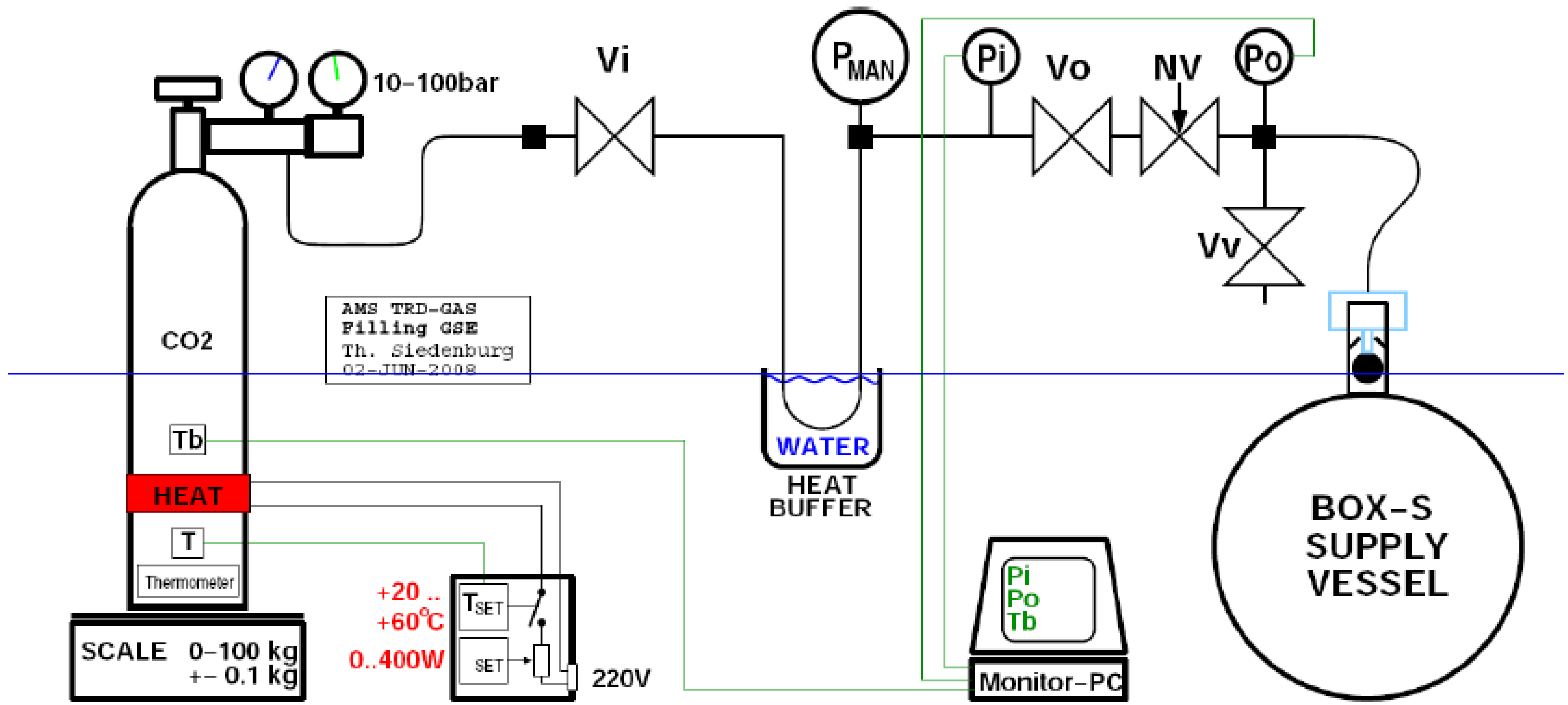


Schematic of TRD Pressure Stabilization System

GROUND SUPPORT PRESSURE SYSTEM COMPONENTS

COMPONENT	MAXIMUM OPERATING PRESSURE (MOP)	DESIGN MAXIMUM ALLOWABLE WORKING PRESSURE (MAWP)	PROOF PRESSURE	DESIGN BURST PRESSURE	PROOF TEST DATE	**COMMENTS** (GAUGE OR REGULATOR RANGE, RELIEF SETTINGS, ETC.)
TRD Pressure Stabilization System						
Commercial gas bottle	70 bar (1029 psia)	200 bar (2940 psia)	300 bar (4410 psia)	?	March 2009	Regulator 1-2 bar abs. (15-30 psia)
1/8” stainless steel tubing	2 bar abs (30 psia)					Relief valve in Box-C opens at 1.7 bar diff. (25 psid)

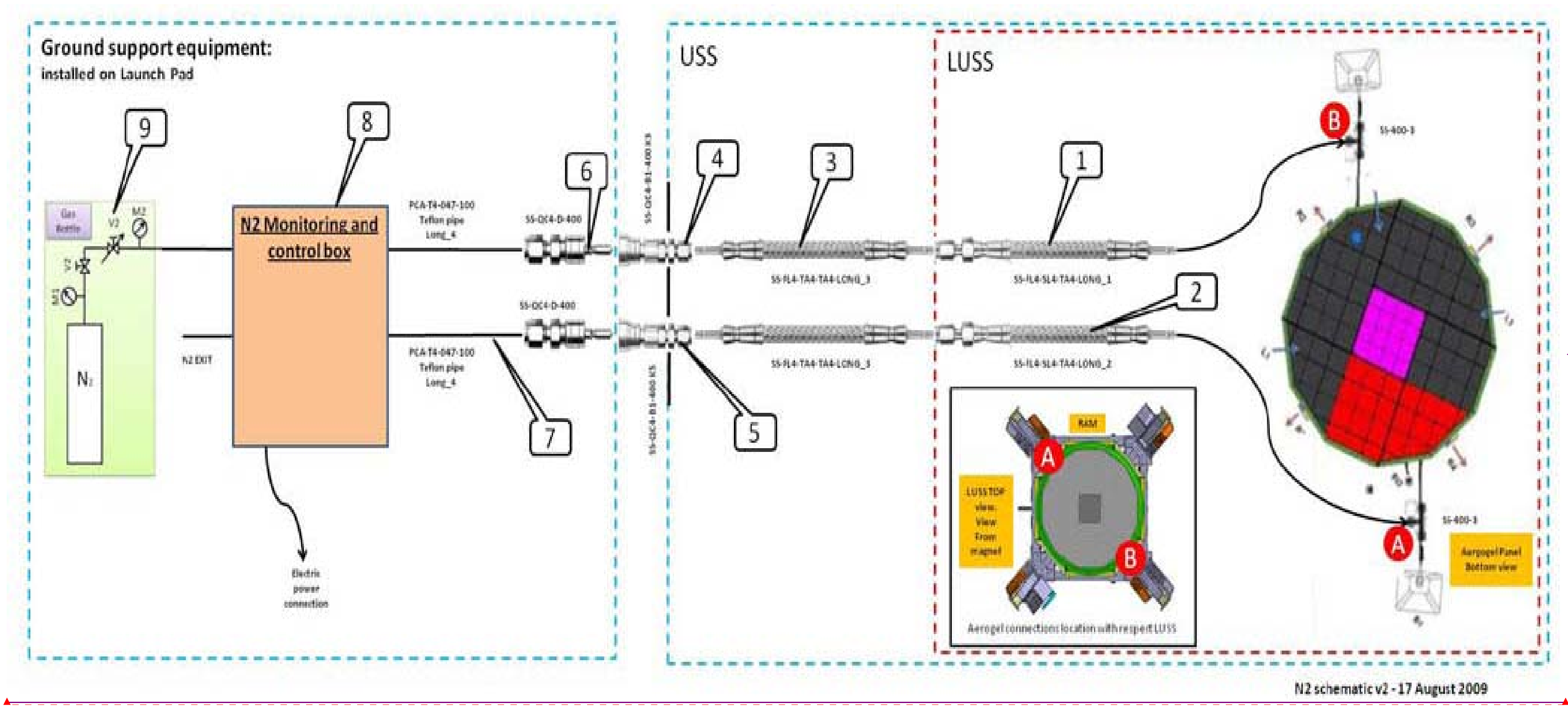

CAGE
144–1440psi
10–100bar
Vi
NV
PMAN
Pi
Vo
Po
Filter
Vf
Vv
AMS TRD-GAS
Filling GSE
Th. Siedenburg
09-JUN-2008
CO2
FLUSH
WATER
Tw
Therm.
BUFFER
Tb
500W
HEAT
T
Thermometer
SCALE 0–100 kg
+– 0.1 kg
+20 ..
+60℃
0..Pmax
TSET
SET
220V
Pi Po
Tb Tw
Monitor–PC
BOX–S
SUPPLY
VESSEL



CO2 Supply Filling System (Xenon System the Same)

GROUND SUPPORT PRESSURE SYSTEM COMPONENTS

COMPONENT	MAXIMUM OPERATING PRESSURE (MOP)	DESIGN MAXIMUM ALLOWABLE WORKING PRESSURE (MAWP)	PROOF PRESSURE	DESIGN BURST PRESSURE	PROOF TEST DATE	**COMMENTS** (GAUGE OR REGULATOR RANGE, RELIEF SETTINGS, ETC.)
TRD Xe and CO_2 Resupply System-TBD						
Commercial gas bottles						
a) Xenon b) CO2	60 bar (882 psia) 60 bar (882 psia)	200 bar (2940 psia) 200 bar (2940 psia)	300 bar (4410 psia) 300 bar (4410 psia)	? ?	Available when bought Available when bought	both with regulator 0-100 bar (0-1470 psia)
¼” stainless steel tubing	60 bar (882 psia)	200 bar (2940 psia)		880 bar (12800 psi)		
1/8” stainless steel tubing	60 bar (882 psia)	200 bar (2940 psia)		880 bar (12800 psi)		
Pressure Gauge Omega	60 bar (882 psia)	200 bar (2940 psia)	> 400 bar (5880psi)			
Pressure Gauge Manual	60 bar (882 psia)	100 bar (1470 psia)				


Ground support equipment:
installed on Launch Pad
USS
LUSS
9
8
6
4
3
1
2
7
5
N2 Monitoring and control box
PCA-T4-047-100
Teflon pipe
Long_4
SS-QC4-D-400
N2 EXIT
Electric power connection
SS-FL4-TA4-TA4-LONG_3
SS-FL4-SL4-TA4-LONG_1
SS-FL4-SL4-TA4-LONG_2
SS-400-3
RAM
LUSS TOP view. View From magnet
Aerogel connections location with respect LUSS
Aerogel Panel Bottom view
A
B
N2 schematic v2 - 17 August 2009

RICH GSE

ITEM	QTY	COMPONENT DESCRIPTION	COMPONENT NAME	MAXIMUM OPERATING PRESSURE (MOP)	DESIGN MAXIMUM ALLOWABLE WORKING PRESSURE (MAWP) DESIGN MAXIMUM ALLOWABLE	PROOF PRESSURE	DESIGN BURST PRESSURE	PROOF PRESSURE TEST DATE	COMMENTS (GAUGE OR REGULATOR RANGE, RELIEF SETTINGS, ETC.)
1	1	N2 Bottle and Regulator (K)	N2 Standard K bottle	200 bar	200 bar		NA		Standard COT's K Bottle.
2	3	Pressure Valves	Pressure Valves				NA		
3		P1 (Gauge 1)	P1 (Gauge 1)	315 bar	315 bar		NA		
4		P2 (Gauge 2)	P2 (Gauge 2)	16 bar	16 bar		NA		
5		P3 (Gauge 3)	P3 (Gauge 3)	2.5 bar	2.5 bar		NA		
6	1	Monitoring and Control Box		2.5 bar	NA*	NA*	NA	NA*	
7	ar	Teflon pipe	PFA-T4-047-100	2.5 bar	200 (13.7) (at 70F) **	NA*	1757.9 psi (121 bar)	NA*	
8	2	Quick Disconnects male	SS-QC4-D-400	2.5 bar	3000psi (206 bar)	NA*	Based on Tube Data	NA*	
9	1	Quick Disconnects female	SS-QC4-B1-400K5	2.5 bar	3000psi (206 bar)	NA*	Based on Tube Data	NA*	
10	1	Quick Disconnects female	SS-QC4-B1-400K3	2.5 bar	3000psi (206 bar)	NA*	Based on Tube Data	NA*	
11	2	Connector	SS-400-61	2.5 bar	8000psi (550 bar)	NA*	Based on Tube Data	NA*	
12	2	T-Connector	SS-400-3	2.5 bar	8000psi (550 bar)	NA*	Based on Tube Data	NA*	

Notes

* Fluid system that contains this component operates at a pressure just slightly above atmosphere and is in effect a venting /purge system by design. The fluid system with the exception of the Nitrogen bottle item 1 is not desinged or intended to maintain pressure.

**Zues Technical Bulletin on approximate Burst Pressure Rating for PFA Tubing.

http://www.zeusinc.com/technicalservices/technicalbulletins/technicalinformation/burstpressure.aspx

Tensile Strength T = 4000psi (approximate)

$$P=\frac{T(x^2-y^2)}{y^2\left(1+\frac{x^2}{y^2}\right)}$$

P=Burst Pressure

$x=\frac{OD}{2}$

$y=\frac{ID}{2}$

T=Tensile Strength

P (Burst for PFA-T4-047-100) approximate 1757.9 psi (121 bar)

PAYLOAD HAZARD REPORT	a. NO: GHR-AMS02-005
b. PAYLOAD: Alphamagnetic Spectrometer-02 (AMS-02) GSE	c. PHASE: III

d. SUBSYSTEM: Pressure Systems	e. HAZARD GROUP: Injury/Illness	f. DATE: January 2010
g. HAZARD TITLE: Exposure to High-Pressure Gas plume effects.		i. HAZARD CATEGORY ☒ CATASTROPHIC ☐ CRITICAL

h. APPLICABLE SAFETY REQUIREMENTS:

KHB 1700.7C, Section: 4.4.2.1.b. Oxygen Deficient Atmospheres and 4.4.4 Toxic Materials.

j. DESCRIPTION OF HAZARD

Exposure of personnel to vented gases (gas plume) leads to an asphyxiation, high velocity gas, projectile, and/or touch temperature hazard.

k. HAZARD CAUSES:

1 Exposure to high-pressure gas and/or cold He gas at vents or pressure relief devices on the AMS-02 payload, GSE He supply dewars or TRD GSE pressure systems due to equipment failure or operator error.

2 Exposure to high pressure gas at AMS-02 payload or CGSE supply dewar vents during normal fill/transfer operations.

3. Improper handling, assembly or operations of gas systems.

(Note: Some operations will occur with partially filled cryogenic containers and some connectors may be changed during operations.)

l. HAZARD CONTROLS:

(See continuation sheet)

m. SAFETY VERIFICATION METHODS:

(See continuation sheet)

n. STATUS OF VERIFICATION:

(See continuation sheet)

o. APPROVAL	PAYLOAD ORGANIZATION	SSP/ISS
PHASE I		
PHASE II		
PHASE III	[signature] 1/7/10	

JSC Form 542B (Rev November 22, 1999) (MS Word September 1997)

PAYLOAD HAZARD REPORT CONTINUATION SHEET	a. NO: GHR-AMS02-005
b. PAYLOAD: Alphamagnetic Spectrometer-02 (AMS-02) GSE	c. PHASE III

k. HAZARD CAUSES:

1. Exposure to high-pressure and/or cold gas at vents or pressure relief devices on the AMS-02 payload or GSE pressure systems due to equipment failure or operator error.

l. HAZARD CONTROLS:

1.1 Vents and relief devices will be directed out of the work area by proper GSE set-up design or by use of vent shields and deflectors.

1.2 Labels clearly identifying vents and relief devices will be provided to warn personnel of potential gas plume locations.

1.3 Low risk vents will be identified and those vents will not require shields, deflectors or diffusers due to the low probability of venting or the low vent rate.

1.4 AMS-02 operations do not require personnel in the vicinity of high volume vents during manual operations.

1.5 Use of PPE during direct operations on Cryogenic systems.

m. SAFETY VERIFICATION METHODS:

1.1.1 Review of ground layout to show that vents ~~lines are appropriately sized and secured to~~are directed ~~venting~~ outside the work area~~ and to prevent lines whipping~~.

1.2.1 QA inspection of warning labels to verify they are located at each vent and pressure relief device.

1.3.1 PO ~~KSC review~~ ~~R~~review and provide to GSRP ~~of~~ the AMS-02 venting analysis and labeling plan.

1.4.1 Review of manual operations to ensure personnel not in high volume vent areas.

1.5.1 Review AMS-02 procedures to ensure use of PPE.

n. STATUS OF VERIFICATION:

1.1.1 ~~Open~~Closed 11/16/09. ESCG-4295-09-CPAS-MEMO-0014, *Review of AMS-02 Vent Locations*, 11/13/09.
1.2.1 Open
1.3.1 Open
1.4.1 Open
1.5.1 Open

PAYLOAD HAZARD REPORT CONTINUATION SHEET	a. NO: GHR-AMS02-005
b. PAYLOAD: Alphamagnetic Spectrometer-02 (AMS-02) GSE	c. PHASE III

k. HAZARD CAUSES:

2. Exposure to high pressure gas at AMS-02 payload or CGSE supply dewar vents during normal fill/transfer operations, assembly.

l. HAZARD CONTROLS:

2.1 Personnel will use appropriate protective clothing (e.g., face shield, gloves, apron, etc.) during fill/transfer operations.

2.2 Access to payload and GSE supply dewars will be limited during fill/transfer operations.

2.3 Labels clearly identifying vents and cold surfaces will be provided to warn personnel to stay clear.

2.4 Personnel training in fill/transfer operations will be provided.

2.5 CGSE will include clear and obvious indications when filling operations are taking place.

m. SAFETY VERIFICATION METHODS:

2.1.1 Review of procedures to ensure appropriate PPE is included.

2.2.1 Review of procedures to ensure listing of limited access areas. Procedures stating obvious markings (cones, ropes, warning tape etc) to identify filling operations.

2.3.1 QA inspection of warning labels to verify they are located at each vent and on all cold surfaces.

2.4.1 Certification of personnel cryogen handling training.(AMS-02 retains a master list of personnel and certifications)

2.5.1 Review of CGSE operational hardware/procedures to indicate when active filling operations are occurring.

n. STATUS OF VERIFICATION:

2.1.1 Open
2.2.1 Open
2.3.1 Open
2.4.1 Open
2.5.1 Open

PAYLOAD HAZARD REPORT CONTINUATION SHEET	a. NO: GHR-AMS02-005
b. PAYLOAD: Alphamagnetic Spectrometer-02 (AMS-02) GSE	c. PHASE III

k. HAZARD CAUSES:

3. Improper handling, assembly, or operations of gas systems.
(Note: some operations will occur with partially filled cryogenic containers and some connectors may be changed during operations)

l. HAZARD CONTROLS:

3.1 Assembly procedures to ensure proper installation (PPE will be called out when necessary).

3.2 Operating procedures listing mandatory inspection points (MIP's) and listing the required PPE needed during the operations.

3.3 Visual inspection of hardware for leaks during testing.

3.4 Only trained personnel will be in the area during gas systems operations.

m. SAFETY VERIFICATION METHODS:

3.1.1 Review and approval of AMS-02 procedures to ensure proper installation of hardware.

3.2.1 Review and approval of AMS-02 procedures to ensure that MIPs are included in operating procedures.

3.3.1 QA review and approval of successful AMS-02 and CGSE functional test.

3.4.1 Review of AMS procedures to ensure only trained personnel are allowed in the area during operations.

n. STATUS OF VERIFICATION:

3.1.1 Open
3.2.1 Open
3.3.1 Open
3.4.1 Open

PAYLOAD HAZARD REPORT

PAYLOAD HAZARD REPORT	a. NO: GHR-AMS02-006
b. PAYLOAD: Alpha Magnetic Spectrometer-02 (AMS-02) GSE	c. PHASE: III

d. SUBSYSTEM: CGSE, Flight Cryogenic System	e. HAZARD GROUP: Touch Temperatures	f. DATE: January 2010

g. HAZARD TITLE:
Injury to Personnel due to Excessively Low Temperatures.

i. HAZARD CATEGORY

☒ CATASTROPHIC

☐ CRITICAL

h. APPLICABLE SAFETY REQUIREMENTS:

KHB 1700.7, Section 4.2.1.5 Temperature

j. DESCRIPTION OF HAZARD:

Excessively low temperatures present touch temperature hazards to ground personnel. (Below 0°C or 32°F)

k. HAZARD CAUSES:

1. Inadequate insulation of cryogen systems.
2. Release of cryogenic material.
3. Accumulation of ice/liquefaction of air on cryogenic equipment.

l. HAZARD CONTROLS:

(See continuation sheet)

m. SAFETY VERIFICATION METHODS:

(See continuation sheet)

n. STATUS OF VERIFICATION:

(See continuation sheet)

o. APPROVAL	PAYLOAD ORGANIZATION	SSP/ISS
PHASE I		
PHASE II		
PHASE III	[signature] 1/14/10	

PAYLOAD HAZARD REPORT CONTINUATION SHEET	a. NO: GHR-AMS02-006
b. PAYLOAD: Alpha Magnetic Spectrometer-02 (AMS-02) GSE	May 2008 PHASE:III

k. HAZARD CAUSES:

1 Inadequate insulation of cryogen systems.

l. HAZARD CONTROLS:

1.1 Proper design of cryogen systems. Plumbing has either vacuum insulation or high R value insulation to preclude excessively cold contact potential.

1.2 Keep-out zones will be marked for those areas that exceed touch temperature limits.

1.3 PPE to be used by personnel who are working with cryogenic systems.

m. SAFETY VERIFICATION METHODS:

1.1.1 Review of design to ensure proper insulation.

1.1.2 Inspection of as built hardware to ensure proper insulation.

1.1.3 Thermal ~~Analysis~~ analysis/operational data of touch temperatures at external surfaces of dewars and plumbing.

1.2.1 Inspection of AMS-02 and GSE for proper labeling of keep-out zones.

1.3.1 Review of procedures to ensure personnel are issued PPE.

n. STATUS OF VERIFICATION:

1.1.1 ~~Open~~Closed 08/07/2009. ESCG-4175-09-REENTES-MEMO-0054, *AMS-02 CGSE Design Review*, 08/07/2009.
1.1.2 Open
1.1.3 Open
1.2.1 Open
1.3.1 Open

PAYLOAD HAZARD REPORT CONTINUATION SHEET	a. NO: GHR-AMS02-006
b. PAYLOAD: Alpha Magnetic Spectrometer-02 (AMS-02) GSE	May 2008 c. Phase III

k. HAZARD CAUSES:

2. Release of cryogenic material.

l. HAZARD CONTROLS:

2.1 The SFHe vents are positioned to preclude impingement of very cold gases upon critical structures, systems, and work areas. The area that AMS-02 is in while at KSC (SSPF, PCR, etc.) ,will determine how the vents are positioned.

2.2 Cryogenic systems will be monitored -by trained personnel via flight and ground monitoring equipment to identify any leaks or other cryogenic system fault and apply appropriate corrective procedures.

m. SAFETY VERIFICATION METHODS:

2.1.1 Review of design to ensure the inclusion of vents.

2.1.2 Inspection of as built hardware to determine the proper positioning of vents.

2.1.3 Venting analysis to determine positioning of vents.

2.1.4 Thermal analysis to ensure the positioning of vents will not adversely affect structures, systems, and work areas.

2.1.5 ~~Keep-out zones posted around vent areas~~Review of procedure for diverter installation, taking into consideration where AMS-02 is located.

2.1.6 CGSE will include clear and obvious indications of which portions of the flight hardware and GSE contain cryogenic fluids.

2.2.1 Verification of training of those personnel handling cryogenic systems.

n. STATUS OF VERIFICATION:

2.1.1 ~~Open~~Closed, 11/13/09. ESCG-4295-09-CPAS-MEMO-0014, *Review of AMS-02 Vent Locations*, 11/13/09.
2.1.2 Closed, 11/13/09. ESCG-4295-09-CPAS-MEMO-0014, *Review of AMS-02 Vent Locations*, 11/13/09.~~Open~~
2.1.3 Closed, 11/13/09. ESCG-4295-09-CPAS-MEMO-0014, *Review of AMS-02 Vent Locations*, 11/13/09.~~Open~~
2.1.4 Closed, 11/13/09. ESCG-4295-09-CPAS-MEMO-0014, *Review of AMS-02 Vent Locations*, 11/13/09.~~Open~~
2.1.5 Open
2.1.6 Open
2.2.1 Open

PAYLOAD HAZARD REPORT CONTINUATION SHEET	a. NO: GHR-AMS02-006
b. PAYLOAD: Alpha Magnetic Spectrometer-02 (AMS-02) GSE	May 2008 c. Phase III

k. HAZARD CAUSES:

3. Accumulation of ice/liquefaction of air on cryogenic equipment.

l. HAZARD CONTROLS:

3.1 Proper insulation of cryogenic system to preclude accumulation of ice.

3.2 If insulation has been found to be inadequate in specific areas where the potential for air liquefaction is possible, “diapers” or “catch pans”, as appropriate, will be used to preclude excessive cold contact with neighboring systems and structures.

3.3 Use of localized heaters (i.e. warm air blowers) to preclude formation of ice.

3.4 Warning signs will be placed on those areas where ice might accumulate.

m. SAFETY VERIFICATION METHODS:

3.1.1 Review of design to ensure proper installation of cryogenic system.

3.2.1 ~~Preflight Thermal Analysis~~Operational measurements to ensure all hazardous areas are properly insulated.

3.2.2 Review of design to ensure proper placement of “diapers” and “catch pans”.

3.2.3 Inspection of installed “diapers” and “catch pans”.

3.3.1 Review of AMS procedures to ensure placement of heaters.

3.4.1 Review of AMS procedures to ensure placement of warning signs.

n. STATUS OF VERIFICATION:

~~4.1.1~~3 ~~Open~~Closed 08/07/2009. ESCG-4175-09-REENTES-MEMO-0054, *AMS-02 CGSE Design Review*, 08/07/2009.
~~4.2.1~~3 Open
~~4.3.1~~3 Open
3.2.3 Open
3.3.1 Open
3.4.1 Open

PAYLOAD HAZARD REPORT

a. NO: GHR-AMS02-007

b. PAYLOAD: Alpha Magnetic Spectrometer-02 (AMS-02) GSE

c. PHASE: III

d. SUBSYSTEM:
CGSE, TRD, Warm He System, Associated Flight Hardware

e. HAZARD GROUP:
Injury, Illness

f. DATE:
January 2010

g. HAZARD TITLE:

Loss of breathable atmosphere in KSC facilities.

i. HAZARD CATEGORY

☒ CATASTROPHIC

☐ CRITICAL

h. APPLICABLE SAFETY REQUIREMENTS:

KHB 1700.7, ~~section~~ Section 4.3.3.1.3.j, 4.4.2 Hazardous Atmosphere.

j. DESCRIPTION OF HAZARD:

Non-breathable gas leaks causes asphyxiation during ground support operations.

k. HAZARD CAUSES:

1. Leakage/Release of oxygen displacing gases.
2. Prolonged close proximity to a gas release location causes personnel to suffer from reduced oxygen availability (deprivation).
3. Helium Tank burst disk rupture or other off-nominal venting in canister during transport to the pad.

NOTE: Rupture of pressurized systems/dewars and pressurized lines addressed in hazard reports GHR-AMS02-003, GHR-AMS02- 004. Flight Hazard Reports are AMS-02-F03 and AMS-02-F05.

l. HAZARD CONTROLS:

(See continuation sheet)

m. SAFETY VERIFICATION METHODS:

(See continuation sheet)

n. STATUS OF VERIFICATION:

(See continuation sheet)

o. APPROVAL	PAYLOAD ORGANIZATION	SSP/ISS
PHASE I		
PHASE II		
PHASE III		

PAYLOAD HAZARD REPORT CONTINUATION SHEET	a. NO: GHR-AMS02-007
b. PAYLOAD: Alpha Magnetic Spectrometer-02 (AMS-02) GSE	c. PHASE III

k. HAZARD CAUSES:

1. Leakage/Release of oxygen displacing gases.

l. HAZARD CONTROLS:

1.1 Accumulation of oxygen displacing gases within all rooms and facilities where AMS-02 Flight and Ground sources of gases (compressed or cryogenic) will be precluded by providing adequate ventilation to account for all nominally vented/unvented gas evolution (as from a dewar) or inadvertent release.

1.2 Oxygen sensors will be used to monitor any volume of air where oxygen displacing gases may accumulate and analysis indicates a potential for reducing ambient concentrations of oxygen below 19.5%.

1.3 Personnel will be trained regarding evacuation procedures for the event of an alarm warning.

1.4 Condition of AMS cryogenic systems will be monitored by AMS CGSE. This system will provide appropriate warnings to personnel ~~to~~ well before a vent occurs.

m. SAFETY VERIFICATION METHODS:

1.1.1 Oxygen displacement/accumulation analyses for Helium, Xenon, Carbon Dioxide, Nitrogen release into each KSC location for GSE and flight hardware to assure that a >19.5% oxygen concentration will be maintained or that sources that will not maintain that level are identified for venting/additional control.

1.1.2 Review of venting design/installation requirements to ensure there is adequate ventilation.

1.1.3 Inspection of as built/installed venting provisions to ensure there is adequate ventilation.

1.2.1 Verification of O_2 level monitoring and warning system(s) in all handling and operational procedures involving the flight hardware and GSE gas supplies.

1.2.2 Monitor and warning systems will be adjusted/calibrated to account for the sensor bias when in a helium environment.

1.3.1 Certification of personnel training on evacuation procedures.

1.4.1 CGSE monitor and warning system will be tested prior to use at KSC.

1.4.2 CGSE warning levels will be verified by procedure.

n. STATUS OF VERIFICATION:

1.1.1 ~~Open~~Closed 04/08/09. ESCG-490-08-SP-MEMO-0017, *Helium Venting Analysis*, dated 05/15/08.
1.1.2 Closed 04/08/09. ESCG-490-08-SP-MEMO-0017, *Helium Venting Analysis*, dated 05/15/08. This memo details the helium leak scenarios the different facilities at KSC. Venting installation was deemed to be unnecessary.~~Open~~
1.1.3 Closed 04/08/09. ESCG-490-08-SP-MEMO-0017, *Helium Venting Analysis*, dated 05/15/08. This memo details the helium leak scenarios the different facilities at KSC. Venting installation was deemed to be unnecessary.~~Open~~
1.2.1 Open
1.2.2 Open
1.3.1 Open
1.4.1 Open
1.4.2 Open

PAYLOAD HAZARD REPORT CONTINUATION SHEET	a. NO: GHR-AMS02-007
b. PAYLOAD: Alpha Magnetic Spectrometer-02 (AMS-02) GSE	c. Phase III

k. HAZARD CAUSES:

2. Prolonged close proximity to a gas release location causes personnel to suffer from reduced oxygen availability (deprivation).

l. HAZARD CONTROLS:

2.1 Nominal operations will not require proximity to uncontrolled evolution of oxygen displacing gases.

2.2 Labels will be provided which clearly indicate vent, relief, or other sources of oxygen displacing gases to warn personnel.

m. SAFETY VERIFICATION METHODS:

2.1.1 Operational procedures analysis will ensure that work locations avoid potential oxygen depletion zones or streams.

2.2.1 QA inspection of warning labels to verify that they are appropriately sized and located.

n. STATUS OF VERIFICATION:

2.1.1 Open
2.2.1 Open

PAYLOAD HAZARD REPORT CONTINUATION SHEET	a. NO: GHR-AMS02-007
b. PAYLOAD: Alpha Magnetic Spectrometer-02 (AMS-02) GSE	c. Phase III

k. HAZARD CAUSES:

3. Helium Tank burst disk rupture or other off-nominal venting in canister during transport to the pad.

l. HAZARD CONTROLS:

3.1 Proper venting to preclude displacement of oxygen.

3.2 Measurement of atmosphere for adequate oxygen levels prior to allowing personnel into canister.

3.3 Requirement that during any entry while AMS-02 is in the canister that PPE be used~~/available~~ for each person within the confined volume.

m. SAFETY VERIFICATION METHODS:

3.1.1 Inspection of layout of payload and GSE in canister.

3.2.1 Review of procedures for entering canister to ensure adequate atmospheric testing is included.

3.3.1 Review of procedures for entering canister to ensure that PPE is called out.

n. STATUS OF VERIFICATION:

3.1.1 Open
3.2.1 Open
3.3.1 Open

PAYLOAD HAZARD REPORT		a. NO: GHR-AMS02-009
b. PAYLOAD: Alpha Magnetic Spectrometer-02 (AMS-02) GSE		c. PHASE: III
d. SUBSYSTEM: GHE Lifting Equipment	e. HAZARD GROUP: Structures	f. DATE: January 2010
g. HAZARD TITLE: Structural failure of hardware during ground handling/moving/operations.		i. HAZARD CATEGORY ☒ CATASTROPHIC ☐ CRITICAL

h. APPLICABLE SAFETY REQUIREMENTS:

KHB1700.7C

For Structural Failure of Flight Hardware, see AMS- 02-F01.

j. DESCRIPTION OF HAZARD:

Structural failure or inadvertent separation of the AMS-02 lifting equipment could result in injury to personnel and/or damage to STS/ISS equipment, payloads, ground support equipment and/or facilities.

(Note: The eyebolts on the Lower USS-02 Shipping Cover are not permanently attached.)

k. HAZARD CAUSES:

1. Inadequate structural design of the AMS-02 lifting equipment.
2. Structural deterioration of the AMS-02 lifting equipment due to use or aging.
3. Improper attachment of the AMS-02 swivel hoist rings.
4. Overload of the AMS-02 lifting equipment.
5. Improper assembly of the AMS-02 lifting equipment.
6. Personnel error.

l. HAZARD CONTROLS:

(See continuation sheet)

m. SAFETY VERIFICATION METHODS:

(See continuation sheet)

n. STATUS OF VERIFICATION:

(See continuation sheet)

o. APPROVAL	PAYLOAD ORGANIZATION	SSP/ISS
PHASE I		
PHASE II		
PHASE III	[signature] 1/14/10	

PAYLOAD HAZARD REPORT CONTINUATION SHEET	a. NO: GHR-AMS02--009
b. PAYLOAD: Alpha Magnetic Spectrometer-02 (AMS-02) GSE	c. Phase III

k. HAZARD CAUSES:

1. Inadequate structural design of the AMS-02 lifting equipment.

l. HAZARD CONTROLS:

1.1. The AMS-02 lifting equipment is being designed to a safety factor of 5:1 against ultimate for all crane lifting operations. For forklift operations, the Lower USS-02 Support Fixture is being designed to a safety factor of 3:1 against yield. For dolly towing (5 mph), the PSS is being designed to a safety factor of 2:1 against yield and 3:1 against ultimate. (See attached AMS-02 Ground Support Lifting/Handling Equipment Matrix)

m. SAFETY VERIFICATION METHODS:

1.1.1 Stress analyses will be performed to verify the proper safety factors defined in KHB 1700.7C were used.

1.1.2 Load testing and tagging of all AMS-02 lifting hardware.

n. STATUS OF VERIFICATION:

1.1.1 Open
1.1.2 Open

PAYLOAD HAZARD REPORT CONTINUATION SHEET	a. NO: GHR-AMS02-009
b. PAYLOAD: Alpha Magnetic Spectrometer-02 (AMS-02) GSE	c. Phase III

k. HAZARD CAUSES:

2. Structural deterioration of the AMS-02 lifting equipment due to use or aging.

l. HAZARD CONTROLS:

2.1 Nondestructive Inspection (NDI) will be performed on AMS-02 shackles, swivel hoist rings, eyebolts that are not permanently attached, and master link assemblies.

2.2 The AMS-02 lifting equipment will be visually inspected each day prior to use and structural inspections for proper identification of load rating and expiration date will be performed per KHB 1700.7C, Section 4.5.1.2.d.

m. SAFETY VERIFICATION METHODS:

2.1.1 Review AMS-02 records to ensure NDI was performed.

2.2.1 Review of AMS-02 lifting procedures to ensure inspections are included.

n. STATUS OF VERIFICATION:

2.1.1 Open
2.2.1 Open

PAYLOAD HAZARD REPORT CONTINUATION SHEET	a. NO: GHR-AMS02-009
b. PAYLOAD: Alpha Magnetic Spectrometer-02 (AMS-02) GSE	c. Phase III

k. HAZARD CAUSES:

3. Improper attachment of the AMS-02 swivel hoist rings.

l. HAZARD CONTROLS:

3.1 Torque values and visual inspections for AMS-02 swivel hoist rings and removable eyebolts will be specified on AMS-02 drawings to ~~assure~~ ensure full thread engagement after mounting.

m. SAFETY VERIFICATION METHODS:

3.1.1 Review of AMS-02 drawings to ensure requirements are called out on them.

3.1.2 QA reports documenting that installed hardware meet requirements.

n. STATUS OF VERIFICATION:

3.1.1 Open
3.1.2 Open

PAYLOAD HAZARD REPORT CONTINUATION SHEET

a. NO: GHR-AMS02-009

b. PAYLOAD: Alpha Magnetic Spectrometer-02 (AMS-02) GSE

c. Phase III

k. HAZARD CAUSES:

4. Overload of the AMS-02 lifting equipment.

l. HAZARD CONTROLS:

4.1 The AMS-02 lifting equipment will be posted with the equipment identification, next required test date, quality control stamp, rated load, proof load and proof load date.

m. SAFETY VERIFICATION METHODS:

4.1.1 QA inspections/verifications that the AMS-02 lifting equipment is properly posted/tagged.

n. STATUS OF VERIFICATION:

4.1.1 Open

PAYLOAD HAZARD REPORT CONTINUATION SHEET	a. NO: GHR-AMS02-009
b. PAYLOAD: Alpha Magnetic Spectrometer-02 (AMS-02) GSE	c. Phase III

k. HAZARD CAUSES:

5. Improper assembly of the AMS-02 lifting equipment.

l. HAZARD CONTROLS:

5.1. Part and serial numbers for components of the AMS-02 lifting equipment that are normally disassembled will be specified on drawings and in procedures to assure proper reassembly.

5.2 Approved drawings and procedures will be used for reassembly of the AMS-02 lifting equipment.

Lower USS Shipping Assembly cover has removable eyebolts with shoulders to ensure proper determination of full thread engagement.

m. SAFETY VERIFICATION METHODS:

5.1.1 Review of AMS-02 drawings and procedures for the AMS-02 lifting equipment.

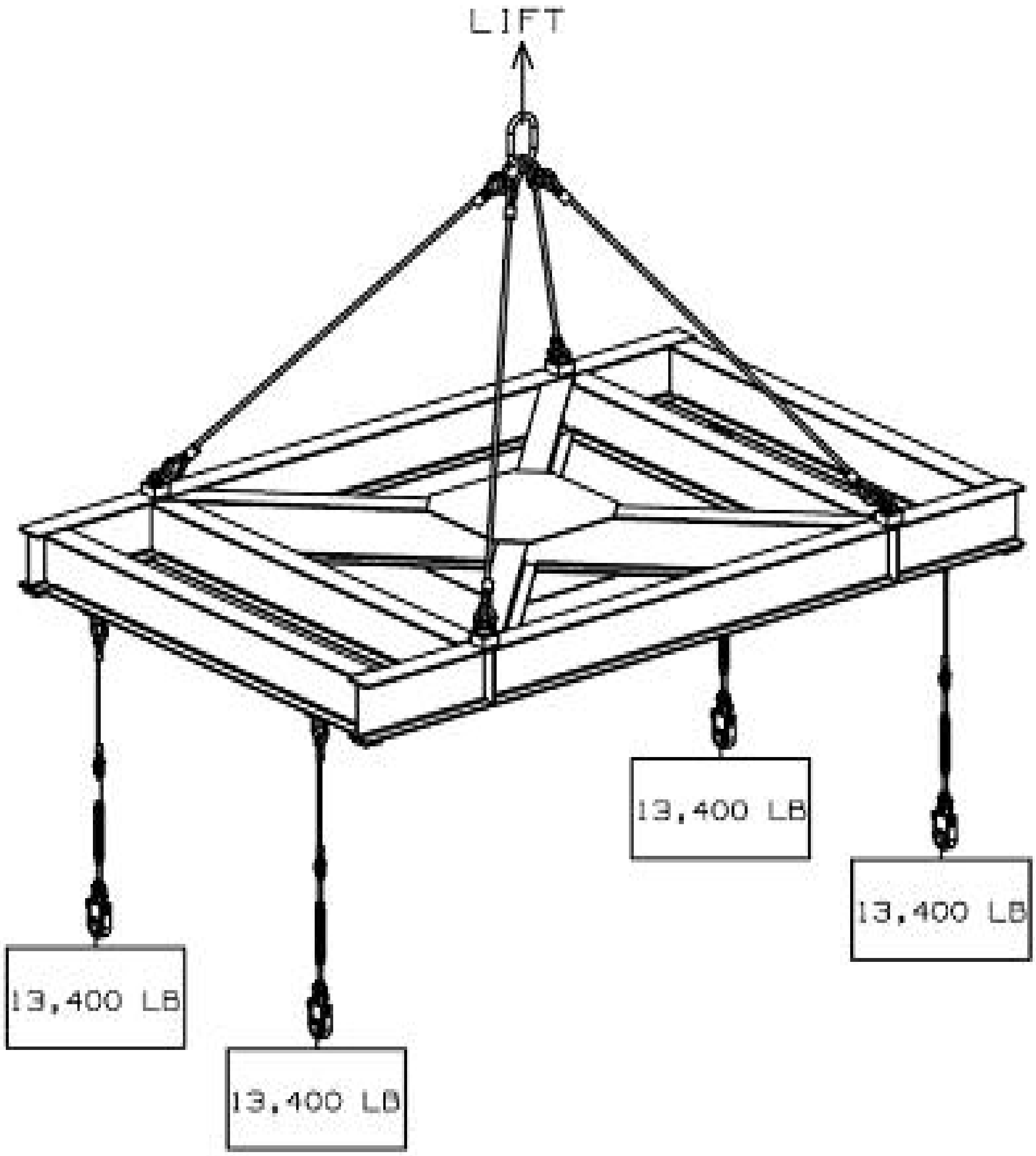
5.2.1 Review of AMS-02 procedures for reassembly instructions and QA inspections/verifications of proper reassembly.

5.3.1 Inspection of eyebolt insertion to ensure proper engagement.

n. STATUS OF VERIFICATION:

5.1.1 Open
5.2.1 Open
5.3.1 Open

PAYLOAD HAZARD REPORT CONTINUATION SHEET	a. NO: GHR-AMS02--009
b. PAYLOAD: Alpha Magnetic Spectrometer-02 (AMS-02) GSE	c. Phase III
k. HAZARD CAUSES: 6. Personnel error.	
l. HAZARD CONTROLS: 6.1 All lifts will be accomplished by approved procedures.	
m. SAFETY VERIFICATION METHODS: 6.1.1 AMS-02 will participate in lift procedure development per AMS-02 Launch Site Safety Plan.	
n. STATUS OF VERIFICATION: 6.1.1 Open	



Primary Lifting Fixture (PLF)

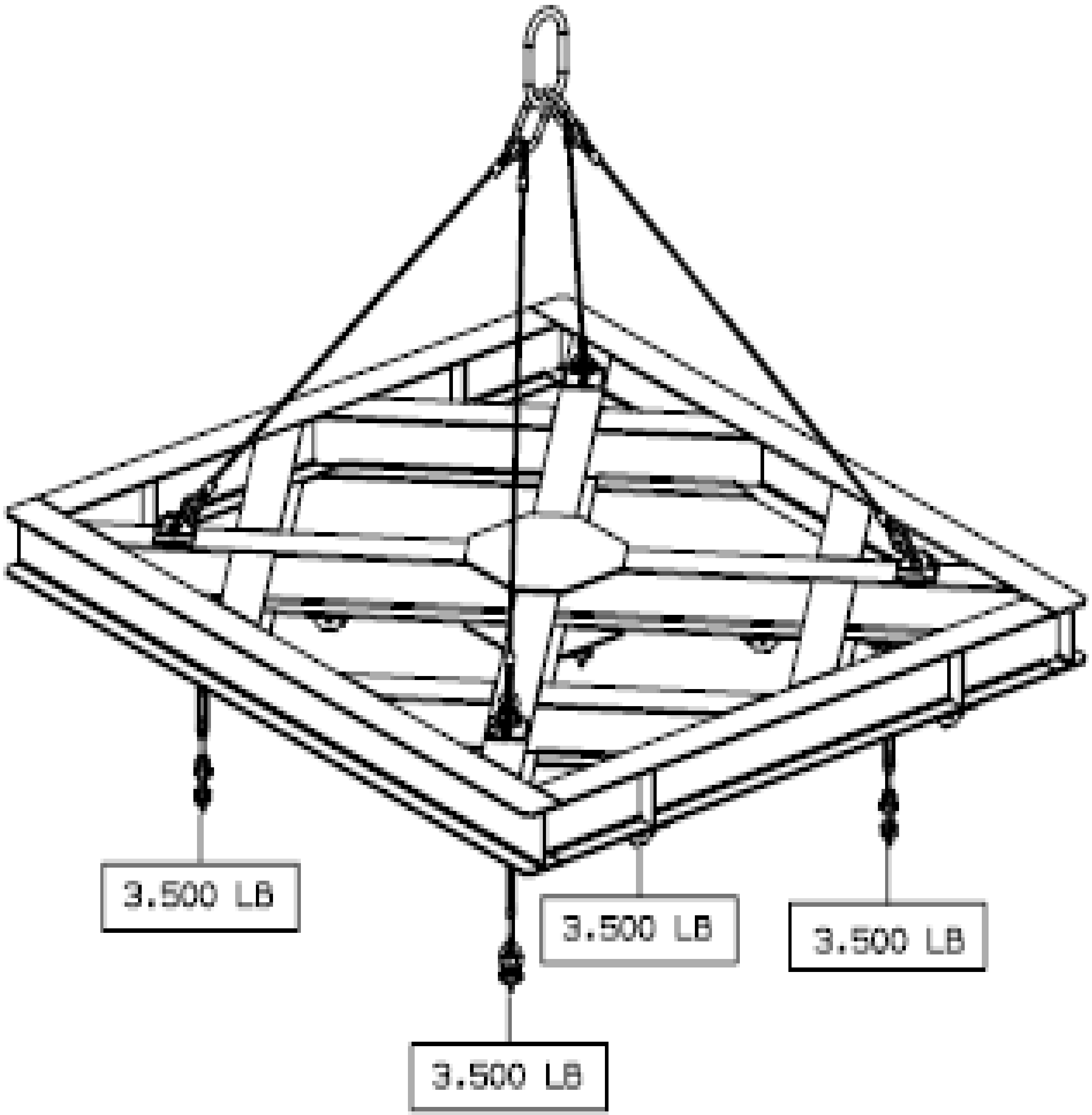
GROUND SUPPORT LIFTING/HANDLING EQUIPMENT MATRIX

DESIGNATOR NUMBER	ITEM NAME	SLING (Note 1)		CRIT WELDS (Note 2)		ACTUAL LOADS (lbs)	RATED LOADS (lbs)	PROOF LOAD (lbs)	SAFTY FACTOR (Note 3)		VERIFICATION STATUS
		Met	Syn	Yes	No				Ult	Yield	
SEG38117112-301	Primary Lifting Fixture Hoist	X			X	25,600	26,800	53,600	<5	<3	Stress Analysis Completed per ESCG-4450-06-STAN-DOC-0049
SEG38117112-303	Assembly Max (-305) 190.8 in (Length) x 123.8 in (Width) x 187.4 in (Height)	X			X	25,600	26,800	53,600	<5	<3	
SEG38117112-305	Material: A-36 Steel	X			X	25,600	26,800	53,600	<5	<3	
SEG38117112-307		X			X	25,600	26,800	53,600	<5	<3	
SEG38117112-309		X			X	25,600	26,800	53,600	<5	<3	

Notes: 1 Identify whether slings are Metallic (Met) or Synthetic (Syn) by placing an "X" in the appropriate column. For synthetic slings, see Table 4-1 of KHB 1700.7 for the required safety factors and proof load test criteria.

2 Denote whether to the device has a critical weld by placing an "X" in the appropriate column. If there are critical welds, other test may to applicable (see KHB 1700.7 para. 4.5.1.1.D). A critical weld is a weld, which constitutes a single point of failure. Where feasibly, critical welds should be eliminated.

3 Per KHB 1700.7, Table 4-1, the safety factor shall be given in Ultimate:Rated. For structural members, a 3:1 safety factor against worst case failure mode that will result in local yielding is acceptable.



Multi-Purpose Lifting Fixture

GROUND SUPPORT LIFTING/HANDLING EQUIPMENT MATRIX

DESIGNATOR NUMBER	ITEM NAME	SLING (Note 1)		CRIT WELDS (Note 2)		ACTUAL LOADS (lbs)	RATED LOADS (lbs)	PROOF LOAD (lbs)	SAFTY FACTOR (Note 3)		VERIFICATION STATUS
		Met	Syn	Yes	No				Ult	Yield	
SEG38117125-301	Multi-Purpose Lifting Fixture Hoist	X			X	3860	7000	14000	<5	<3	Stress Analysis completed per ESCG-4005-05-STAN-DOC-0103 (As per pp 1-7 in report, analysis was done for 7000 lbs)
SEG38117125-305	Assembly Max (-301) 125.3 in (Length) x 109.0 in (Width) x 242.3 in (Height)	X			X	6759	7000	14000	<5	<3	
SEG38117125-307	Material A-36 Steel	X			X	2632	7000	14000	<5	<3	
SEG38117125-309		X			X	700	7000	14000	<5	<3	
SEG38117125-311		X			X	6759	7000	14000	<5	<3	
SEG38117125-313		X			X	6759	7000	14000	<5	<3	

Notes:

1 Identify whether slings are Metallic (Met) or Synthetic (Syn) by placing an “X” in the appropriate column. For synthetic slings, see Table 4-1 of KHB 1700.7 for the required safety factors and proof load test criteria.

2 Denote whether to the device has a critical weld by placing an “X” in the appropriate column. If there are critical welds, other test may to applicable (see KHB 1700.7 para. 4.5.1.1.D). A critical weld is a weld, which constitutes a single point of failure. Where feasibly, critical welds should be eliminated.

3 Per KHB 1700.7, Table 4-1, the safety factor shall be given in Ultimate:Rated. For structural members, a 3:1 safety factor against worst case failure mode that will result in local yielding is acceptable.

GROUND SUPPORT LIFTING/HANDLING EQUIPMENT MATRIX

DESIGNATOR NUMBER	ITEM NAME	SLING (Note 1)		CRIT WELDS (Note 2)		ACTUAL LOADS (lbs)	RATED LOADS (lbs)	PROOF LOAD (lbs)	SAFTY FACTOR (Note 3)		VERIFICATION STATUS
		Met	Syn	Yes	No				Ult	Yield	
	Lifting Lugs – Master Dewar	X			X	1875 (850.5 kg)	1875 (850.5 kg)	3750	5	3	Stress analysis completed per …
	Lifting Lugs – Transfer Dewar	X			X	1875 (850.5 kg)	1875 (850.5 kg)	3750	5	3	Stress analysis completed per …
	Lifting Points – Gas Valve Box	X			X	368 (167 kg)	368 (167 kg)				
	Lifting Points – Leybold Pump (pump, base, controller)	X			X	4288 (1945 kg)					
	Lifting Points – Leybold Pump (pump, base)	X									
	Scroll Pump										
	Heat Exchanger					51 (23 kg)					

Notes:

1 Identify whether slings are Metallic (Met) or Synthetic (Syn) by placing an “X” in the appropriate column. For synthetic slings, see Table 4-1 of KHB 1700.7 for the required safety factors and proof load test criteria.

2 Denote whether to the device has a critical weld by placing an “X” in the appropriate column. If there are critical welds, other test may to applicable (see KHB 1700.7 para. 4.5.1.1.D). A critical weld is a weld, which constitutes a single point of failure. Where feasibly, critical welds should be eliminated.

3 Per KHB 1700.7, Table 4-1, the safety factor shall be given in Ultimate:Rated. For structural members, a 3:1 safety factor against worst case failure mode that will result in local yielding is acceptable.

PAYLOAD HAZARD REPORT		a. NO: GHR-AMS02-010
b. PAYLOAD: Alpha Magnetic Spectrometer-02 (AMS-02) GSE		c. PHASE: III
d. SUBSYSTEM: GHE Static Structures	e. HAZARD GROUP: Structures	f. DATE: January 2010
g. HAZARD TITLE: Structural Failure of AMS-02 Support Stands During Static Operations		i. HAZARD CATEGORY ☒ CATASTROPHIC ☐ CRITICAL

h. APPLICABLE SAFETY REQUIREMENTS:

KHB 1700.7C, Section: 4.5.1.6 Stands

j. DESCRIPTION OF HAZARD:

Structural failure of the Alpha Magnetic Spectrometer-02 (AMS-02) GSE while it is being used as a support/work stand could result in injury to personnel and/or damage to the AMS-02 payload or ground support equipment.

k. HAZARD CAUSES:

1. Inadequate structural design.
2. Improper assembly/adjustment of the PSS vertical corner supports.
3. Improper assembly of cryogenic and vent line support stands.

l. HAZARD CONTROLS:

(See continuation sheet)

m. SAFETY VERIFICATION METHODS:

(See continuation sheet)

n. STATUS OF VERIFICATION:

(See continuation sheet)

o. APPROVAL	PAYLOAD ORGANIZATION	SSP/ISS
PHASE I		
PHASE II		
PHASE III	[signature] 1/14/10	

PAYLOAD HAZARD REPORT CONTINUATION SHEET	a. NO: GHR-AMS02--010
b. PAYLOAD: Alpha Magnetic Spectrometer-02 (AMS-02) GSE	c. Phase III

k. HAZARD CAUSES:

1. Inadequate structural design.

l. HAZARD CONTROLS:

1.1 Ensure the design of all support hardware meets requirements of KHB 1700.7C.

1.2 Procedures to ensure ground support hardware will be configured correctly prior to use.

m. SAFETY VERIFICATION METHODS:

1.1.1 Stress analyses demonstrating positive margins of safety.

1.2.1 Review of procedures to verify compliance with assumptions in stress analysis.

n. STATUS OF VERIFICATION:

1.1.1 Open
1.2.1 Open

PAYLOAD HAZARD REPORT CONTINUATION SHEET	a. NO: GHR-AMS02--010
b. PAYLOAD: Alpha Magnetic Spectrometer-02 (AMS-02) GSE	c. Phase III

k. HAZARD CAUSES:

2. Improper assembly/adjustment of the PSS vertical corner supports.

l. HAZARD CONTROLS:

2.1 The part numbers and torque values for the bolts used to adjust the vertical corner supports of the PSS will be specified in the assembly/adjustment procedure.

2.2 Vertical supports are keyed so that they can only be installed correctly.

2.3 Proper procedures for installing corner supports.

m. SAFETY VERIFICATION METHODS:

2.1.1 Review of the PSS assembly/adjustment procedure to ensure the inclusion of the part numbers and torque values.

2.2.1 Review of design to ensure that supports are keyed.

2.3.1 Review of procedures to ensure they properly direct how to install the corner supports.

n. STATUS OF VERIFICATION:

2.1.1 Open

2.2.1 Closed 12/15/09. ESCG-4420-09-CED-MEMO-0009, *Mechanical Design of the Primary Support Stand Corner Supports (Rail Extensions)*, 12/14/09.

2.3.1 Open

PAYLOAD HAZARD REPORT CONTINUATION SHEET	a. NO: GHR-AMS02-010
b. PAYLOAD: Alpha Magnetic Spectrometer-02 (AMS-02) GSE	c. PHASE: III

k. HAZARD CAUSES:

3. Improper assembly of cryogenic and vent line support stands.

l. HAZARD CONTROLS:

3.1 Ensure that the support stand's fixation device is properly installed.

3.2 Assembly per support stand procedures.

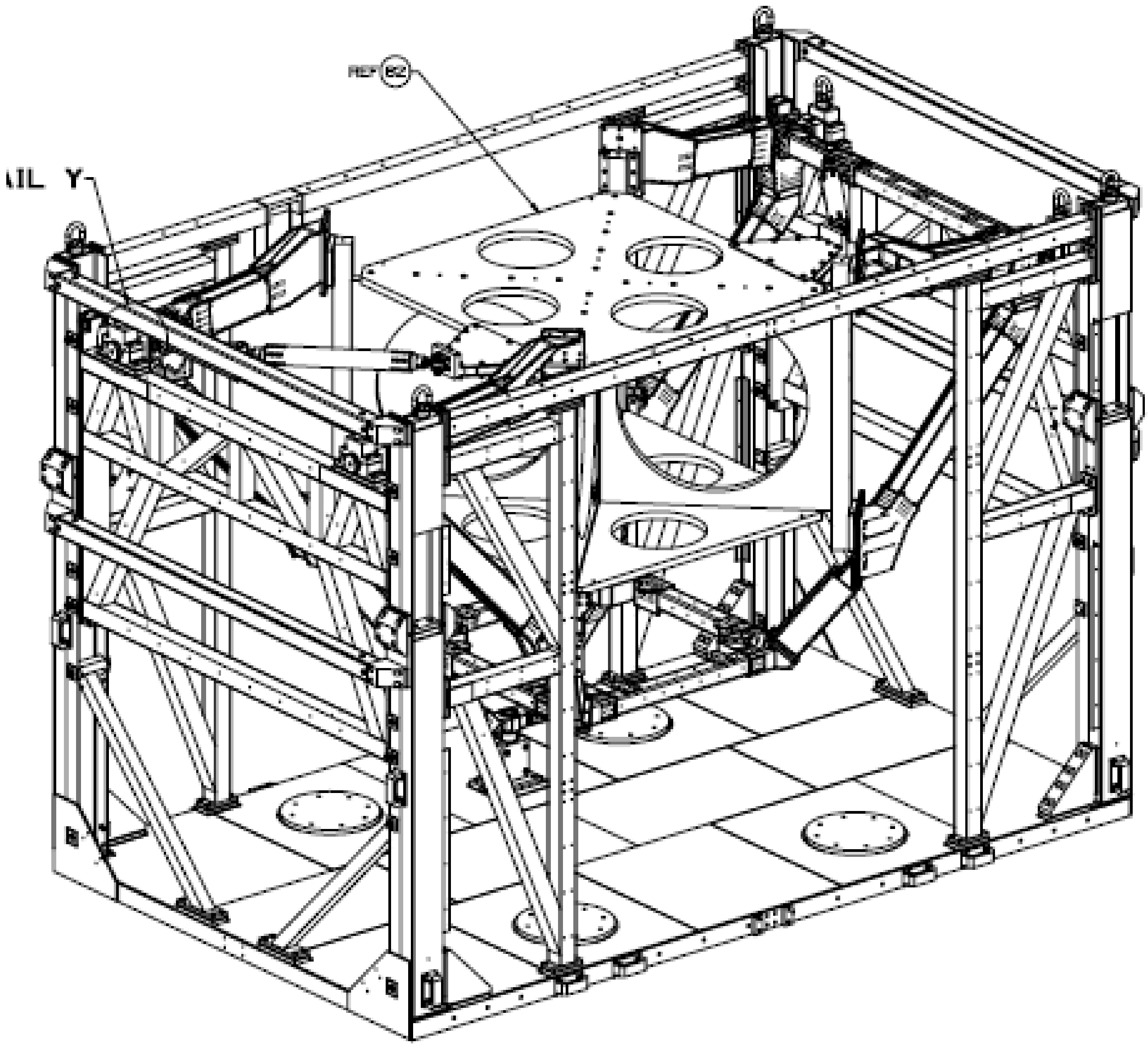
m. SAFETY VERIFICATION METHODS:

3.1.1 Inspection of support stand assembly to ensure proper installation of fixation device.

3.2.1 Review of support stand procedures to ensure they properly direct how to assemble the stands.

n. STATUS OF VERIFICATION:

3.1.1 Open
3.2.1 Open



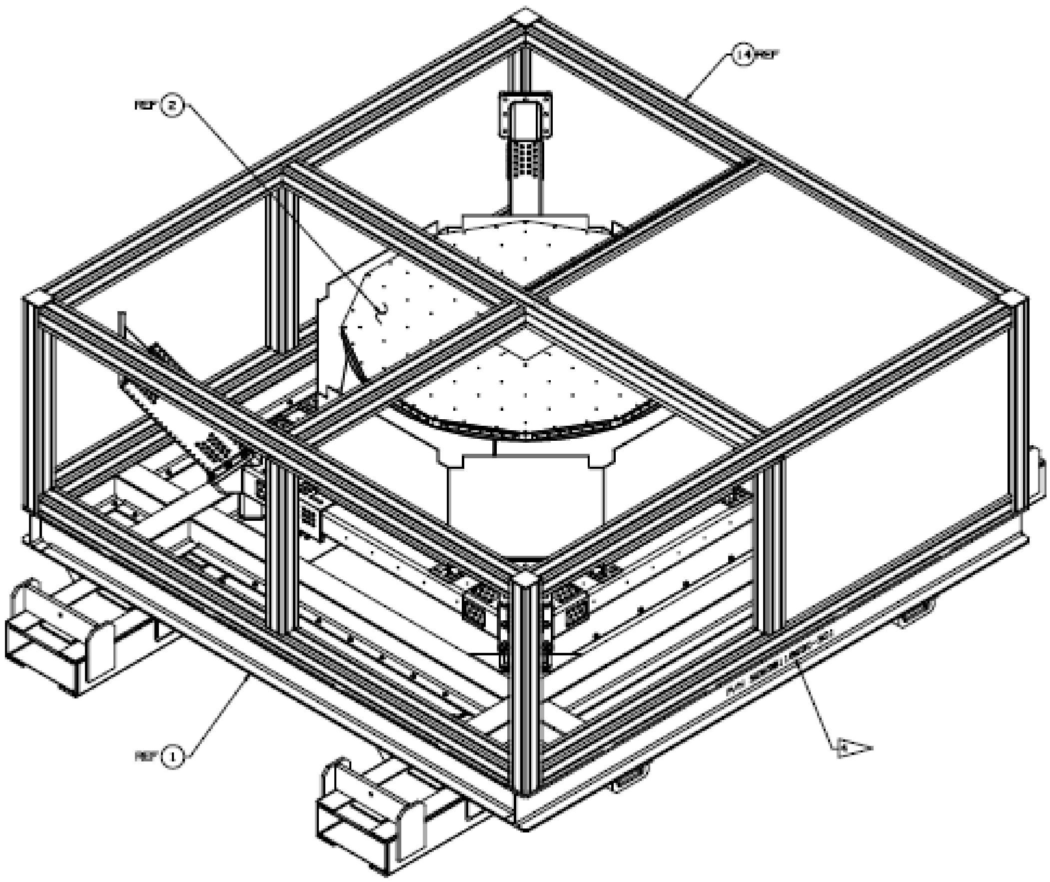
Primary Support Stand (In “High” Configuration)

GROUND SUPPORT LIFTING/HANDLING EQUIPMENT MATRIX

DESIGNATOR NUMBER	ITEM NAME	SLING		CRIT WELDS		ACTUAL LOADS (lbs)	RATED LOADS (lbs)	PROOF LOAD (lbs)	DESIGN LOAD		VERIFICATION STATUS
		Met	Syn	Yes	No				Ult	Yield	
SEG38117000	Primary Support Stand Assembly Ground Ops (-301) 195.0 in (Length) x 135.7 in (Height) x 125.0 in (Width) Transportation (-311) 195.0 in (Length) x 135.7 in (Height) x 125.0 in (Width) Material: 6061 Aluminum	NA	NA	NA	NA	15108. 12358.	--- ---	N/A N/A	45324. (LF=1, FS=3) 111222. (LF=3, FS=3)	30216. (LF=1, FS=2) 74148. (LF=3, FS=2)	Stress Analysis Open pending final review (Document ESCG-4450-06-STAN-DOC-0003)

NOTES: I Identify whether slings are Metallic (Met) or Synthetic (Syn) by placing an “X” in the appropriate column. For synthetic slings, see Table 4-1 of KHB 1700.7 for the required safety factors and proof load test criteria.

Denote whether to the device has a critical weld by placing an “X” in the appropriate column. If there are critical welds, other test may to applicable (see KHB 1700.7 para. 4.5.1.1.D). A critical weld is a weld, which constitutes a single point of failure. Where feasibly, critical welds should be eliminated.



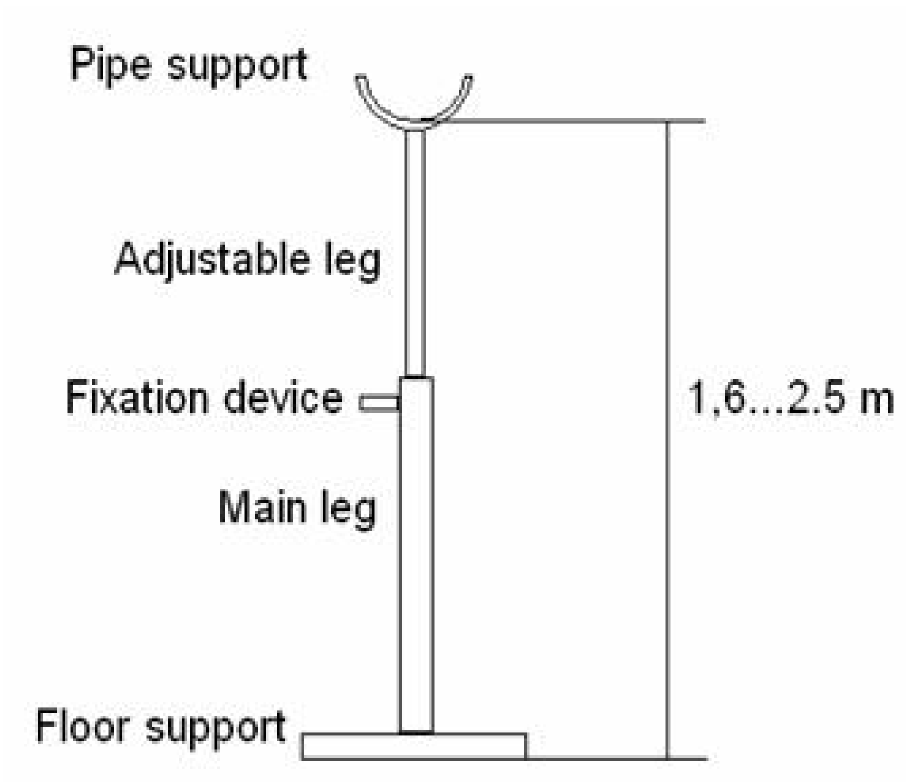
LUSS Shipping Assembly with LUSS and Shipping Panels

GROUND SUPPORT LIFTING/HANDLING EQUIPMENT MATRIX

DESIGNATOR NUMBER	ITEM NAME	SLING		CRIT WELDS		ACTUAL LOADS (lbs)	RATED LOADS (lbs)	PROOF LOAD (lbs)	DESIGN LOAD		VERIFICATION STATUS
		Met	Syn	Yes	No				Ult	Yield	
SEG38116930	Lower USS Shipping Assembly 127.25 in (Length) x 46.7 in (Height) x 97.7 in (Width) Material: 6061 Aluminum	NA	NA	NA	NA	3,051	13,251	26,502	22,120	10,709	Stress Analysis Completed per ESCG-4005-05-STAN-DOC-0102

NOTES: I Identify whether slings are Metallic (Met) or Synthetic (Syn) by placing an “X” in the appropriate column. For synthetic slings, see Table 4-1 of KHB 1700.7 for the required safety factors and proof load test criteria.

Denote whether to the device has a critical weld by placing an “X” in the appropriate column. If there are critical welds, other test may to applicable (see KHB 1700.7 para. 4.5.1.1.D). A critical weld is a weld, which constitutes a single point of failure. Where feasibly, critical welds should be eliminated.



Cryogenic and Vent Line Support Stand

DESIGNATOR NUMBER	ITEM NAME	SLING		CRIT WELDS		ACTUAL LOADS (lbs)	RATED LOADS (lbs)	PROOF LOAD (lbs)	DESIGN LOAD		VERIFICATION STATUS
		Met	Syn	Yes	No				Ult	Yield	
	Cryogenic and Vent Line Support Stand Height: Between 1.6m and 2.5m					TBD	TBD	TBD	TBD	TBD	TBD

DESIGNATOR NUMBER	ITEM NAME	SLING		CRIT WELDS		ACTUAL LOADS (lbs)	RATED LOADS (lbs)	PROOF LOAD (lbs)	DESIGN LOAD		VERIFICATION STATUS
		Met	Syn	Yes	No				Ult	Yield	
	CGSE Casters					TBD	TBD	TBD	TBD	TBD	TBD

PAYLOAD HAZARD REPORT

a. NO: GHR-AMS02-011

b. PAYLOAD: Alpha Magnetic Spectrometer-02 (AMS-02) GSE

c. PHASE: III

d. SUBSYSTEM:
Electrical Systems

e. HAZARD GROUP:
Electrical

f. DATE:
January 2010

g. HAZARD TITLE:
Electric Discharge/Shock

i. HAZARD CATEGORY
☒ CATASTROPHIC
☐ CRITICAL

h. APPLICABLE SAFETY REQUIREMENTS:
KHB 1700.7, 4.3.2 Electrical

j. DESCRIPTION OF HAZARD
Damage occurs to AMS, AMS GSE, facilities, or injury to personnel due to electrical events triggered by electrical shorting or unwanted electrical contract. (>30 V_{rms} and 50 VDC)

k. HAZARD CAUSES:
1. Over voltage/over current.
2. Contact with high voltage sources.
3. Mismating of powered connectors.
4. Water leakage.
5. AMS-02 payload or electrical GSE conductive external parts or surfaces that are not at ground potential.
6. Personnel short an energized AMS-02 payload or GSE electrical circuit during connector mating/demating.
7. Mismatch of three-phase power sequencing between AMS-02 electrical equipment and KSC facilities.

l. HAZARD CONTROLS:

(See continuation sheet)

m. SAFETY VERIFICATION METHODS:

(See continuation sheet)

n. STATUS OF VERIFICATION:

(See continuation sheet)

o. APPROVAL	PAYLOAD ORGANIZATION	SSP/ISS
PHASE I		
PHASE II		
PHASE III	[signature] 1/14/10	

JSC Form 542B (Rev November 22, 1999) (MS Word September 1997)

PAYLOAD HAZARD REPORT CONTINUATION SHEET	a. NO: GHR-AMS02-011
b. PAYLOAD: Alpha Magnetic Spectrometer-02 (AMS-02) GSE	c. Phase III

k. HAZARD CAUSES:

1. Over voltage/over current.

l. HAZARD CONTROLS:

1.1. System is protected by circuit protection devices.

1.2 System designed per AMS approved electrical codes (Chinese Electrical Code, ~~, international~~IEC, or NEC equivalent code).

m. SAFETY VERIFICATION METHODS:

1.1.1 Electrical systems schematics review and approval by AMS to ensure proper fusing for expected loads and appropriate current levels.

1.1.2 Review and approval of facility GFCI.

1.1.3 Review and approval of AMS and AMS ~~C~~GSE electrical systems/schematics to ensure proper GFCI/over voltage protection.

1.2.1 Review and approval of AMS and AMS ~~C~~GSE electrical schematics. (For Flight EPDC, see AMS-02-F017, AMS-02-F08 and AMS-02-F12).

1.2.2 Review of COTS hardware for UL or equivalent electrical safety qualification.

n. STATUS OF VERIFICATION:

1.1.1 Open
1.1.2 Open
1.1.3 Open
1.2.1 Open
1.2.2 Open

PAYLOAD HAZARD REPORT CONTINUATION SHEET	a. NO: GHR-AMS02-011
b. PAYLOAD: Alpha Magnetic Spectrometer-02 (AMS-02) GSE	c. Phase III

k. HAZARD CAUSES:

2. Contact with high voltage/current sources.

l. HAZARD CONTROLS:

2.1 Socket connectors on power (source) side of GSE.

2.2 High voltage sources on GSE are labeled if accessible.

2.3 High voltage sources on flight hardware and GSE are inaccessible during nominal operations.

2.4 Lockout/tag-out procedures during maintenance and mate/demate operations involving power supplies.

m. SAFETY VERIFICATION METHODS:

2.1.1 Inspection of GSE socket connectors/schematics to ensure proper design.

2.2.1 QA inspection of warning labels to verify that they are appropriately sized and located.

2.3.1 QA inspection of hardware ensuring high voltage locations are inaccessible.

2.4.1 Review of operational procedures showing lockout/tag-out of power supplies for AMS GSE to ensure no power to AMS GSE prior to maintenance and/or mate/demate operations.

n. STATUS OF VERIFICATION:

2.1.1 Open
2.2.1 Open
2.3.1 Open
2.4.1 Open

PAYLOAD HAZARD REPORT CONTINUATION SHEET	a. NO: GHR-AMS02-011
b. PAYLOAD: Alpha Magnetic Spectrometer-02 (AMS-02) GSE	c. Phase III

k. HAZARD CAUSES:

3. Mismating of power~~ed~~ connectors, which would lead to personnel injury.

l. HAZARD CONTROLS:

3.1 Connector keying to preclude mismating.

m. SAFETY VERIFICATION METHODS:

3.1.1 Review and approval of ~~Electrical~~ electrical schematics and cable drawings.

3.1.2 QA inspection of as-built hardware (particularly the electrical connectors) to ensure proper connector keying.

n. STATUS OF VERIFICATION:

3.1.1 Closed 12/22/09. ESCG-4390-08-SP-MEMO-0022, *Mate/Demate of Connectors*, 06/11/08. This closes the verification for all flight related hardware. GSE is either COTS or KSC-supplied and will be used as designed.~~Open~~

3.1.2 Open

PAYLOAD HAZARD REPORT CONTINUATION SHEET	a. NO: GHR-AMS02-011
b. PAYLOAD: Alpha Magnetic Spectrometer-02 (AMS-02) GSE	c. Phase III

k. HAZARD CAUSES:

4. Water leakage.

l. HAZARD CONTROLS:

4.1 Follow vacuum pump cooling system assembly procedures to preclude water leakage.

m. SAFETY VERIFICATION METHODS:

4.1.1 Review of AMS-02 vacuum pump assembly procedures to ensure they properly call out assembly instructions.~~and~~

4.1.2 QA inspections of as-built hardware to approved drawings.

n. STATUS OF VERIFICATION:

4.1.1 Open
4.1.2 Open

JSC Form 542B (Rev November 22, 1999) (MS Word September 1997)

PAYLOAD HAZARD REPORT CONTINUATION SHEET	a. NO: GHR-AMS02-011
b. PAYLOAD: Alpha Magnetic Spectrometer-02 (AMS-02) GSE	c. Phase III

k. HAZARD CAUSES:

5. AMS-02 payload or electrical GSE conductive external parts or surfaces that are not at ground potential.

l. HAZARD CONTROLS:

5.1 Proper grounding and bonding between AMS-02 hardware and KSC facilities will be used. The design, construction and installation of the AMS-02 payload and electrical GSE will assure that all conductive external parts and surfaces are at ground potential at all times.

5.2 AMS-02 non-COTS GSE power cords will have a non-current carrying ground conductor.

m. SAFETY VERIFICATION METHODS:

5.1.1 Grounding and bonding verification tests will be performed on the AMS-02 payload, electrical GSE and the interfacing between AMS-02 equipment and KSC facilities.

5.2.1 QA inspections/verification tests of the AMS-02 hardware to ensure a non-current carrying ground conductor has been included.

n. STATUS OF VERIFICATION:

5.1.1 Open
5.2.1 Open

PAYLOAD HAZARD REPORT CONTINUATION SHEET	a. NO: GHR-AMS02-011
b. PAYLOAD: Alpha Magnetic Spectrometer-02 (AMS-02) GSE	c. Phase III

k. HAZARD CAUSES:

6. Personnel short an energized AMS-02 payload or GSE electrical circuit ~~during~~ after improperly ~~connector~~ matinging/dematinging electrical connectors.

l. HAZARD CONTROLS:

6.1 No blind mating will be allowed.

6.~~2~~ 2 Plug design will preclude inadvertently reversing a connection.

6.3 Plugs will be inspected for debris that can short energized pins prior to mating power connectors.

m. SAFETY VERIFICATION METHODS:

6.1.1 Review of AMS-02 procedures to ensure there is a warning to not perform blind mating.

6.2.1 Review of design for non-COTS connectors.

6.3.1 Review of procedures to ensure personnel will inspect power connectors for debris.

n. STATUS OF VERIFICATION:

6.1.1 Open
6.2.1 Closed 12/22/09. ESCG-4390-08-SP-MEMO-0022, *Mate/Demate of Connectors*, 06/11/08. This closes the verification for all flight related hardware. GSE that is either COTS or KSC-supplied and will be used as designed.
6.3.1 Open

PAYLOAD HAZARD REPORT CONTINUATION SHEET	a. NO: GHR-AMS02-011
b. PAYLOAD: Alpha Magnetic Spectrometer-02 (AMS-02) GSE	c. PHASE: III

k. HAZARD CAUSES:

7. Mismatch of three-phase power sequencing between AMS-02 electrical equipment and KSC facilities.

l. HAZARD CONTROLS:

7.1 Phasing of interface will be checked ~~for proper phasing~~ prior to mating, per procedure.

m. SAFETY VERIFICATION METHODS:

7.1.1 Review of procedures to ensure phasing will be checked.

n. STATUS OF VERIFICATION:

7.1.1 Open

AMS ELECTRICAL EQUIPMENT MATRIX

Item	Manufacturer	Model Number	Commercial Yes/No	Electrical Code	3-Phase Yes/No	KSC Facilities	Batteries Yes/No Commercial/Custom	Functions	Quantity	Comments
	_									
1	Tektronix	TDS 7054	Yes	UL	No	No	No	Oscilloscope	1	
2	Tektronix	TDS 11402	Yes	UL	No	No	No	Oscilloscope	1	
3	Fluke, etc,	Multimeters	Yes	N/A	N/A	No	Yes, Commercial	Multimeters	5	
	_									
4	Honeywell	HV180	Yes	UL	No	No	No	Fan for main radiator cooling	8	
5	Honeywell	HV180	Yes	UL	No	No	No	Fan for Zenith radiator cooling	4	
6	Honeywell	HT800-E	Yes	CE/GS	No	No	No	Fan for PDS and CAB cooling	3	
7	Texas Instruments	UNK	Yes	CE	No	No	No	AST LED	1	
8	Spirent	STR4500	Yes	CE	No	No	No	GPS simulator	1	
9	MIDWEST MICROWAVE	STA-1043-04-NNN-79	Yes	CE	No	No	No	GPS Attenuator	1	
10	planTec	UNK	Yes	CE	No	No	No	GPS simulator transmitter	1	
	_									
11	Hewlett-Packard	DC7700-CMT	Yes	UL	No	No	No	Personal computer (POC/GSC)	2	
12	Hewlett-Packard	DC7800-CMT	Yes	UL	No	No	No	Personal computer (POC)	2	
13	Hoojum Design	Cubit3	Yes	UL	No	No	No	Personal computer (GSC)	4	
14	Agilent Technologies	N5770A	Yes	UL	No	No	No	DC power supply (120V)	4	
15	D-Link	DGS-1016D	Yes	UL	No	No	No	Gigabit network switch	1	
16	3Com	4400 24PT	Yes	UL	No	No	No	10/1000 network switch	1	
17	NEC	Multisync LCD2170NX	Yes	UL	No	No	No	LCD Monitors	2	
18	Dataprobe	iBB-2N20	Yes	UL	No	No	No	Remote reboot power outlets	2	
19	AMS	EPPCAN	No		No	No	No	EEPCAN interface, 5V	2	
20	AMS	USB422	No		No	No	No	RS422-USB interface (DDRS)	2	
	_									
21	Hewlett-Packard	DC7700-CMT	Yes	UL	No	No	No	Personal computer (POC/GSC)	4	
22	Hewlett-Packard	DC7800-CMT	Yes	UL	No	No	No	Personal computer (POC)	2	
23	D-Link	DGS-1016D	Yes	UL	No	No	No	Gigabit network switch	1	
24	3Com	4400 24PT	Yes	UL	No	No	No	10/1000 network switch	1	
25	NEC	Multisync LCD2170NX	Yes	UL	No	No	No	LCD Monitors	13	
26	Dell	PowerEdge 2900 III	Yes	UL	No	No	No	Personal computer (SOC)	2	
27	Dell	Dell Power Vault DP 600	Yes	UL	No	No	No	Disk server (POC)	1	

AMS ELECTRICAL EQUIPMENT MATRIX

Item	Manufacturer	Model Number	Commercial Yes/No	Electrical Code	3-Phase Yes/No	KSC Facilities	Batteries Yes/No Commercial/Custom	Functions	Quantity	Comments
28		UPS	Yes	UL	No	No	Yes, Commercial	UPS for disk server	1	
29	Hewlett-Packard	Laserjet printer	Yes	UL	No	No	No	Network printer	1	
	-									
30	Leybold Vacuum	RUTA 2001	Yes	CE	YES	No	No	Main Vacuum Pump	2	One is spare. 400V 3Ph.5--50Hz, 73kVA, 105A
31	BOC Edwards	XDS5	Yes	CE	No	No	No	PVVV Vacuum Pump	1	Intermittent use.
32	Infincon	UL 1000	Yes	CE	No	No	No	He leak detector	1	
33	DAIKIN EUROPE NV	EUWAB8KA ZW1 - - G	Yes	CE	Yes	No	No	Chiller for PCR??	1	3phase, 50Hz, 400V
	-									
34	APC	2200UX Smart UPS	Yes	UL	No	No	Yes, Commercial	UPS for CGSE	2	
35	Le Guan	Lead-Acid Battery Pack	Yes	UNK	No	No	Yes, Commercial	UPS for CGSE	2	May need to be replaced, not suitable for PCR.
36	ADVANTECH	610H	Yes	CE	No	No	Yes, Commercial	Industrial PC for CGSE	3	
37	ADVANTECH	AWS-8259TP-T	Yes	CE	No	No	Yes, Commercial	Industrial PC Display	3	240V?
38	SIEMENS	PanelPC 557	Yes	CE	No	No	Yes, Commercial	Industrial PC for CGSE	1	
39	SIEMENS	FieldBus Modules	Yes	UL	No	No	No	PLC crates for CGSE	10	
40	Scientific Insturements	9350-1	Yes	UL	No	No	No	Temperature Indicator	1	various models
41	Yudain	UNK	Yes	CE	No	No	No	Alarm MUX?	1	
42	TPLink	UNK	Yes	CCC	No	No	No	Ethernet hub	1	
43	AMI	135-2K	Yes	CE	No	No	No	Liquid He level probe	1	240V
44	Shanghai YunJie Vacuum Equip.	2DF-1B	Yes	UNK	No	No	No	"Complex Vacuum Meter"	1	Hopefully not needed.
45	TBD	Transformer	Yes	UL	No	No	No	110-220V transformer	3	or use KSC?
46	AMS	EPPCAN	No		No	No	No	EEPCAN interface, 5V	2	
	-									
47	SIEMENS	FieldBus IO Modules	Yes	UL	No	No	No	CGSE Monitoring & Control	~30	various models
48	TBD	FieldBus IO Modules	Yes	UL	No	No	No	CGSE Monitoring & Control	~20	
49	Various	Laptop computers	Yes	UL	No	No	Yes, Commercial	Laptop computer	40	
50	Hewlett-Packard	Laserjet printer	Yes	UL	No	No	No	Network printer	1	

PAYLOAD HAZARD REPORT		a. NO: GHR-AMS02-012
b. PAYLOAD: Alpha Magnetic Spectrometer-02 (AMS-02) GSE		c. PHASE: III
d. SUBSYSTEM: CGSE Pumps, Burst Disks	e. HAZARD GROUP: Acoustics	f. DATE: January 2010
g. HAZARD TITLE: Excessive Noise Levels		i. HAZARD CATEGORY ☒ CATASTROPHIC ☐ CRITICAL

h. APPLICABLE SAFETY REQUIREMENTS:

KHB 1700.7C, Section 4.2.1.2 Noise.

j. DESCRIPTION OF HAZARD:

Excessive levels of constant noise (above ~~80dB~~85 dB) or impulse of 140 dB leads to hearing damage or loss as well as impeding communication—including caution and warning systems.

k. HAZARD CAUSES:

1. ~~Long duration noise level from equipment (above 85dB according to KHB 1700.7C, 4.2.1.2) causes physiological damage.~~Long duration noise level from equipment (above 85 dB according to KHB 1700.7C, 4.2.1.2) causes physiological damage.~~Long duration excessive noise level from equipment.~~
2. Impulse from burst disc causes startling effect or damages hearing.

l. HAZARD CONTROLS:

(See continuation sheet)

m. SAFETY VERIFICATION METHODS:

(See continuation sheet)

n. STATUS OF VERIFICATION:

(See continuation sheet)

o. APPROVAL	PAYLOAD ORGANIZATION	SSP/ISS
PHASE I		
PHASE II		
PHASE III	[signature] 1/14/10	

PAYLOAD HAZARD REPORT CONTINUATION SHEET	a. NO: GHR-AMS02-012
b. PAYLOAD: Alpha Magnetic Spectrometer-02 (AMS-02) GSE	c. Phase III

k. HAZARD CAUSES:

1. Long duration noise level from equipment (above ~~80dB~~85dB according to KHB 1700.7C, 4.2.1.2) causes physiological damage.

l. HAZARD CONTROLS:

~~1.1 Personnel shall use appropriate hearing protection.~~

1.1 Vacuum pumps will be enclosed in sound absorbing housing to reduce noise ~~levels~~ to acceptable levels.~~Note: Acoustic noise levels will be considered in the purchase of the GSE fans.~~

m. SAFETY VERIFICATION METHODS:

~~1.1.1 Review of procedures to ensure appropriate PPE is required and available at KSC.~~

~~1.2.1 Review of AMS-02 GSE layout at SSPF and launch pad.~~

1.~~.2.2~~1.1 Acoustics survey of noise-generating devices (vacuum pumps) and containment systems to determine whether frequency and intensity of noise are acceptable to preclude health risks and not block out audible caution and warning.

n. STATUS OF VERIFICATION:

1.1.1	Open
~~1.2.1.~~	~~Open~~
~~1.2.2~~	~~Open~~

PAYLOAD HAZARD REPORT CONTINUATION SHEET	a. NO: GHR-AMS02-012
b. PAYLOAD: Alpha Magnetic Spectrometer-02 (AMS-02) GSE	c. Phase III

k. HAZARD CAUSES:

2. Impulse of 140dB causes hearing damage.

l. HAZARD CONTROLS:

2.1 Monitoring of the AMS-02 systems for pressure and temperature increases while personnel are present.

m. SAFETY VERIFICATION METHODS:

2.1.1 Review of procedures to ensure AMS-02 and CGSE pressures and temperatures are monitored at appropriate levels.

2.1.2 Review of Cryosystem performance characteristics to establish time to burst.

2.1.3 Review of procedures/cautions for warnings to personnel in the event a warming/high pressure trend is noted.

n. STATUS OF VERIFICATION:

2.1.1 Open
2.1.2 Open
2.1.3 Open

PAYLOAD HAZARD REPORT

a. NO: GHR-AMS02-013

b. PAYLOAD: Alpha Magnetic Spectrometer-02 (AMS-02) GSE

c. PHASE: III

d. SUBSYSTEM:
Cryomagnet

e. HAZARD GROUP:
Magnetic Fields

f. DATE:
January 2010

g. HAZARD TITLE:
Magnetic Fields

i. HAZARD CATEGORY

☒ CATASTROPHIC

☐ CRITICAL

h. APPLICABLE SAFETY REQUIREMENTS:

KHB 1700.7C, Section 4.3.4 Radiation

j. DESCRIPTION OF HAZARD:

Equipment malfunctions and/or personnel injury due to excessive magnetic fields from the AMS-02 magnet.

k. HAZARD CAUSES:

1. Production of excessive magnetic fields.
2. Equipment placed inside magnetic field range.
3. Personnel inside magnetic field range.

l. HAZARD CONTROLS:

(See continuation sheet)

m. SAFETY VERIFICATION METHODS:

(See continuation sheet)

n. STATUS OF VERIFICATION:

(See continuation sheet)

o. APPROVAL	PAYLOAD ORGANIZATION	SSP/ISS
PHASE I		
PHASE II		
PHASE III	[signature] 1/14/10	

PAYLOAD HAZARD REPORT CONTINUATION SHEET	a. NO: GHR-AMS02-013
b. PAYLOAD: Alpha Magnetic Spectrometer-02 (AMS-02) GSE	c. Phase III

k. HAZARD CAUSES:

1. Production of excessive magnetic fields.

l. HAZARD CONTROLS:

1.1 Design of AMS-02 coils limits the strength of the magnetic fields outside of the magnet's core.

1.2 Design of AMS-02 cryomagnet avionics box limits the maximum current that can be introduced into the superconducting magnet coils, limiting the maximum magnetic field generated.

m. SAFETY VERIFICATION METHODS:

1.1.1 Review of design to ensure it limits the strength of the magnetic fields outside of the core.

1.1.2 Measurement of magnetic field to ensure the design limits it.

1.2.1 Functional testing of cryomagnet (at CERN), including avionics, to ensure it limits the strength of the magnetic field by restricting the amount of current going to the coils.

1.2.2 Review of CAB design to ensure it is properly limits the current going into the coils.

n. STATUS OF VERIFICATION:

1.1.1 ~~Open~~Closed. *AMS Stray Field During Unprotected Quench*, technical report written by Space Cryomagnetics, 01/30/2004.
1.1.2 Open
1.2.1 Open
1.2.2 ~~Open~~Closed 11/10/09. CAB-TP-CRS-0004, *CAB Electrical and Functional Test Procedure*; CAB-TR-CRS-0008, *CAB Electrical and Functional Test Report*; and CAB-TR-CRS-0135, *CAB Electrical and Functional Delta Test Report after Magnetic Shielding*.

PAYLOAD HAZARD REPORT CONTINUATION SHEET	a. NO: GHR-AMS02-013
b. PAYLOAD: Alpha Magnetic Spectrometer-02 (AMS-02) GSE	c. Phase III

k. HAZARD CAUSES:

2. Equipment placed inside magnetic field range.

l. HAZARD CONTROLS:

2.1 Warning signs will be posted indicating keep-out zones for equipment affected by magnetic fields.

2.2 Use of non-magnetic tools if actions required.

m. SAFETY VERIFICATION METHODS:

2.1.1 Review of procedures to ensure placement of warning signs.

2.2.1 Review list of tools to ensure inclusion of non-magnetic tools.

n. STATUS OF VERIFICATION:

2.1.1 Open
2.2.1 Open

PAYLOAD HAZARD REPORT CONTINUATION SHEET	a. NO: GHR-AMS02-013-
b. PAYLOAD: Alpha Magnetic Spectrometer-02 (AMS-02) GSE	c. PHASE: III

k. HAZARD CAUSES:

3. Personnel inside magnetic field range.

l. HAZARD CONTROLS:

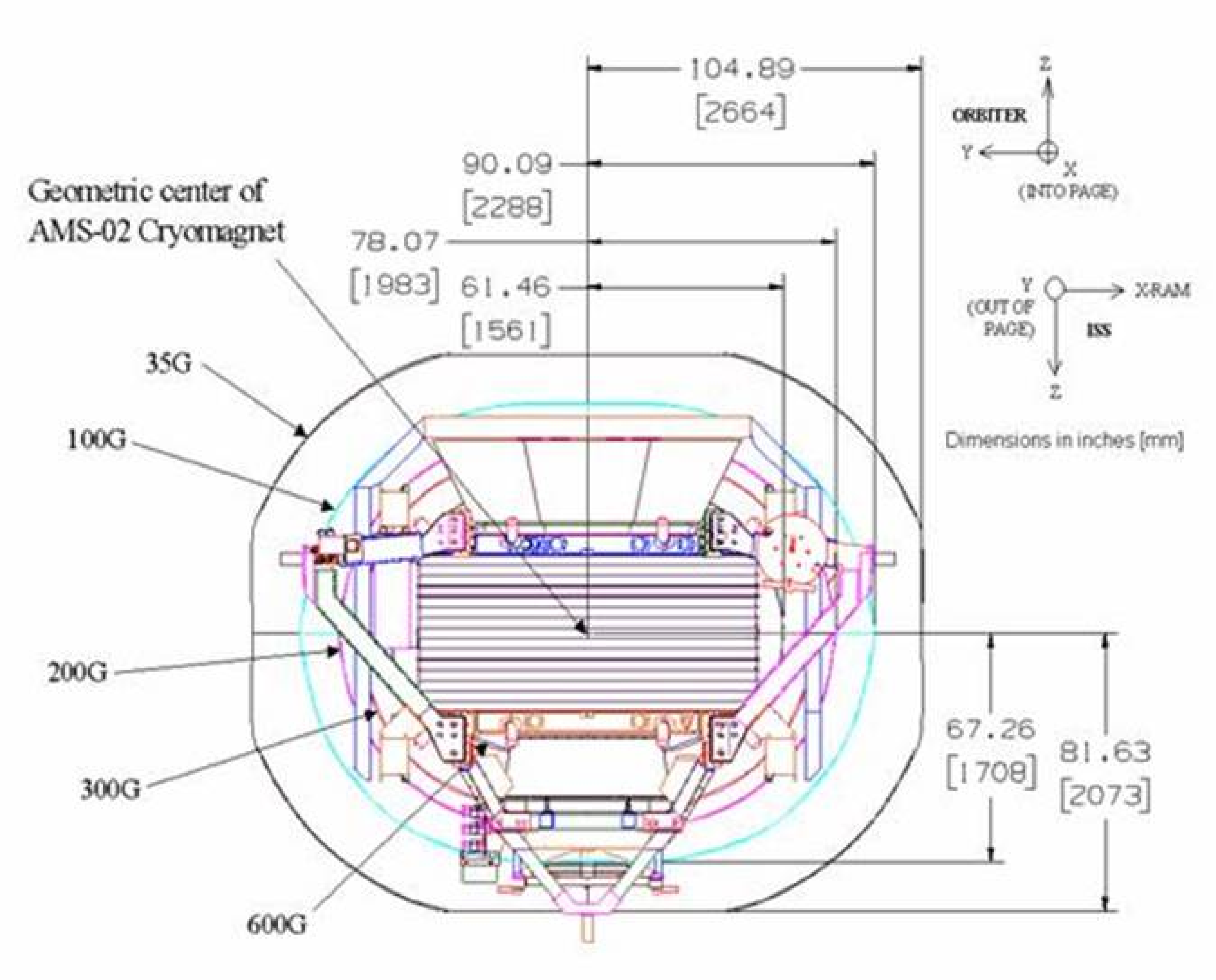
3.1 Warning signs will be posted indicating keep-out zones for personnel who may be adversely affected by magnetic fields.

m. SAFETY VERIFICATION METHODS:

3.1.1 Review of procedures to ensure placement of warning signs.

n. STATUS OF VERIFICATION:

3.1.1 Open



AMS-02 External Magnetic Field

PAYLOAD HAZARD REPORT

PAYLOAD HAZARD REPORT	a. NO: GHR-AMS02-014
b. PAYLOAD: Alpha Magnetic Spectrometer-02 (AMS-02) GSE	c. PHASE: III

d. SUBSYSTEM: GSE, Payload	e. HAZARD GROUP: Human Factors	f. DATE: January 2010
g. HAZARD TITLE: Sharp Edges		i. HAZARD CATEGORY ☐ CATASTROPHIC ☒ CRITICAL

h. APPLICABLE SAFETY REQUIREMENTS:
KHB 1700.7C, Section 4.2.1., 4.2.1.4.

j. DESCRIPTION OF HAZARD:
Personnel injury as a result of coming into contact with sharp edges on AMS-02 GSE and flight hardware.

k. HAZARD CAUSES:

1. Improper manufacturing of GSE.
2. Sharp edges on flight hardware.

l. HAZARD CONTROLS:

(See continuation sheet)

m. SAFETY VERIFICATION METHODS:

(See continuation sheet)

n. STATUS OF VERIFICATION:

(See continuation sheet)

o. APPROVAL	PAYLOAD ORGANIZATION	SSP/ISS
PHASE I		
PHASE II		
PHASE III	[signature] 1/14/10	

PAYLOAD HAZARD REPORT CONTINUATION SHEET	a. NO: GHR-AMS02-014
b. PAYLOAD: Alpha Magnetic Spectrometer-02 (AMS-02) GSE	c. Phase III

k. HAZARD CAUSES:

1. Improper manufacturing of GSE.

l. HAZARD CONTROLS:

1.1 GSE design will meet the requirements of MIL-STD-1472 and NASA-STD-3000.

1.2 Procedures will implement methods of controlling sharp edges (i.e. such as from locking wire and wire ties).

1.3 ~~Warnings~~ Warning labels will be in place for sharp edges that cannot be controlled by design.

m. SAFETY VERIFICATION METHODS:

1.1.1 Inspection of GSE to ensure there are no sharp edges.

1.2.1 Review of AMS-02 procedures to ensure sharp edges are avoided during maintenance operations.

1.3.1 Review of procedures to ensure warnings are in place.

n. STATUS OF VERIFICATION:

1.1.1 Open
1.2.1 Open
1.3.1 Open

PAYLOAD HAZARD REPORT CONTINUATION SHEET	a. NO: GHR-AMS02-014
b. PAYLOAD: Alpha Magnetic Spectrometer-02 (AMS-02) GSE	c. Phase III

k. HAZARD CAUSES:

2. Sharp edges on flight hardware.

l. HAZARD CONTROLS:

2.1 Flight hardware meets the requirements of NSTS 07700, Vol XIV, Appendix 7 (with the exception of the Star Tracker baffles).

2.2 Keep out zones will be established for those areas that have sharp edges.

m. SAFETY VERIFICATION METHODS:

2.1.1 Review of design to ensure compliance with NSTS 07700, Vol XIV, Appendix 7 (with the exception of the Star Tracker baffles.

2.2.1 Review of AMS-02 procedures to ensure inclusion of keep out zones.

n. STATUS OF VERIFICATION:

2.1.1 ~~Open~~Closed 10/23/2009. ESCG-4295-09-CPAS-MEMO-0005, *AMS-02 Sharp Edge Review*, 10/8/2009.
2.2.1 Closed 10/23/2009. ESCG-4295-09-CPAS-MEMO-0005, *AMS-02 Sharp Edge Review*, 10/8/2009.~~Open~~

PAYLOAD HAZARD REPORT

a. NO: GHR-AMS02-015

b. PAYLOAD: Alpha Magnetic Spectrometer-02 (AMS-02) GSE

c. PHASE: III

d. SUBSYSTEM:
Electrical, Mechanical

e. HAZARD GROUP:
Touch Temperatures

f. DATE:
January 2010

g. HAZARD TITLE:
Touch Temperatures-Hot

i. HAZARD CATEGORY

☒ CATASTROPHIC

☐ CRITICAL

h. APPLICABLE SAFETY REQUIREMENTS:

KHB 1700.7, Section: 4.2.1.5 Temperature

j. DESCRIPTION OF HAZARD:

Excessively high temperatures present touch temperature hazards to Ground Support Operators. (Above 45° C or 113° F)

k. HAZARD CAUSES:

1. Pumps/motors overheat.
2. Operation of flight Cryomagnet dump diodes.
3. TRD K-bottle heaters malfunction.
4. Payload electronics operations.

l. HAZARD CONTROLS:

(See continuation sheet)

m. SAFETY VERIFICATION METHODS:

(See continuation sheet)

n. STATUS OF VERIFICATION:

(See continuation sheet)

o. APPROVAL	PAYLOAD ORGANIZATION	SSP/ISS
PHASE I		
PHASE II		
PHASE III	[signature] 1/14/10	

JSC Form 542B (Rev November 22, 1999) (MS Word September 1997)

PAYLOAD HAZARD REPORT CONTINUATION SHEET	a. NO: GHR-AMS02-015
b. PAYLOAD: Alpha Magnetic Spectrometer-02 (AMS-02) GSE	Phase III

k. HAZARD CAUSES:

1. Pumps/motors overheat.

l. HAZARD CONTROLS:

1.1 Pumps/motors are cooled either by water coolant system or air cooled.

1.2 Large vacuum pumps (Roots pumps) will be covered with acoustic dampening housing which will preclude inadvertent personnel contact.

1.3 Hot temperature surfaces will be labeled.

m. SAFETY VERIFICATION METHODS:

1.1.1 Review of various pump systems to ensure they have adequate cooling.

1.2.1 Review of various pump systems to ensure they are enclosed by acoustic housing that precludes inadvertent personnel contact (Roots pumps).

1.3.1 Review of AMS procedures to ensure they call out labeling of hot temperature surfaces.

n. STATUS OF VERIFICATION:

1.1.1 Closed 11/09/09. ESCG-4295-09-CPAS-MEMO-0012, *AMS-02 Ground Pump Requirements*, dated 11/06/09. ~~Open~~
1.2.1 Open
1.3.1 Open

PAYLOAD HAZARD REPORT CONTINUATION SHEET	a. NO: GHR-AMS02-015
b. PAYLOAD: Alpha Magnetic Spectrometer-02 (AMS-02) GSE	Phase III

k. HAZARD CAUSES:

2. Operation of dump diodes.

l. HAZARD CONTROLS:

2.1 Diodes are located in an area out of reach of personnel contact on the USS-02.

2.2 Diodes are shielded by an enclosure.

2.3 Access will be restricted to the AMS-02 when it is charged. Discharge will occur while restrictions are still in place.

2.4 Procedures will include warnings about the potential high temperature ~~location of the~~ dump diodes after a discharge.

m. SAFETY VERIFICATION METHODS:

2.1.1 Review of AMS-02 drawings to ensure diodes are out of reach of ground personnel.

2.2.1 Review of AMS-02 drawings to ensure they are shielded.

2.3.1 Review of AMS-02 procedures to ensure there are steps in place to remind ground personnel to restrict access to AMS-02 when it is charged/discharged.

2.4.1 Review of AMS-02 procedures to ensure it warns ground personnel of the potential of the diodes to have a high temperature after discharge.

n. STATUS OF VERIFICATION:

2.1.1 Closed. ESCG-4175-09-REENTES-MEMO-0025, *Cryomagnet Dump Diode Accessibility*, dated 06/22/09.~~Open~~
2.2.1 ~~Open~~Closed. ESCG-4175-09-REENTES-MEMO-0025, *Cryomagnet Dump Diode Accessibility*, dated 06/22/09.
2.3.1 Open
2.4.1 Open

PAYLOAD HAZARD REPORT CONTINUATION SHEET	a. NO: GHR-AMS02-015
b. PAYLOAD: Alpha Magnetic Spectrometer-02 (AMS-02) GSE	Phase III

k. HAZARD CAUSES:

3. TRD K-bottle heaters malfunction.

l. HAZARD CONTROLS:

3.1 Thermal controller will not be set over 40° C (104° F).

3.2 The thermal controller has a temperature sensor that keeps the controller from going over set limit of 40° C.

3.3 The K-bottle has a frame to prevent personnel from touching it.

m. SAFETY VERIFICATION METHODS:

3.1.1 Review of procedures to ensure it includes a warning not to set the thermal controller over 40° C (104° F).

3.2.1 Review of thermostat specifications to ensure there is a temperature sensor.

3.2.2 Operational testing conducted at CERN to ensure the proper operation of the thermal sensor.

3.3.1 Review of hardware layout to ensure a frame is included.

n. STATUS OF VERIFICATION:

3.1.1 ~~Open~~Closed, 07/06/09. AMS-02 Task Sheet (ATS) TRD-090522-1, *TRD Gas Supply System Xenon Vessel Filling for Flight* and TRD-090131-1, *TRD Gas Supply System CO2 Vessel Filling for Flight.*

3.2.1 Open

3.2.2 Open

3.3.1 Open

PAYLOAD HAZARD REPORT CONTINUATION SHEET	a. NO: GHR-AMS02-015
b. PAYLOAD: Alpha Magnetic Spectrometer-02 (AMS-02) GSE	c. PHASE: III

k. HAZARD CAUSES:

4. Payload electronics operations.

l. HAZARD CONTROLS:

4.1 Access will be restricted to the AMS-02 when it is powered. Restrictions will remain in force until it is deemed safe for personnel to approach the payload.

m. SAFETY VERIFICATION METHODS:

4.1.1 Review of AMS-02 procedures to insure access to AMS-02 will be restricted while it is powered.

n. STATUS OF VERIFICATION:

4.1.1 Open

PAYLOAD HAZARD REPORT

a. NO: GHR-AMS02-016

b. PAYLOAD: Alphamagnetic Spectrometer-02 (AMS-02) GSE

c. PHASE: III

d. SUBSYSTEM:	e. HAZARD GROUP:	f. DATE:
Tracker Alignment System (TAS)	Lasers	January 2010

g. HAZARD TITLE:
Exposure to Lasers

i. HAZARD CATEGORY

☒ CATASTROPHIC

☐ CRITICAL

h. APPLICABLE SAFETY REQUIREMENTS:

KHB 1700.7C, Section: 4.3.4.3.2 and 4.3.4.3.3.

j. DESCRIPTION OF HAZARD:

Personnel injury due to exposure to lasers.

Lasers are generated by Eagleyard EYP-RWL-1083 infrared (1083 nm) laser diodes with a maximum power output of 80 mW. Each laser will emit at a 100 Hz interval with 0.5 μs to 4 μs pulse duration when operating.

k. HAZARD CAUSES:

1. Laser is inadequately contained.

l. HAZARD CONTROLS:

(See continuation sheet)

m. SAFETY VERIFICATION METHODS:

(See continuation sheet)

n. STATUS OF VERIFICATION:

(See continuation sheet)

o. APPROVAL	PAYLOAD ORGANIZATION	SSP/ISS
PHASE I		
PHASE II		
PHASE III	[signature] 1/14/10	

JSC Form 542B (Rev November 22, 1999) (MS Word September 1997)

PAYLOAD HAZARD REPORT CONTINUATION SHEET	a. NO: GHR-AMS02-016
b. PAYLOAD: Alphamagnetic Spectrometer-02 (AMS-02) GSE	c. Phase III

k. HAZARD CAUSES:

1. Laser is inadequately contained.

l. HAZARD CONTROLS:

1.1 Laser emissions occur inside sealed boxes and are conducted to the interior of the tracker via shielded fiber optic cables.

1.2 All connections and fiber optics cables are under thermal blankets.

1.3 There is no planned (nominal, contingency) access to the laser system.

m. SAFETY VERIFICATION METHODS:

1.1.1 Design review to ensure the containment is designed to contain the lasers.

1.1.2 KSC "Use Authorization Approval" which approves the design of the lasers.

1.2.1 Design review to connections and fiber optic cables are under thermal blankets.

1.3.1 Design review to ensure there is no need to access the laser.

n. STATUS OF VERIFICATION:

1.1.1 ~~Closed. Class 1 operational configuration approved by KSC per KU-G-50101 dated 03/05/2008~~Closed. Memo ESCG-4390-07-SP-MEMO-007, *Review of TAS Design*, dated 08/14/~~ Aug 20~~07.

1.1.2 Closed. Class 1 operational configuration approved by KSC per KU-G-50101 dated 03/05~~ March /20~~08.

1.2.1 Closed. Memo ESCG-4390-07-SP-MEMO-007, *Review of TAS Design*, dated 08/14~~ Aug 20~~/07.~~Open~~

1.3.1 Closed. Memo ESCG-4390-07-SP-MEMO-007, *Review of TAS Design*, dated 08/14/~~ Aug 20~~07.~~Open~~

CHS

Comprehensive
Health Services
INCORPORATED

May 8, 2008 HP08-242

Mr. Leland Hill
ESCG GROUP/Jacobs Engineering
224 Bay Area Blvd. Box 7
Houston, TX 77058

RADIATION PROTECTION PROGRAM APPROVAL OF RADIATION USE AUTHORIZATION NO. K-GU-50101, MODIFICATION 000

The subject Radiation Use Request/Authorization has been evaluated in accordance with KSC Radiation Protection Program requirements.

This Radiation Use Authorization (RUA) has been reviewed and approved by the KSC Radiation Protection Officer. Attached is the RUA outlining use requirements.

If you have any questions regarding this Radiation Use Authorization, please contact the undersigned at 853-5688.

Rod E. Nickell
Health Physics Manager

REN:msj

Attachment as stated

cc: Randy Scott, TA-C2

P.O. Box 21045 • Kennedy Space Center, FL 32815-0045

LASER DEVICE USE REQUEST / AUTHORIZATION

(Please Type / Print Legibly)
(Note - Complete Unshaded Sections of Form Only) (Instructions for completion in Field Help)

Originator Name/Telephone	Organization Mail Code / Address	Date	Authorization Number
Leland D. Hill / 281 461 5701	JE-46B / JSC / HOUSTON	3/19/2008	K-GU 50101

I. LASER DESCRIPTION

A.

1. Type of Laser	2. Manufacturer	3. Model Number	4. Serial Number	5. ANSI Class	6. Registration Number (if applicable)
Laser diode	Eagleyard	EYP-RWL-1083		3A (pulse) 3B (cont.)	

7. Operating Mode	8. Peak Power	9. Pulse Length	10. Pulse Frequency	11. Wavelength	12. TEM	13. Beam Diameter	14. Aperture	15. Divergence	16. Scanning (if applicable) a. Rate	b. Angle
Pulse	80mW	8µS	1kHz	1083nm	00	0.02mm at source		0.5 rad	—	—

B.

1. Type of Laser	2. Manufacturer	3. Model Number	4. Serial Number	5. ANSI Class	6. Registration Number (if applicable)
diode-fiber internal emmission	Output from LBBX	—	—	—	

7. Operating Mode	8. Peak Power	9. Pulse Length	10. Pulse Frequency	11. Wavelength	12. TEM	13. Beam Diameter	14. Aperture	15. Divergence	16. Scanning (if applicable) a. Rate	b. Angle
Pulse	160nJ assume no loss	8µS	1kHz	1083	00	1.4mm	—	1m rad [redacted]		

C.

1. Type of Laser	2. Manufacturer	3. Model Number	4. Serial Number	5. ANSI Class	6. Registration Number (if applicable)

7. Operating Mode	8. Peak Power	9. Pulse Length	10. Pulse Frequency	11. Wavelength	12. TEM	13. Beam Diameter	14. Aperture	15. Divergence	16. Scanning (if applicable) a. Rate	b. Angle

II. AREA DESCRIPTION

A. Use Location
- Area SSPF - PAD
- Building No. ______
- Room Number ______

B. Storage Location
- Area SAME
- Building No. ______
- Room Number ______

C. Attach sketch of system use area including locations of devices, beam paths, warning lights, interlocks, etc. INTERNAL TO FLIGHT HARDWARE

D. Provide optical path sketch (if applicable)

III. USE DESCRIPTION

A. Mission/Payload Designation AMS-02

B. Breif description of use INTERNAL TO FLIGHT HARDWARE SYSTEM DETECTS RELATIVE DISPLACEMENT OF THE TRACKER PLANES

IV. PROCEDURES

A. Operating Procedures: TBD

B. Accident/Emergency Procedure: ______

C. Maintenance Procedure: ______

D. Attach copies of procedures.

V. SYSTEM USERS

A. Area Radiation Officer Leland Hill

B. Use Supervisor/Custodian Leland Hill

C. Attach list of user/operators ☐ Yes ☐ No ☑ N/A

D. Submit Completed KSC Form 16-450 for each of the above named individuals ☐ Yes ☐ No ☑ N/A

E. Maintenance/Calibration Organization ______

VI. PROPOSED PERIOD OF USE

From: ______ To: ______

VII. SIGNATURES

A. Originator ______ Date ______

B. Area Radiation Officer ______ Date ______

VIII. AUTHORIZING SIGNATURES

	Date
Health Physics R. L. Bullock [signature]	4/21/08
KSC Radiation Protection Officer [signature]	5/2/08
ESMC Radiation Protection Officer (if applicable)	
Chmn. KSC Radiation Protection Committee [signature]	5/2/08

KSC FORM 16-447 (REV. 8/91) PREVIOUS EDITIONS ARE OBSOLETE

RADIATION TRAINING & EXPERIENCE SUMMARY
(NONIONIZING RADIATION)

Please Type /Print Legibly
Instructions for completion on next page

I. GENERAL INFORMATION

A. Applicant Name/Telephone	B. Date of Birth	C. Organization Mail Code	D. Reference Number
Leland D. Hill - 281 4615701	02-29-1964	JSC/EGG/JE4EB	K.CU.50101

E. Badge Number	F. System/Device to be Used
	Alpha Magnetic Spectrometer -02 TRACKER ALIGNMENT SYSTEM

G. Type of User

- [x] Area Radiation Officer
- [ ] Operator
- [ ] Use Supervisor/Custodian
- [ ] Maintenance
- [ ] Other (describe) ____

II. TRAINING (Use Supplemental Sheets as Needed)

TYPE OF TRAINING	YES	NO	WHERE TRAINED	DURATION
A. Biological Effects	X		JSC - Flight Safety Aspects	1day
B. Radiation Protection				
C. Other				

III. EXPERIENCE (Use Supplemental Sheets as Needed)

TYPE OF EXPERIENCE	LOCATION	DURATION
A. Payload Flight Safety Engineer	Johnson Space Center	20yrs.
B. *design Analysis & compliance		
C. AMES RESEARCH CENTER INDEPENDENT INVESTIGATION OF WIND TUNNEL LASER INCIDENT	Ames Research Center	5 days
D.		

IV. REFERENCE DOCUMENTS

I have read and understand the following:

	Yes	No	N/A
A. KMI 1860.1	[x]	[ ]	[ ]
B. KHB 1860.2	[x]	[ ]	[ ]
C. 29 CFR 1910.97	[x]	[ ]	[ ]
E. 45th SWI 40-201	[ ]	[ ]	[x]
F. Fla. Administrative Code Chapter 64E-5	[ ]	[ ]	[x]

Signature of Applicant [signature] Date ____

Signature of ARO [signature] Date 3/26/2008

V. AUTHORIZING SIGNATURES

	Date
Health Physics [signature]	4/21/08
KSC Radiation Protection Officer [signature]	5/2/08
45th SW Radiation Protection Officer (if applicable)	
Chmn. KSC Radiation Protection Committee [signature]	5/2/08

KSC FORM 16-450 NS (REV. 4/99) PREVIOUS EDITIONS ARE OBSOLETE

RADIATION PROTECTION PROGRAM USE AUTHORIZATION

Use Authorization: **K-GU-50101** **Modification:** **000** **Date:** **04/14/2008**

User Organization: **Johnson Space Center**
JE-4EB
Houston, TX

Area Radiation Officer: **Leland Hill** Phone: **(281) 461-5701** Fax:

Use Authorization (UA) K-GU-50101 is issued subject to the controls and provisions specified herein.

I. PROTECTION GUIDES:

The Protection Guides (PGs) applicable to the evaluation of this UA is as determined in accordance with ANSI Z136.1and specified for each authorized source in Section VI.A. of this UA.

II. USE DESCRIPTION: Class 3R laser / Tracker Alignment System -Alpha Magnetic Spectrometer 02, internal to flight hardware, operated in a Class 1 configuration.

III. AUTHORIZED SOURCES AND APPROVED USE / STORAGE LOCATIONS:

Use Authorization K-GU-50101 provides for the radiation sources and locations described below:

A. Authorized Sources:

Manufacturer	No of Sources	Model Number	Serial Number	Wavelength (nanometers)	Class	Use Description
Eagleyard	1	EYP-RWL 1083	N/A	1083 nm	IIIR	Tracker Alignment

B. Authorized Locations:

Building/Area I.D	Location Type	Source Authorization
SSPF/PAD 39	Testing/USE	Alpha Magnetic Spectrometer (AMS – 02)

IV. AUTHORIZED PERSONNEL:

The following named personnel are approved for activities under Use Authorization K-GU-50101.

Name	Function / Duties
* Leland Hill	Area Radiation Officer (ARO)

* Training & Experience Summary Form attached. All users will be under the supervision of the ARO / US/C and be familiar with the control provision outlined below.

V. PROCEDURES:

Use of the laser identified by the provisions of this UA will be in accordance with user-submitted procedures identified below and the radiation protection controls and provisions identified in Section VII of this UA.

1) Manufacturer's recommended precautions and operating procedures.

VI. HAZARD EVALUATION:

Hazard evaluations have been made based on the Protection Guide (PG) and operating parameters identified for the authorized source specified in Section A. below:

A. Evaluation Parameters:

1. AMS-02 Lasers

Manufacture	:	Eagleyard
Laser Type	:	Diode
Wavelength	:	1083 nm
Peak Power	:	160 nJ (peak)
Pulse Length	:	8usec
Operating Mode	:	Pulsed
Beam Divergence	:	1.0 mrad
Beam Diameter	:	1.14 mm
MPE (Ocular)	:	420 nJ/cm^2

B. Worst-Case Hazard Assessment:

Worst-case hazard assessment defines the controlled area and any personal protective equipment requirements for operation of the authorized lasers under 'uncontrolled' conditions.

Nominal Ocular Hazard Distance (NOHD)

The NOHD is defined for unprotected intrabeam viewing (IBV) conditions.

Optical Density (OD) Requirements

The OD is defined at specific wavelengths for unprotected IBV exposure conditions within the NOHD.

Source Description	NOHD	OD
Alpha Magnetic Spectrometer (AMS – 02)	6.809 m	1

- Normal operating configuration does not require an NOHD or an OD unless maintenance is being performed on the AMS-02 laser.

VII. CONTROL PROVISIONS:

Continued authorized use of the source identified by this UA is contingent upon operations in accordance with the representation of the LDURA submitted and the controls and provision described herein.

A. Operational Controls:

1. Laser Radiation Controlled Areas (LRCA)

   The AMS-02 is a Class 3R operated in a Class 1 configuration. No laser controlled area is required as long as the AMS-02 is operated in a Class 1 configuration. Maintenance on the AMS-02 will require a Laser Radiation Controlled Area (LRCA). The (LRCA) as required and defined by this document will be posted in accordance with the provisions of this UA and access limited to approved user/operator personnel.

2. Notification Requirements

   a. Telephone numbers for the Health Physics Office (HPO) notifications are:

During Normal Working Hours: (Mon-Fri 0700-1700)	HPO	:	853-5688
Kennedy Space Center	RPO	:	867-6958
After Normal Working Hours:	KSC/CCAFS	:	853-5211

   b. ARO must notify the HPO upon transfer of the laser sources to other use/storage locations at KSC/CCAFS.

   c. ARO must notify the HPO upon transfer of the laser sources on or off of KSC/CCAFS areas.

   d. All real or suspected exposures to laser radiation must be immediately reported to the HPO.

   e. Operators are not required to notify the HPO prior to operations of laser sources.

   f. Operators are required to wear eye protection within the NOHD per section VI. B during operations/maintenance other then the Class 1 configuration.

3. Medical Surveillance Requirements

   Medical certification of eye examinations is not required.

A. Operational Controls: (cont.)

4. Postings and Labeling Requirements

   a. The LRCA as defined in Section VII.A.1 of this UA will be posted with approved "Laser Warning Signs" and will be as defined by ANSI Z136.1. (2007), whenever the lasers are having maintenance performed on them or being operated in other than a Class 1 configuration. (Prior approval from the HPO will be required for any operations of the lasers in other then a Class 1 configuration while at KSC).

   b. Where posting of the LRCA is not feasible; surveillance of the area will be maintained by the system operators to verify a clear in the immediate work area prior to and during operations. (prior approval from the Health Physics Office at KSC will be required).

   c. All lasers will be appropriately labeled in accordance with their ANSI classification. Labels shall be affixed to a conspicuous location on the laser housing.

5. Inventory/Accountability Requirements

   a. Inventory and accountability control of all lasers shall be maintained by the ARO.

   b. The ARO will functions as the point of contact for scheduling of periodic survey/audits by the HPO.

6. General Operating Provision

   a. The laser system will be operated only by qualified and authorized personnel identified by Section IV of this UA.

   b. Personnel whose job duties require entry into LRCA's shall be adequately trained, provided with appropriate protective equipment where required, and be familiar with the administrative and procedural controls established by operating procedures and this UA.

   c. Maintenance of the lasers sources must be performed by qualified and approved personnel.

   d. It is the responsibility of the user organization ARO to supply the hazard evaluation information listed in Section VI.B. of this UA to the organization performing maintenance on the laser device(s).

   e. Use of a laser **"beam stop"** is required during maintenance laser operations. All personnel within the NOHD must wear approved laser eye protection.

B. Administrative Provisions

1. Authorized Use Period

   Radiation Use Authorization K-GU-50101 is a General Use Authorization and is valid for an indefinite period of time, for the sources, personnel, use/storage locations and the procedures identified in this document.

RADIATION PROTECTION PROGRAM USE AUTHORIZATION

Use Authorization: **K-GU-50101** **Modification:** **000** **Date:** **04/14/2008**

B. Administrative Provisions (cont.)

2. Changes to Authorized Use

   a. Changes in sources, procedures, personnel, or use/storage location as described by Use Authorization K-GU-50101 must be identified through submittal of KSC Form 16-353NS "Modification of Radiation Use Authorization" describing such changes to the KSC Radiation Protection Office (TA-C2).

   b. Request for changes in authorized use must be submitted not less than thirty (30) days prior to Implementation of intended change, as described by KNPR-1860.2 "KSC Nonionizing Radiation Protection Program".

3. Operations not in accordance with the conditions or this Use Authorization may result in revocation of Use Authorization and possible impoundment of radiation source.

4. Further correspondence regarding sources, personnel or procedures governed by this Use Authorization must reference Use Authorization Number K-GU-50101.

[signature]
CHS/Health Physics Dept.

4/21/08
Date:

[signature]
NASA/KSC Radiation Protection Officer

5/2/08
Date:

PAYLOAD HAZARD REPORT		a. NO: GHR-AMS02-017
b. PAYLOAD: Alpha Magnetic Spectrometer-02 (AMS-02) GSE		c. PHASE: III
d. SUBSYSTEM: Tools	e. HAZARD GROUP: Human Factors	f. DATE: January 2010
g. HAZARD TITLE: Injury/Damage from Hand Tools or Loose Hardware		i. HAZARD CATEGORY ☒ CATASTROPHIC ☐ CRITICAL

h. APPLICABLE SAFETY REQUIREMENTS:

KHB 1700.7C, Section 4.1.6.; KHB 5310.1, General Operating Procedure 5-3.

j. DESCRIPTION OF HAZARD:

Personnel injury or hardware damage due to unsecured or unaccounted for hand tools or loose hardware.

k. HAZARD CAUSES:

1. Unsecured tools used above personnel or sensitive equipment.
2. Unaccounted for tools left in flight hardware, GSE, or payload bay.
3. Unaccounted for parts/components.
4. Tip over of GSE racks.

l. HAZARD CONTROLS:

(See continuation sheet)

m. SAFETY VERIFICATION METHODS:

(See continuation sheet)

n. STATUS OF VERIFICATION:

(See continuation sheet)

o. APPROVAL	PAYLOAD ORGANIZATION	SSP/ISS
PHASE I		
PHASE II		
PHASE III	[signature] 1/14/10	

JSC Form 542B (Rev November 22, 1999) (MS Word September 1997)

PAYLOAD HAZARD REPORT CONTINUATION SHEET	a. NO: GHR-AMS02-017
b. PAYLOAD: Alpha Magnetic Spectrometer-02 (AMS-02) GSE	c. Phase III

k. HAZARD CAUSES:

1. Unsecured tools used above personnel or sensitive equipment.

l. HAZARD CONTROLS:

1.1 Temporary restraints will be used to preclude tools from falling on personnel or critical hardware.

1.2 COPVs will be protected against tool damage during fixed ground operations.

1.3 Only secured tools will be used in proximity of COPV's when protective shielding is not in place.

1.4 Personnel will be trained to secure tools when they are being used above people or equipment.

m. SAFETY VERIFICATION METHODS:

1.1.1 Review of tool control plan to ensure it includes the use of temporary restraints.

1.2.1 Review of COPV plan to ensure adequate protection of the COPVs.

1.3.1 Review of tool control plan to ensure personnel are directed to use only secured tools.

1.4.1 Certification of personnel in proper use of tools.

n. STATUS OF VERIFICATION:

1.1.1 ~~Open~~Closed 11/06/09. ESCG-4295-09-C{AS-MEMO-0011, *Tool Control Plan*, dated 11/03/09.
1.2.1 ~~Open~~Closed 04/29/09. ESCG-4390-09-SP-MEMO-0002 , *AMS-02 COPV Damage Control Plan*, dated 01/26/09.
1.3.1 Closed 11/06/09. ESCG-4295-09-C{AS-MEMO-0011, *Tool Control Plan*, dated 11/03/09.~~Open~~
1.4.1 Closed 11/06/09. ESCG-4295-09-C{AS-MEMO-0011, *Tool Control Plan*, dated 11/03/09.

PAYLOAD HAZARD REPORT CONTINUATION SHEET	a. NO: GHR-AMS02-017
b. PAYLOAD: Alpha Magnetic Spectrometer-02 (AMS-02) GSE	c. Phase III

k. HAZARD CAUSES:

2. Unaccounted for tools left in flight hardware, GSE, or payload bay.

l. HAZARD CONTROLS:

2.1 Personnel training in AMS-02 tool control plan.

m. SAFETY VERIFICATION METHODS:

2.1.1 Verification of training in the tool control plan.

n. STATUS OF VERIFICATION:

2.1.1 Closed 11/06/09. ESCG-4295-09-CPAS-MEMO-0011, *Tool Control Plan*, dated 11/03/09.~~Open~~

JSC Form 542B (Rev November 22, 1999) (MS Word September 1997)

PAYLOAD HAZARD REPORT CONTINUATION SHEET	a. NO: GHR-AMS02-017
b. PAYLOAD: Alpha Magnetic Spectrometer-02 (AMS-02) GSE	c. Phase III

k. HAZARD CAUSES:

3. Unaccounted for parts/components.

l. HAZARD CONTROLS:

3.1 Personnel training to account for parts/components.

m. SAFETY VERIFICATION METHODS:

3.1.1 Verification of training to account for parts/components.

n. STATUS OF VERIFICATION:

3.1.1 Closed 11/06/09. ESCG-4295-09-C{AS-MEMO-0011, *Tool Control Plan*, dated 11/03/09.~~Open~~

JSC Form 542B (Rev November 22, 1999) (MS Word September 1997)

PAYLOAD HAZARD REPORT CONTINUATION SHEET	a. NO: GHR-AMS02-017
b. PAYLOAD: Alpha Magnetic Spectrometer-02 (AMS-02) GSE	c. PHASE: III

k. HAZARD CAUSES:

4. Tip over of movable GSE.

l. HAZARD CONTROLS:

4.1 Racks/movable items will be loaded to ensure low center of gravity.

4.2 Personnel will be trained to properly handle/load GSE racks.

m. SAFETY VERIFICATION METHODS:

4.1.1 Review of rack loading procedures to ensure low center of gravity.

4.1.2 Tip Over Analysis of all movable items, including items to be moved in the PCR (7 degree incline and expanded metal flooring).

4.2.1 ~~Personnel~~ Review of personnel training in loading/handling racks.

n. STATUS OF VERIFICATION:

4.1.1 Open
4.1.2 Open
4.2.1 Open

APPENDIX B: FLIGHT/GROUND ANOMALIES

Appendix B

Anomaly, Failure and Mishap Reporting

D.1 Introduction

In accordance with NSTS/ISS 13830, Payload Safety Review and Data Submittal Requirements, the AMS-02 Project has prepared this summary of anomalies, failures and Mishaps associated with flight and qualification hardware. This summary does not consider what are considered normal manufacturing deviations and discrepancies as failures or anomalies unless they rise to a clear safety impact status. All such manufacturing discrepancies associated with the AMS-02 Integration Hardware built and procured through Johnson Space Center are documented in the JSC QARC system.

Similar discrepancies from international suppliers of hardware are reported along with anomalies and failures to the AMS-02 Project Office, but only the anomalies and failures are recorded.

D.2 Significant Events

No.	ID	Title	Status
1.	AMS-02-A01	HV Board Interconnect Failure.	Closed
2.	AMS-02-A02	Uninterruptible Power Supply FET Cracked	Closed
3.	AMS-02-A03	Improper Torquing of ECAL Fasteners	Closed
4.	AMS-02-A04	Anomaly of Thermal Conductor of AMS Internal Tracker	Closed
5.	AMS-02-A05	Cryomagnet Arcing Discharge During Initial Ground Testing	Closed
6.	AMS-02-A06	Magnet did not reach design maximum field during qualification testing	Closed
7.	AMS-02-A07	STE wiring disconnected during magnet qualification test	Closed
8.	AMS-02-A08	Failure Anomaly Report for DALLAS Temperature Sensors (DTS) in TRD-GAS Box-C Canister	Closed
9.	AMS-02-A09	Cryomagnet/Vacuum Case Burst Disk Post Vibration Test Anomaly	Closed
10.	AMS-02-A10	AMS-02 Super Fluid Helium Tank BD03 Duct Excessive Thermal Conductance	Closed
11.	AMS-02-A11	Battery Box Fire	Closed
12.	AMS-02-A12	Battery Cell Under Voltage	Closed
13.	AMS-02-A13	Excessive Helium Consumption in Pilot Valves to Cold Weka Valves	
14.	AMS-02-A14	Unreliable Cryosystem Pressure Sensors	Closed
15.	AMS-02-A15	DDRS-02 Error during EMI Testing	Closed
16.	AMS-02-A16	Leakage of Explosively Bonded Bimetallic Joint in Cryosystem	Closed
17.	AMS-02-A17	Warm Helium Gas Supply Regulator Divergence	Closed
18.	AMS-02-A18	Bubbles in Radiator Heaters	
19	AMS-02-A19	Cleanliness of inside of the Superfluid Helium Tank	Closed
20.	AMS-02-A20	Deviation from documented procedure for Installation of MLI Pins	Closed

1. AMS-02-A01 – HV Board Interconnect Failure.

Description of Event: During thermal cycle testing high voltage electronics associated with the ECAL, RICH and TOF High Voltage power supplies experienced channel failures. Subsequent investigation indicated that during thermal cycling testing the straight forked pins that inteconnect the 16 mini-boards of the linear regulator were shown to have experienced thermally induced stresses that broke the solder connection. These thermal stresses were induced between the solder joint and the resin of the boards.

Corrective Action: The straight forked pins interconnecting between the 16 mini-boards were replaced in a test configuration and qualification unit 2 with reshaped pins that provide a strain relief function that the straight pins could not provide. A test board has been constructed and tested at CAEN as follows: 1) burn-in for 8 hours with a temperature of 70ºC ; 2) thermo-vacuum test with pressure of 0.1mBar, verifying the absence of discharges ; 3) thermal cycles (10 cycles in total between -30 ºC and +70 ºC, with a ramp-up rate of 4 ºC /min, down-ramp rate of 2 ºC /min and time of permanence at each temperature of 1 hour). At the end of each cycle, all the channels were inspected. No problem was observed.

Safety Impact: The loss of the high voltage sources within the RICH, ECAL and TOF would have had a significant impact on the science objectives of the AMS-02, but no significant impact to safety. Flight bricks will be fully potted, and the separation of the of the solder joint would not have created a sparking/ignition source concern or coronal discharge source. At worst this failure may have manifested as an increase in EMI noise because of intermittent contact and operation. This failure/anomaly has been classified as NON SAFETY CRITICAL.

Status: Closed

SUPPORTING DOCUMENTATION: (follows)

Modifications of ECAL, RICH and TOF High Voltage Power Supply QM design

Marco Incagli – INFN Pisa

5 september 2005

This note describes the modifications applied to the QM2 version of the High Voltage Power Supply (*brick*), to be used by ECAL, RICH and TOF subdetectors. The modifications became necessaries in front of failures registered during thermal tests performed both by the supplying company (CAEN - Italy) and by the INFN-Pisa, responsible of the ECAL subdetector construction.

In this note we report (1) how the QM1 was constructed, (2) the failures observed, (3) the new design of the QM2 and the status of the tests necessary to validate the new design.

1 – Construction of QM1

The *AMS brick* is described in AMS note 2005-09-01 .

In short, it is a modular structure providing the High Voltage (from 0.5kV up to 2.5kV) for the readout Photomultipliers (PMTs) used by the three subdetectors.

Three main components characterize the brick:

1. *Controller Board* communicating with the AMS electronics through the LeCroy slow control protocol and providing the low voltages to the DC/DC converters ;
2. *DC/DC Converter* generating the HV (up to 2.5 kV) from the 28V supplied by the International Space Station ;
3. *Linear Regulators* regulating the output voltage to the PMTs with a precision of $\Delta V/1024$, where ΔV is the operative range of the readout .

The number of DC/DC convertors and Linear Regulators is different for the three subdetectors, as reported in AMS note 2005-09-01 .

The *Linear Regulator* consists of a main board, with approximate dimensions 5×20 cm^2, on which 16 *mini boards*, actually performing the HV regulation for each channel, are soldered in the vertical position (see picture 1). The soldering is done through *fork pins* which are shown in figure 2.

In the QM1, the *fork pins* had a straight shape, so that no strain relief was foreseen.

After soldering the 16 mini boards, all the Linear Regulator is filled with resin, both to limit discharges and to mechanically protect the electrical components.

2 – Tests done on QM1

The different parts of two *brick* for ECAL and TOF subdetectors were mounted, and tested at CAEN and at INFN Pisa (ECAL *brick*, only). After thermal cycles between -20^{o}C and +70^{o}C (and after some trips from Pisa to CERN!) the two HV modules showed some malfunctioning channels.

To investigate the problem, the TOF *brick* was dismounted and the Linear Regulators were carefully inspected. As a result, some of the SMD soldering of the straight pins were found to be broken, as shown in figure 3. According to CAEN, the failures were due to different thermal coefficient between resin and soldering material, generating a stress able to cause the connection rupture.

To solve the problem, CAEN suggested to modify the pin shape.

3 – Modifications on the design and tests on QM2

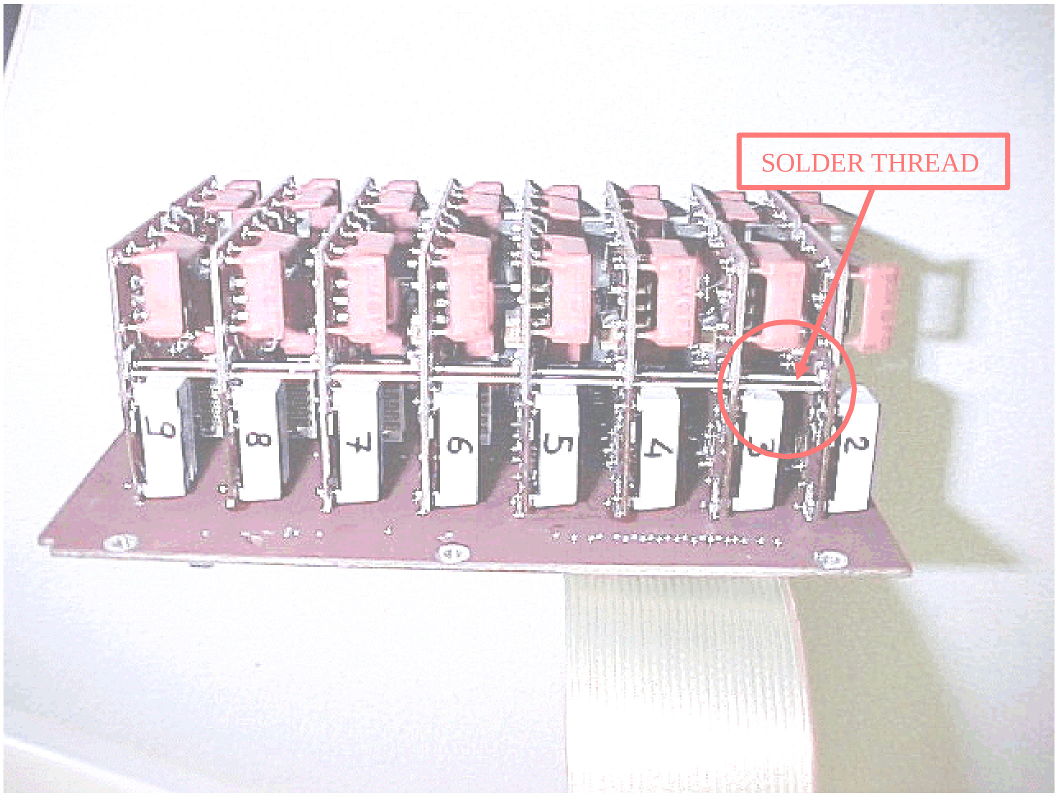
The CAEN proposal for the new pin shape is shown in figures 4 and 5. With this new shape, the pins should act as a strain relief and decrease the stress generated on the soldering pads by the thermal expansion.

A test board has been constructed and tested at CAEN as follows:

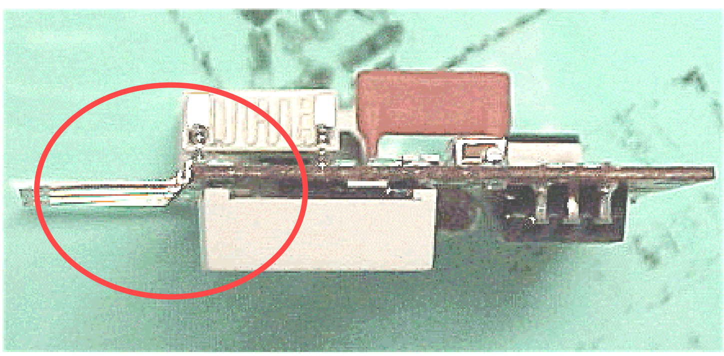
1. burn-in for 8 hours with a temperature of 70^{o}C ;
2. thermo-vacuum test with pressure of 0.1mBar, verifying the absence of discharges ;
3. thermal cycles (10 cycles in total between -30^{o}C and +70^{o}C, with a ramp-up rate of 4^{o}C/min, down-ramp rate of 2^{o}C/min and time of permanence at each temperature of 1 hour).

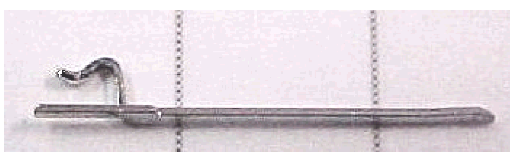
At the end of each cycle, all the channels were inspected. No problem was observed.

After these tests, a QM2 *brick* module, with 5 *Linear Regulator* boards and 1 *DC/DC converter*, was built to be tested by the RICH and ECAL groups. The tests will be performed in September 2005. Results will be reported in a following note.



Picture 1 – side view of TOF Linear Regulator.





Picture 2 – View of the single regulator mini board with closeup of the straight pins used used for the soldering of this component with the Linear Regulator main board.

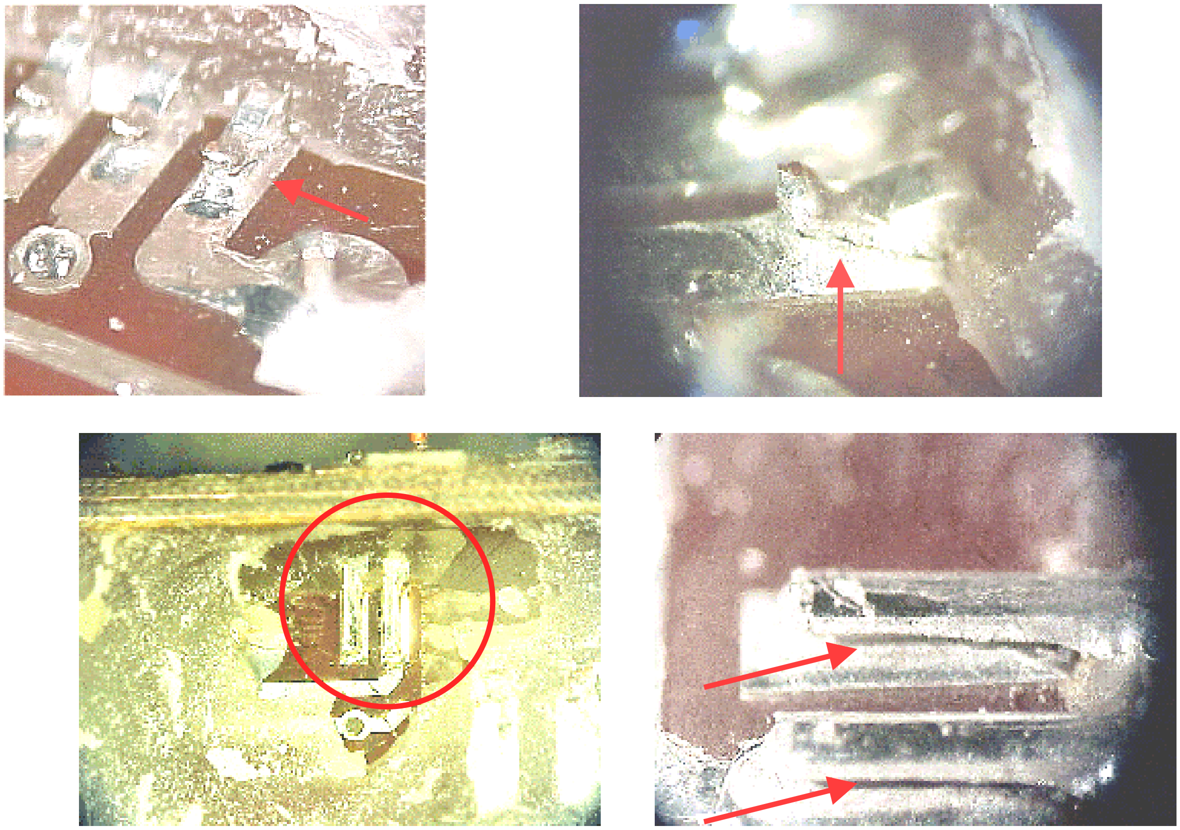


Figure 3 – Pictures of the pads where the *fork pins* were soldered.

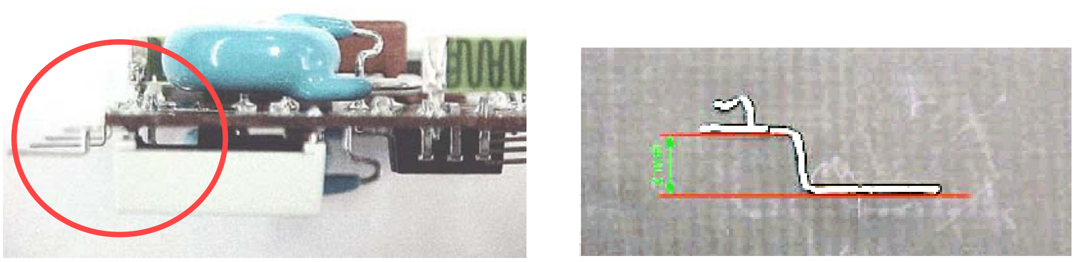


Figure 1 – New mini board with preformed pins(left). New shape of *fork pins* (right).

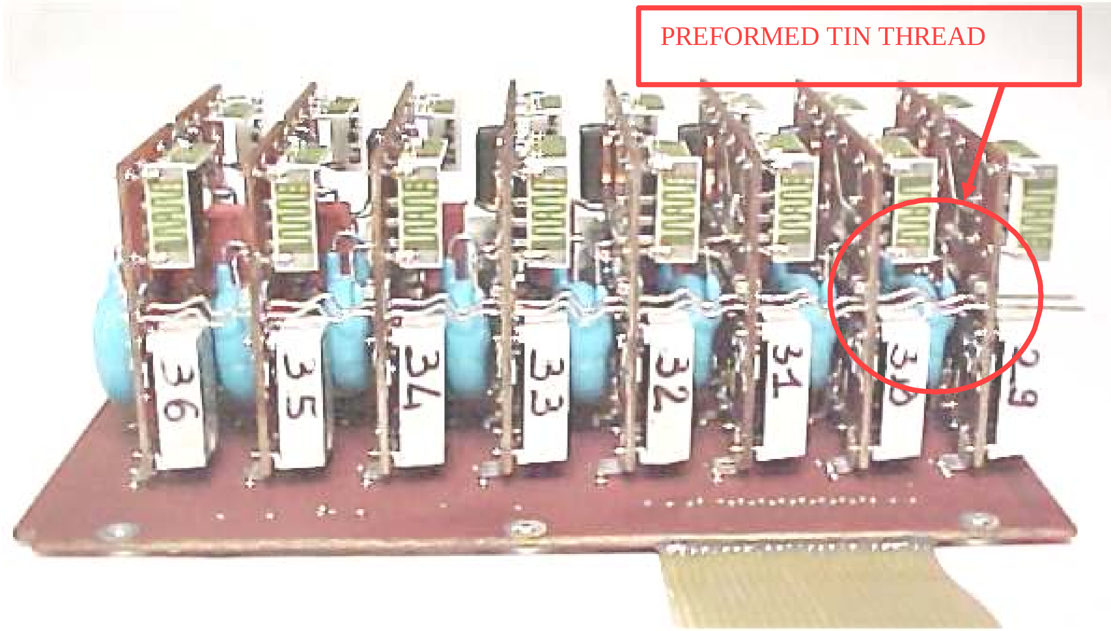


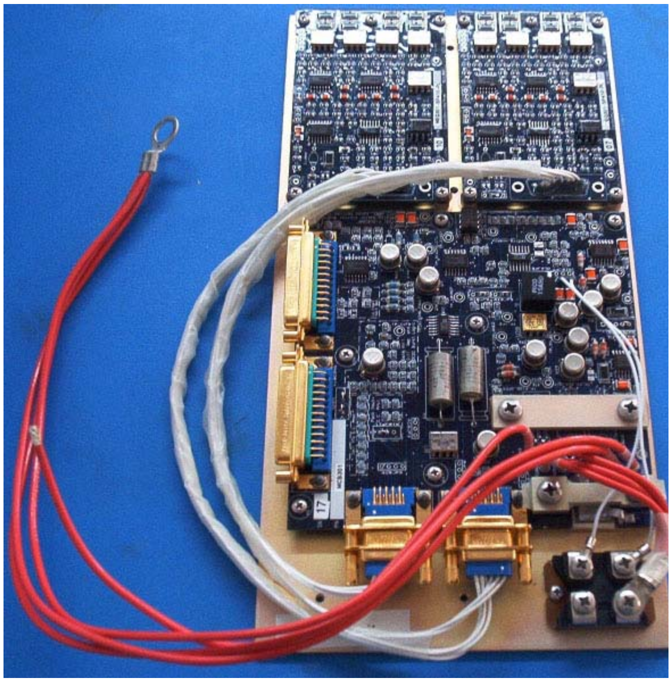
Figure 5 – QM2 test board. Also the interconnection thread has been preformed.

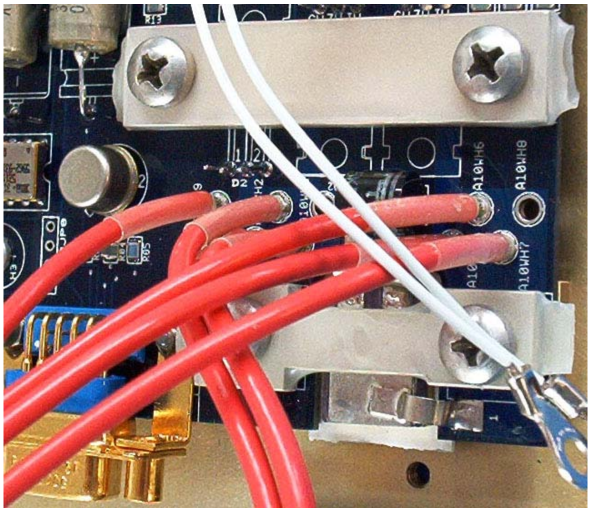
2. AMS-02-A02 – Uninterruptible Power Supply FET Cracked

Description of Event: During the final system testing of the full electronics assembly at Eaves Devices, the last board (5th out of 5) tested failed the current interruption test (support 77A for 360ms to 1500ms). Upon examination of the board, it was discovered that the FET was cracked under the compression bar holding it in contact with the heat sink. These cracks apparently shorted the device, causing it to fail under high current. As shown in the attached pictures, the FET (located in the front right of the AMS BMS picture, near all the big red wires) has a compression bar over the top of it, holding it in contact with two layers of SIL-PAD and an aluminum heat sink. Per Eaves Devices assembly procedures, the screws on this compression bar are only torqued to 6 in-lbs.

Further examination of the other 4 boards revealed that the FETs in those boards showed signs of cracking, but had not failed any testing.

The FET on the failed board was removed and an industrial version of the FET was put in place to test the rest of the circuitry and confirm that no other damage had been done. All circuits performed normally.





Corrective Action: Compression bar was eliminated from the design an a thermally conductive adhesive was used. Material usage was approved by JSC Materials. Thermal performance and board function were retested and found acceptable.

Safety Impact: The FET was functioning in a critical battery protection function, protecting the system against external shorts. Corrective actions were essential in maintaining system safety.

Status: Closed

3. AMS-02-A03 – Improper Torquing of ECAL Fasteners

Description of Event: The torques specified and used in the assembly of the ECAL were for a dry installed fastener interface. Dry install torques are higher than lubricated install torques due to the need to overcome the higher coefficient of friction of bare metal to metal contact. All of the structural inserts and nuts used to assembly the ECAL have a dry film lubricant coating that acts to reduce the friction of the fasteners during installation. Margins of safety for the ECAL fasteners were recalculated using the torques called out in the assembly process with a lubricated interface. The analysis results showed that possible yielding had occurred during the installation of the fasteners.

Corrective Action: All of the structural fasteners that showed negative margins of safety have been either be removed, inspected and reinstalled or be replaced with new fastener and preloaded to torques specified according the latest analysis results. Drawings/installation instructions indicating the dry insertion torques have been corrected to reflect correct lubricated values. Structural margins have been confirmed to be positive after rework.

Safety Impact: The ECAL bolts improperly installed failed to have sufficient structural margin, making this assembly error SAFETY CRITICAL. Corrective actions were witnessed to confirm full compliance and to assure positive margins were regained.

Status: Closed

4. AMS-02-A04 – Anomaly of Thermal Conductor of AMS Internal Tracker

Description of Event: During assembly copper braids used as thermal conductors were observed as having broken wire elements after undergoing in situ compression (a required process). None were found to be loose, but separated.

Corrective Action: Heat shrink tubing implemented over braids to contain any possible fragments. Fragment generation unlikely as copper conductors were only broken on one side and still retained on the other. Additional containment within tracker is provided by mesh filters at light tight vents.

Safety Impact: There was a potential of generating small debris that was electrically conductive. While this is not a concern beyond mission success for the Tracker, the loose wire fragments co-orbiting with the ISS was undesirable. The safety assessment considered this Safety Critical, and design features in place and corrective procedures were deemed adequate to protect against this remote hazard.

Status: Closed

SUPPORTING DOCUMENTATION: (follows)

UNIVERSITÉ DE GENÈVE
FACULTÉ DES SCIENCES
Département de Physique Nucléaire et Corpusculaire
24, quai Ernest-Ansermet
CH-1211 Genève 4
Tel: +41 22 379 6273
Fax: +41 22 379 6992

Report on Anomalies and Modifications of Thermal Connectors during Assembly of AMS Internal Tracker

Prof. Divic RAPIN

Date: September 1, 2006

Re: Thermal connectors (Copper braids) connecting to each other the thermal bars of planes 2, 3 and 4 of the tracker.

Location: University of Geneva clean rooms (veranda).

Observations: Some threads of the Copper braids used as thermal connectors between inner planes were found to be damaged during the assembly *(See Appendix A)*. The damaged threads are broken on one side only and none was found to be loose. The loss of thermal conductivity is negligible.

Reporting: AMS TIM July 2006 at CERN

Actions taken: Study of a containment procedure of the Copper braids using space qualified heat shrink tubing *(See Appendix B)*. This tubing must be installed *in situ* after vacuum cleaning of the braids with examination of the filter. The heating should not damage the electronics.

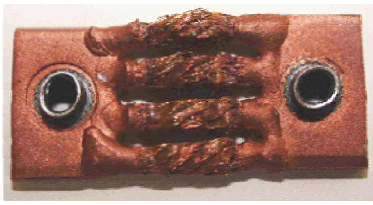
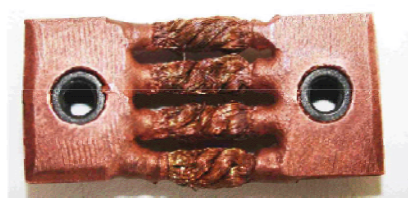
Results: Application of this procedure to the 192 thermal connectors of the inner tracker during its assembly. *(See Appendix C)*

Safety assessment:

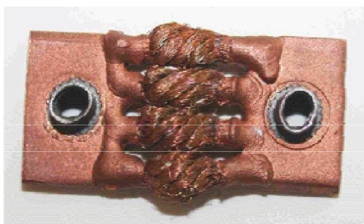
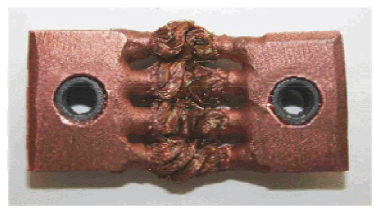
- No damaged thread was found to be loose.
- Damaged threads are broken on a single location, reducing the stress.
- Two containment barriers exist:
  1: heat shrink tubing around the braids (new).
  2: mesh in the light tight venting apertures containing material in the inner tracker.

Appendix A: **Thermal connector compression, damages**

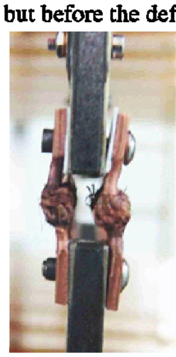
Thermal bars are connected by thermal connectors made of Copper braids welded to small plates. Both faces of one connector are shown below:

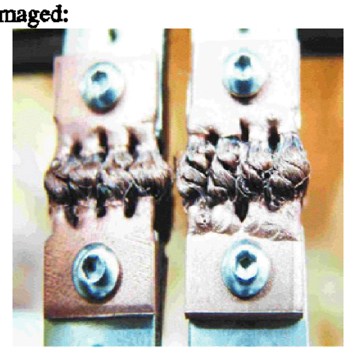



Compression along Z-axis is applied to the braids in order to restore flexibility and to adjust the length in Z. Pictures below show a connector after compression.

This compression was performed *in situ* during assembly of the 3 planes of the inner tracker but before the definitive connexion. Some braids were damaged:



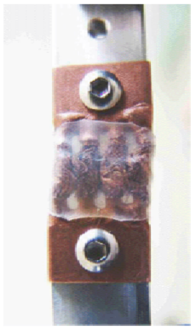



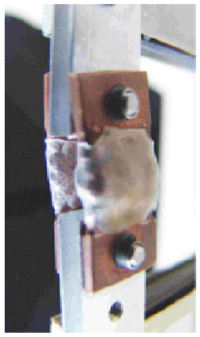
Remarks:

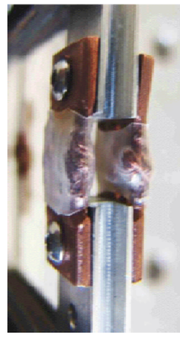
- Some weakness of the metal properties might have been introduced by the welding of the Copper braids
- The effect on thermal conductivity is negligible.
- The damaged threads showed a single break.
- No one was found to be loose.

Appendix B: **Containment of Copper braids**

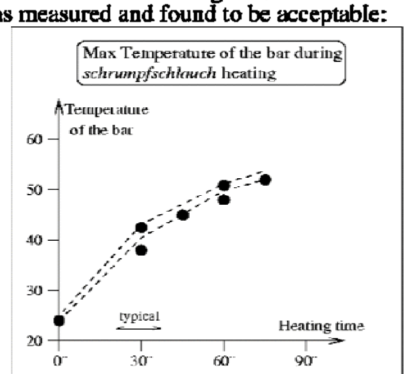
We studied the use of Kynar heat shrink tubing (space qualified) to enclose the Copper braids. Preliminary tests on prototypes are shown below:



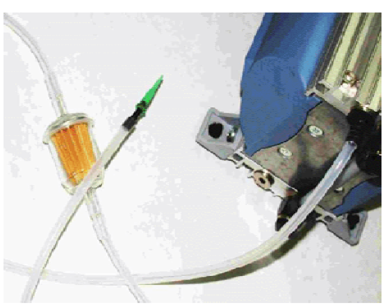


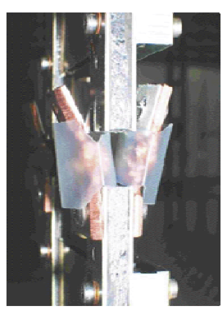


The tube is heated during ~ 30 seconds. The effect on the temperature of electronic hybrid circuits was measured and found to be acceptable:



A procedure was established and was applied on all thermal connectors. A preliminary cleaning was made with a micro vacuum cleaner. The filter was examined. No broken thread was found in the filter.





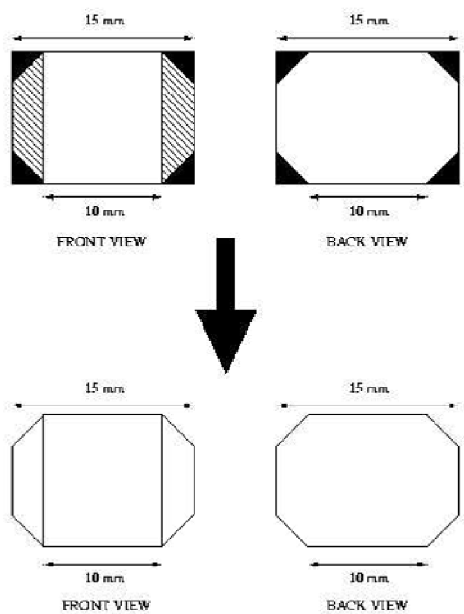
Appendix C: **Detailed implementation of procedure and controls**

AMS-02 Tracker : Heat-Shrink Tube Installation

Date : .... / .... / 200...	Time :	Done by : ....
Octant :	Column :	

1- Preparation of the Samples

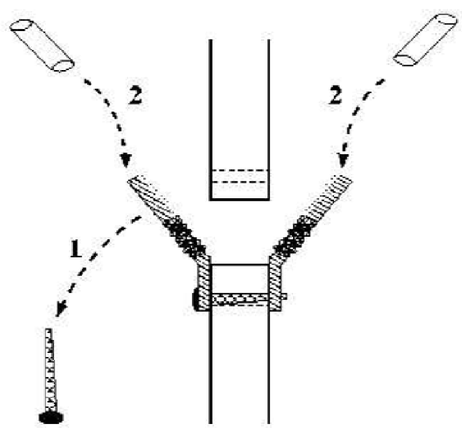
		Ok	Comment
1.	Take the Heat-Shrink Tube : diameter=21,1 mm (flattened).	☐	....
2.	Cut 4 Samples of 15 mm length.	☐	....
3.	Adjust the shape of the samples in accordance with the following pattern :	☐	....



4.	Clean the samples (Isopropyl alcohol).	☐	....

2- Installation

		Ok	Comment
1.	Protect the corresponding plane with a 'PlexiBulle' cover.	☐	....
2.	Find the location of the 4 copper connectors on the half-column.	☐	....
3.	Rectify copper braids which exceed the width of the copper connectors.	☐	....
4.	Unscrew the two pairs of copper connectors on the not-stuck side of the column.	☐	....
5.	Clean the braids with the vacuum pump equiped with a filter.	☐	....
6.	Check the filter.	☐	....
7.	Put the heat-shrink tubes on each pairs (adjust the form if necessary).	☐	....



8.	Screw up the two pairs of connectors in order to maintain the tubes in the good position.	☐	....
9.	Use the 'micro-heater' (settings : 'heat'=3, 'blow'=5) to heat the heat-shrinkable tubes. Pay attention to the hot air direction (no hot air near the electronics boxes!)	☐	....
10.	Check that the heat-shrinkable tubes cover well the braided part of the copper connectors.	☐	....

5. AMS-02-A05 – Cryomagnet Arcing Discharge During Initial Ground Testing

Description of Event: During initial charging during pre-integration testing in a ground dewar assembly, the flight Cryomagnet experienced an electrical discharge exterior to its inductive coils that damaged circuit boards and structural cables. The cause of this event was an incomplete evacuation of the helium that the coils had been immersed in as part of the cool down procedure (not done in the flight configuration). The easily ionized residual helium allowed a corona discharge to form and carry the stored power of the superconducting magnet from the initiation point on a sensing circuit board to the grounding structure.

Corrective Action: 1) Ground dewar for containing the AMS-02 Cryomagnet was repaired to eliminate vacuum leaks that precluded total evacuation of helium gas.

2) Cryomagnet was carefully inspected to establish complete damage assessment of structural cables.

3) Damaged cables were carefully examined to establish the remaining number of strands at each damage location. Cables were "locked" with wedges and adhesive to preclude any single section of cable structural integrity loss would be isolated. Testing confirmed adequacy of design. Worst location received additional load sharing with plates and rods to offset loads.

4) Damaged cable sections were saturated with epoxy and wrapped with glass take to strengthen interstrand strength and preclude any "unwravelling."

5) Damaged Circuit boards were replaced.

6) Cryomagnet was energized and found to successful withstand magnetic field loading (the worst case structural loading on the damaged cables.)

Safety Impact: The damage to the structural cables that keep the magnetic coils structurally sound during the loading of the Cryomagnet's magnetic field is a significant safety concern. Analyses and the testing program for the corrective action showed that there was no significant reduction in load carrying capabilities and pose no threat to either the Shuttle or the ISS.

Status: Closed

SUPPORTING DOCUMENTATION: (follows)

6. AMS-02-A06 – Magnet did not reach design maximum field during qualification testing

Description of Event: During the magnet qualification testing, the team was unable to reach to full design current due to differences between the test configuration and the flight configuration. The magnet will never be run at a current higher than was tested on the ground. The magnet qualification testing included several current ramp-ups. During these tests, it is expected that the superconducting magnets will experience training quenches. The maximum design current is 459 Amps. While performing tests to reach this design current level, the magnet quenched at 411 Amps. During the next test, the magnet quenched at 408 Amps. Although it was originally believed that these quenches were training quenches, it was later determined that these quenches were caused by a thermal effect to do with the interaction of the persistent switch with the helium-filled cooling loop. This interaction is ramp-rate dependent, which means that it would probably be possible to reach higher currents in the magnet by charging more slowly. In principle, given enough time and schedule, the magnet could have been tested to a higher level. However given time and budget constraints, a decision was made to perform the final test to only 390 Amps in the Magnet Assembly Test Rig. A test to a higher value is still possible in the flight configuration, but a decision has not been made yet as to whether or not this additional testing will be performed. Trying to reach higher field in the flight cryostat carries a risk of bursting a burst disc, so the number of quenches should be minimized if possible.

Corrective Action: Utilize the magnet with a new current limit of only 424 Amps. This is acceptable for science, and minimizes the risk to damaging the flight system. A simple change of the ramp rate in the flight system, along with some minor movements of the cooling loop versus the current leads will minimize the risk of these same kind of thermal effect quenches occurring on the flight magnet. Additional tests will be performed on the flight magnet to ensure that it reaches the new full field without quenches.

Safety Impact: None. The magnet will be run at a field below the level that we have analyzed for safety. Structural qualifications, which originally were to use a magnetic field induced load to test the structure to demonstrate margin has been shown to be good by analysis to a FOS of 2.0. This analytic approach has been coordinated and approved by the SWG.

Status: Closed

SUPPORTING DOCUMENTATION: (none)

7. AMS-02-A07 – STE wiring disconnected during magnet qualification test

Description of Event: Prior to completing the assembly of the AMS Superconducting magnet, the magnet assembly was tested in a Magnet Assembly Test Rig. During this testing, several Special Test Equipment heaters were added to the magnet. These heaters were used to intentionally induce a quench in the magnet coils. Essentially, they were put in place to mimic the flight quench protection heaters or a random quench. The wiring for these heaters, which was also STE, was not adequately held in place to prevent movement during a quench. Essentially, the wires were bundled together with Kapton tape only (Figures 1 and 2). At the operating temperature of 1.8 Kelvin, the adhesive on the Kapton tape was not adequate to hold the wires together. During a magnet quench several of the wires experienced loads induced by the rapidly changing magnetic fields. These loads moved and pulled some of these wires out of the STE circuit board or the heater (Figure 3). The result of this was that several of the test necessary heaters to ensure no damage is done to the magnet were not functioning and the test had to be abandoned.

Figure 1: Test Wiring Before Magnet Testing

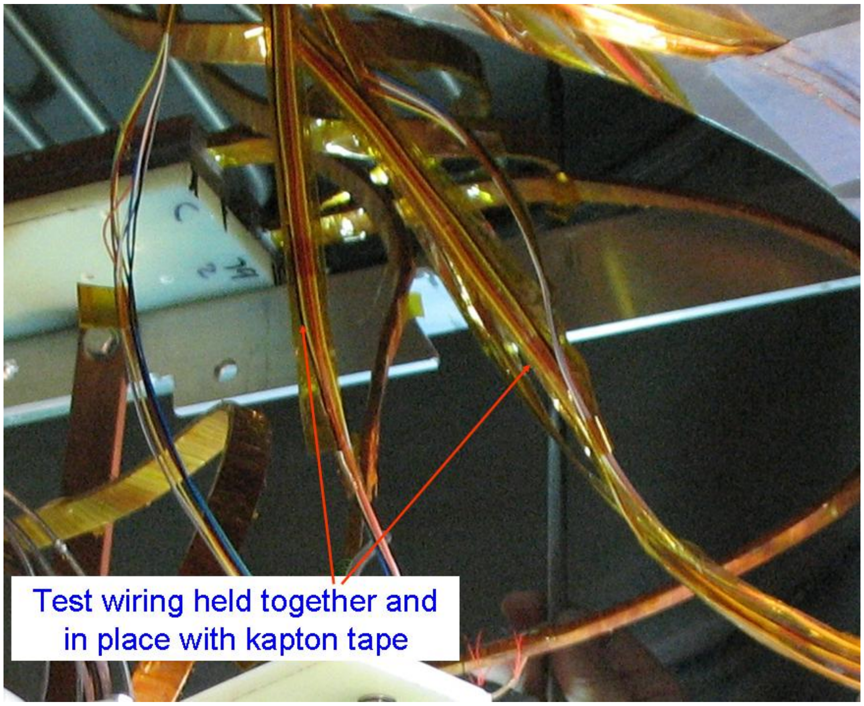


Figure 2: Close-up of Test Wiring Before Magnet Testing

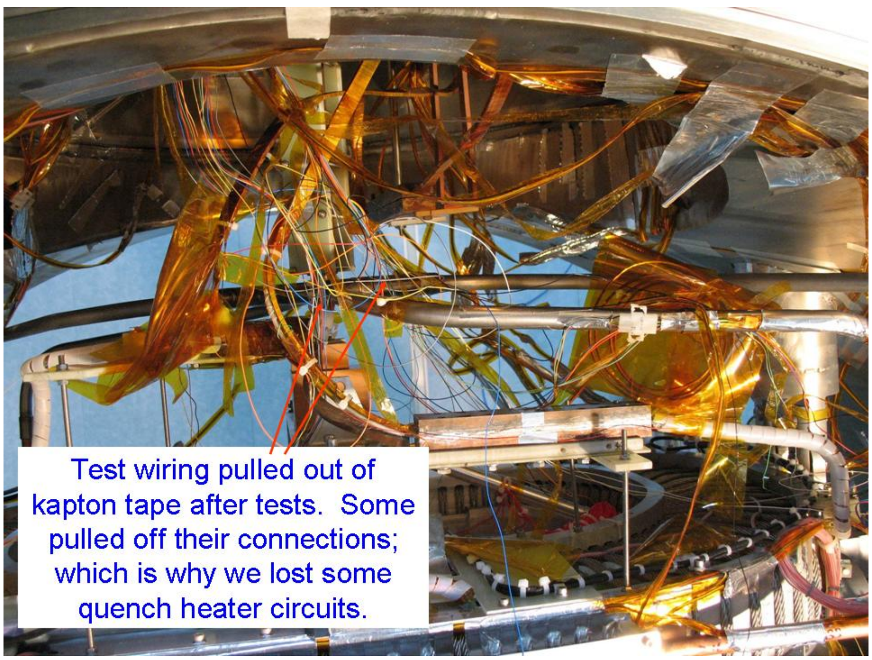


Figure 3: Test Wiring After Magnet Testing

Corrective Action: Flight systems were not directly impacted by this event, however actions were taken to assure that all wiring for the flight system has adequate restraints to prevent movement and pull-out of necessary electronic equipment and wiring.

Safety Impact: None. Even in the event that the quench protection system does not fire the quench protection heaters, any 'damage' to the magnet is not a safety concern. The tiny movements could be a concern for the mission success of the magnet, but pose no danger.

Status: Closed

SUPPORTING DOCUMENTATION: (None)

8. AMS-02-A08 – Failure Anomaly Report for DALLAS Temperature Sensors (DTS) in TRD-GAS Box-C Canister

Description of Event: Non functional DTS were observed when testing on Aug.15th 2007, before the welding of TRD-GAS Box-C Canister. Upon investigation it was determined that the supply voltage had been applied to the sensor with reversed polarity due to wrong Box-C canister internal cabling documentation.

Corrective Action: The DTS were replaced as they had been used out of the manufacturer's Absolute Maximum Rating (by applying reversed power which is limited in the manufacturer's specification to -0.5 V) and all documentation was corrected to note the correct polarization. Wiring corrected all DTS sensors worked per design.

Safety Impact: None. The DTS system is used to health maintenance and system performance, not safety.

Status: Closed

SUPPORTING DOCUMENTATION: (None)

9. AMS-02-A09 – Cryomagnet/Vacuum Case Burst Disk Post Vibration Test Anomaly

Description of Event: During post vibration testing, the burst disk assembly (of three series burst disks) was pressure tested to assure that it's performance met standards, that is that with the application of pressure in excess of the rupture value the sequence of burst disks would rupture allowing for venting. During testing the first (closes to pressure source) burst disk ruptures properly, but the second burst disk only partially opened, the third remained entirely intact. This effect was repeated on subsequent testing. Additional testing led to the understanding that the large low pressure burst disk was responding to a low energy shock wave that had sufficient pressure to begin a rupture, but insufficient energy to complete the rupture of the second burst disk. This phenomena appeared to be design specific, as it was no duplicated when the first burst disk was removed the second and third burst disks opened properly. The AMS-02 Project sent a request to the PSRP to establish if the triple burst disk design imposed at the AMS-02 Phase I Flight Safety Review was properly applied to the vacuum case burst disk configuration. With the PSRP representative's concurrence AMS-02 is proceeding with a revised design that utilizes a pair of burst disks in series not three.

Corrective Action: Fike is redesigning the entire vacuum case burst disk assembly using the lessons learned from this unique phenomena and configuration and will be re-qualifying the design.

Corrective Action of AMS-02-A09 is linked to Corrective Action to AMS-02-A10.

Safety Impact: An improperly functioning burst disk assembly could allow pressure to rise in the vacuum case in the event of a Helium tank rupture that leads to pressure build up in the vacuum case. This makes this a Safety Critical anomaly and the revised system will undergo all appropriate qualification testing.

Status: Closed. See AMS-02-A10

SUPPORTING DOCUMENTATION: (follows)

Engineering and Science Contract Group
2224 Bay Area Boulevard
Houston, Texas 77058

ESCG-4390-08-SP-MEMO-0002
9 January 2008

TO: Ray Rehm, Paul Mensingh, PSRP Executive Secretary

FROM: Chris Tutt, Leland Hill

SUBJECT: Review of Anomalous AMS-02 Burst Disk Test Results

Introduction

One of the primary scientific elements of the Alpha Magnetic Spectrometer (AMS-02) is a cryogenic, superconducting magnet. This magnet is enclosed in a dewar, the outer surface of which is referred to as the Vacuum Case (VC). The VC has a maximum design pressure of 0.8 bar, with overpressurization protection provided by burst disks. The disks use a reverse-acting circumferentially scored mechanism with cutting teeth. When the disk reaches burst pressure, the disk membrane reverses and the scored line presses against a cutting blade to induce a full rupture. This meets the standards of NASA/JSC TA-88-074 for single fault tolerance.

Originally, the system was designed with a single burst disk, which is typical for most high-performance cryogenic systems. At the Phase 0/I Flight Safety Review, the panel identified a new failure mode for the system. If the disk were to leak or spontaneously rupture within the atmosphere, air could enter the dewar's vacuum space. This would lead to a massive influx of heat into the tank of superfluid helium inside, which would cause it to rapidly warm up. As the helium begins boiling, the tank pressure would eventually rise to the burst pressure of the tank's burst disks and begin venting. If this were to occur during the point of maximum load during ascent, the Shuttle payload bay could be overpressurized. The panel therefore demanded a triple-redundant burst disk design to provide two additional levels of control against leakage. This arrangement is shown in Figure 1.

In the overall design, the original burst disk was called BD07, so in the new design, the disks were named BD07A, BD07B, and BD07C. Because the disks have a design burst pressure less than atmospheric pressure, vent lines have to be added to the interspaces between the individual disks to allow the air sealed in the tubes during manufacturing to escape. Otherwise, disk B and C would rupture when the outside atmosphere during ascent reached 0.2 bar. Given the small air volumes behind the disk, this would almost certainly lead to an incomplete rupture, which would prevent the assembly from providing the required overpressure protection. In Figure 1, these vent lines are shown as rising 90-degree bends from the interspaces.

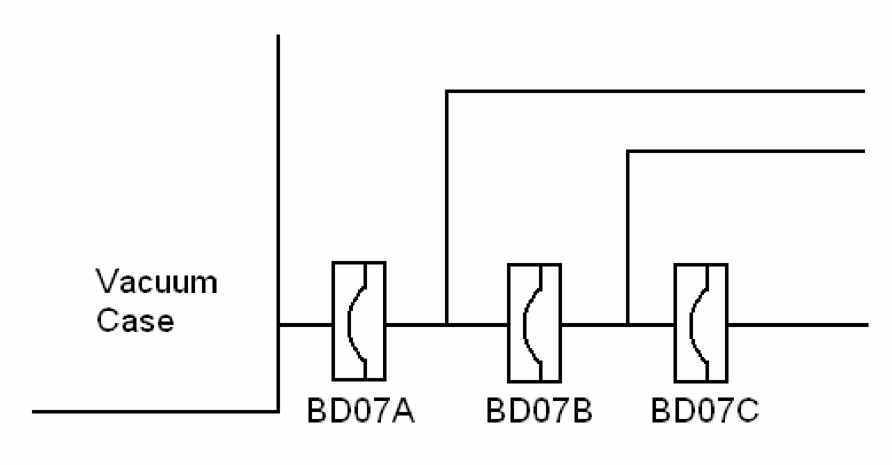


Figure 1: Vacuum Case Burst Disk Schematic

The triple disk assembly was designed and manufactured by the Fike Corporation based on the schematic in Figure 1. The main vent channel has a large flange with redundant O-ring seals where the assembly bolts to a port in the VC. Figure 2 shows a section through the assembly. The small holes in the interspaces are the 0.25" OD vent lines, while the two 2.688" through holes are the zero-thrust vents for the exhaust.

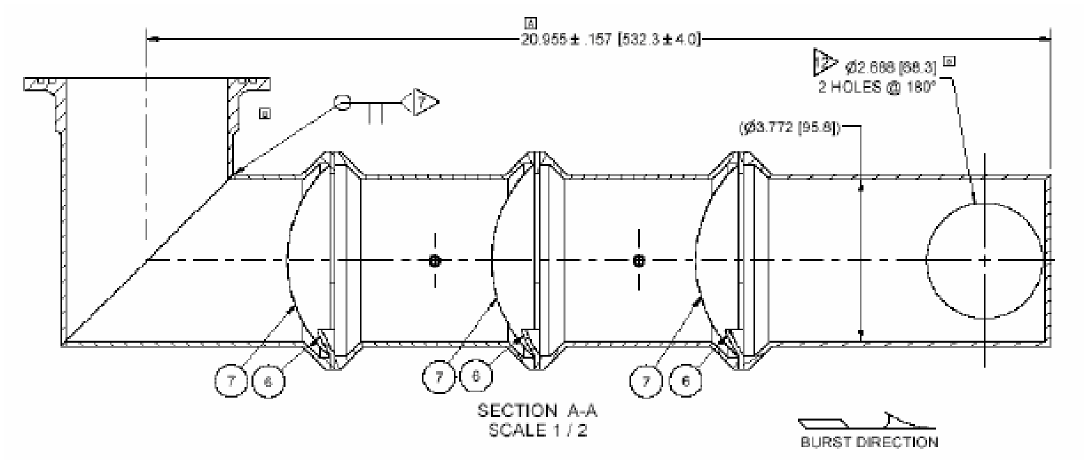


Figure 2: Burst Disk Assembly Design

Test Anomaly

As described in the burst disk qualification plan (SCL Memo #2484), three qualification units will be built and burst for each flight unit. Originally, there were to be two flight VC burst disk assemblies delivered: one for the flight unit and one for the structural test article (STA), which was to have a working cryosystem. Six qualification units were therefore built, along with a flight spare. The STA cryosystem was later removed from the design, so that unit became a second flight spare. The order with Fike had already been placed at this point; therefore all six qualification units were made. These will be referred to subsequently as Units 1-6, while the flight spares will be referred to as Units 7 and 8. This plan was presented in the Phase II Flight Safety Review package and was approved by the panel at that time.

For qualification testing, each test unit was attached to a large pressure vessel filled with gaseous helium. Pressure in the space behind BD07 was allowed to rise slowly to the design burst pressure, at which point all three disks should have burst. The setup is shown in Figure 3.

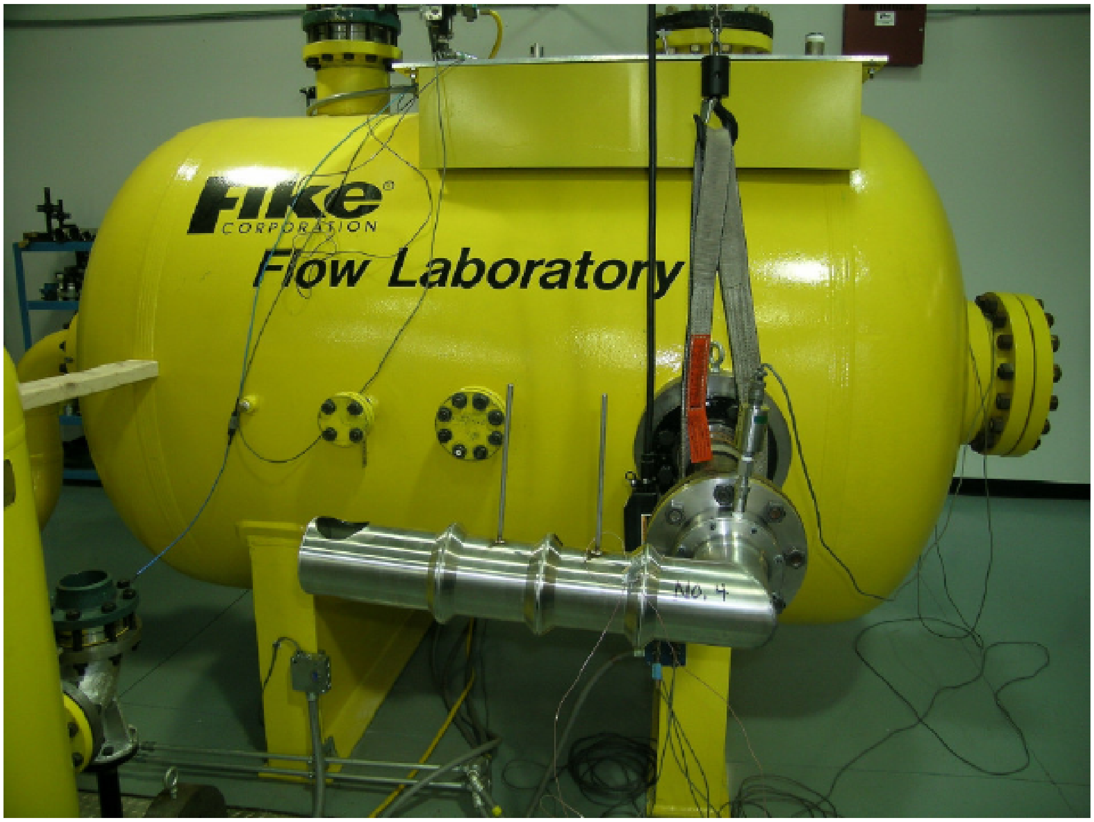


Figure 3: Qualification Test Setup

In the qualification burst of Units 1-4, BD07A ruptured normally, but BD07B failed to fully open. The disk membrane appeared to reverse, but did not fully tear. (This was confirmed when Unit 1 was cut open for a visual inspection of the disk, shown in Figure 4.) Airflow through BD07B was restricted enough that all air passing through simply vented through the interspace vent line. Air flow into the test volume was shut off at the sound of the event, preventing a renewed pressure rise.

Figure 4: Incomplete Tear of BD07B

During the test of Unit 4, pressure taps recorded data at the inlet of BD07A and the interspace between BD07B and BD07C. The pressure data for the BD07A inlet is shown in Figure 5. Immediately after burst, there is a series of wide pressure oscillations ranging over nearly 3 psig at approximately 20 Hz. The cause of this oscillation is not immediately clear, but it is the likely cause of the anomalous behavior. The first spike at 12 psig is more than enough to reverse disk BD07B, but since it drops to less than 9 psig within approximately 0.05 seconds, there may not be enough energy to completely tear the disk along the score line. (The pressure measurements in the BD07B/C interspace did not show these oscillations.)

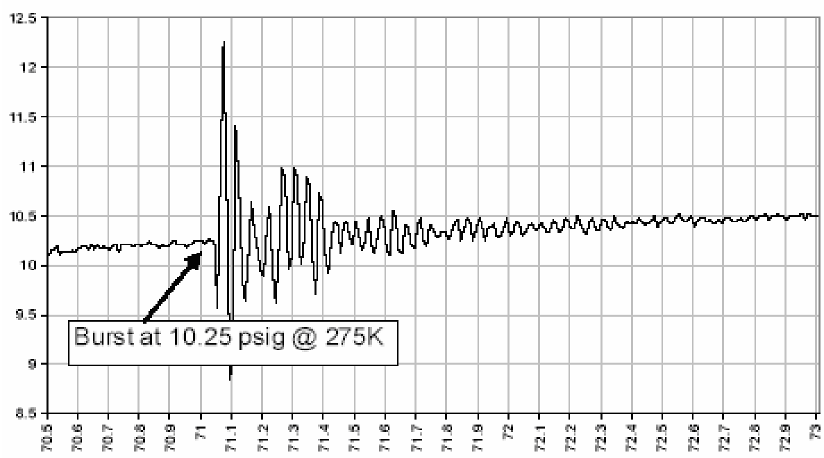


Figure 5: Pressure v. Time for Unit 4 Qualification Test

After further discussion, Fike mechanically cut out BD07A in Unit 5 and subjected disks B&C to a qualification burst. Unit 5 operated nominally, with both disks operating exactly as designed. Pressure taps in the new VC/BD07B interspace did not record any oscillatory behavior similar to Figure 5.

While the root cause of the pressure oscillation has not been completely determined, it is most likely a shockwave-related event caused by the 90-degree bend in the assembly tube just prior to BD07A. This would explain why the anomalous results occurred in Units 1-4 but not in Unit 5, where the initial burst surface was much further away from the bend.

In addition to these tests, Units 1 and 4 were tested a second time to see if the second disk would eventually rupture nominally if repressurized to the design burst. In both cases, BD07C burst normally, but BD07B remained in the partially torn condition.

Proposed Modification

The anomalous test results clearly require a change in the overall design of this assembly, but because of the advanced stage of payload manufacturing and design, the goal is make the modifications as simple as possible. The project's proposal is to remove BD07A from all remaining assemblies using a similar process to what was done for Unit 5. The vent line for the BD07A/B interspace would be crimped and welded shut as well. The flight system would then look exactly like Unit 5, which has undergone a successful qualification test. Units 6 and 7 would also undergo qualification bursts to give the 3:1 test ratio mandated in the burst disk verification plan. The new schematic is shown in Figure 6.

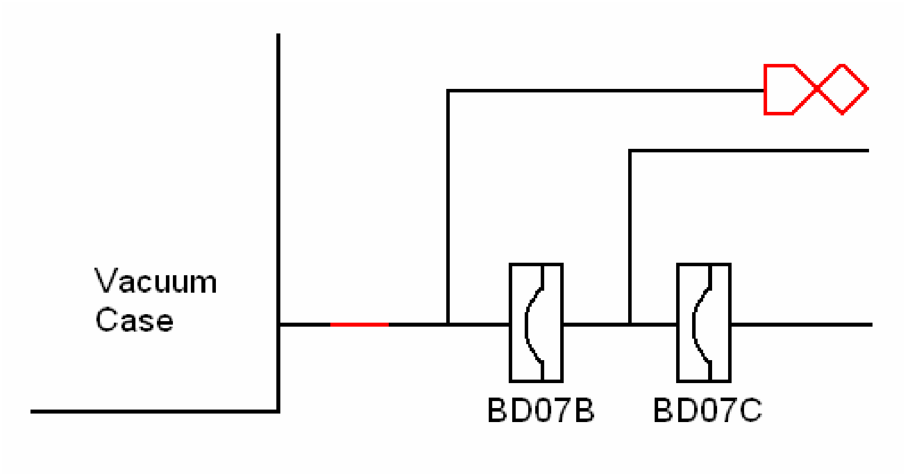


Figure 6: Proposed VC Design Modification

This may seem to remove one level of safety control in the design, but in fact it has no bearing on the risk of leakage through the assembly discussed in the previous section. As shown in Figure 1, there was always a potential leak path through the vent tube in the BD07A/B interspace if a leak were to develop in BD07A. This potential leakage has already been assessed against the maximum credible leak used in the overall VC design and found to be encompassed by the existing analysis. In the new system, the potential leak path is through BD07B instead of BD07A, but this has no bearing on either the safety acceptance rationale in the overall safety analysis or on our compliance with it.

In order to exceed the existing analysis, both BD07B and BD07C would have to spontaneously fail fully open, allowing air to rush in through the full-sized vent orifice. The only potential causes of a spontaneous failure would be launch vibration or material corrosion. These scenarios are not credible for several reasons:

1) The disks are made of 316 series stainless steel, a standard Class I aerospace material with no history of spontaneous corrosion if treated properly.
2) All six qual units were vibration tested to acceptance vibration levels. None of the disks (18 in total) failed post-test leak checks.
3) Neither burst disk is designed to burst from the outside. As shown in the retests of Units 1 and 4, once the disk has reversed and even partially torn, it sustained a pressure of approximately 0.8 bar without fully opening. Outside air pressure above 1.8 bar psia is clearly not credible.

The project therefore feels that the proposed design change does not in any way affect the overall safety of the AMS-02 VC and thus should present no concern to the Payload Safety Review Panel.

9. AMS-02-A10 – AMS-02 Super Fluid Helium Tank BD03 Duct Excessive Thermal Conductance

<u>Description of Event:</u> During developmental work on the flight hardware for the duct that takes any released gas/liquid from the BD03 (3 bar) on the superfluid helium (SFHe) tank to the BD06A-B (2, 3 bar) in the port of the vacuum case, the thermal conductivity and inability to block heat radiation of the fiberglass duct was found to be unacceptable and work to develop an alternative means of conducting effluence from the SFHe Tank through to the exterior of the AMS-02.

During development a collapsed Kapton tube was developed and tested to substitute, this tub could be "pinched" to eliminate radiation cooling and the thermal conductivity was acceptable.

Testing had proceeded with a "fast" valve substituting for the BD03 element, and the activation time for this valve was ~200 milliseconds.

Testing with an actual burst disk however yielded unexpected results in the test setup. The tube was ruptured unexpectedly.

Burst disk pressurization does not take place over ~200 milliseconds, but ~ 4 milliseconds, creating a more distinct pressure wave that the tube had to endure.

Additionally for the only time in testing of the BD03 design, the membrane detached from the burst disk.

It is not established if the pressure spike or the travel of the membrane through the fabric tube was the specific cause of the dissolution of the tube's integrity. The tube's design was rejected and a new "telescoping" fiberglass design was created with additional super insulation and a aluminum "petal" shield for heat radiation blocking. The term "telescoping" refers to the method of installation, not operation of the tube.

The disconnection of the membrane from the burst disk has been attributed to a design error in the test set up where the tube immediately downstream of the burst disk was smaller than specification from the BD manufacturer. This provided a fulcrum by which the membrane was left in the gas flow, the curving surface enhancing the "tear" through the hinge area of the membrane.

<u>Corrective Action:</u>

The Tube from BD03 has been redesigned to have sufficient static and dynamic pressure loading characteristics and sized to not induce severing of the burst disk membrane. Rather than exiting through a single BD on the vacuum case ring, it will now exist through two four inch burst disks that will open at 0.8 bar, the same as the vacuum case pressure relief. This is accomplished by turning the prior evacuation port for the duct into another burst disk location and making the duct "leaky" so that during vacuum case evacuation, the tube is evacuated as well.

This design change also removes the “layers” of serial burst disks as being more reliable in providing overpressurization protection as discovered in response to AMS-02-A09. A single 0.8 bar burst disk now exits at each of the BD06 ports and the BD07 port that is dedicated to protecting the overpressurization of the vacuum case. This design change was presented to the PSRP at a technical interchange meeting on August 13, 2009 and the design modification accepted by the PSRP.

<u>Safety Impact:</u>

The pressure relief system has been revised to be more reliable, provide additional venting area for the SFHe tank and reduce the thermal conductivity into the SFHe tank increasing the longevity of the AMS-02 Mission. While the latter is mission success, the former is clearly safety related making this anomaly safety critical.

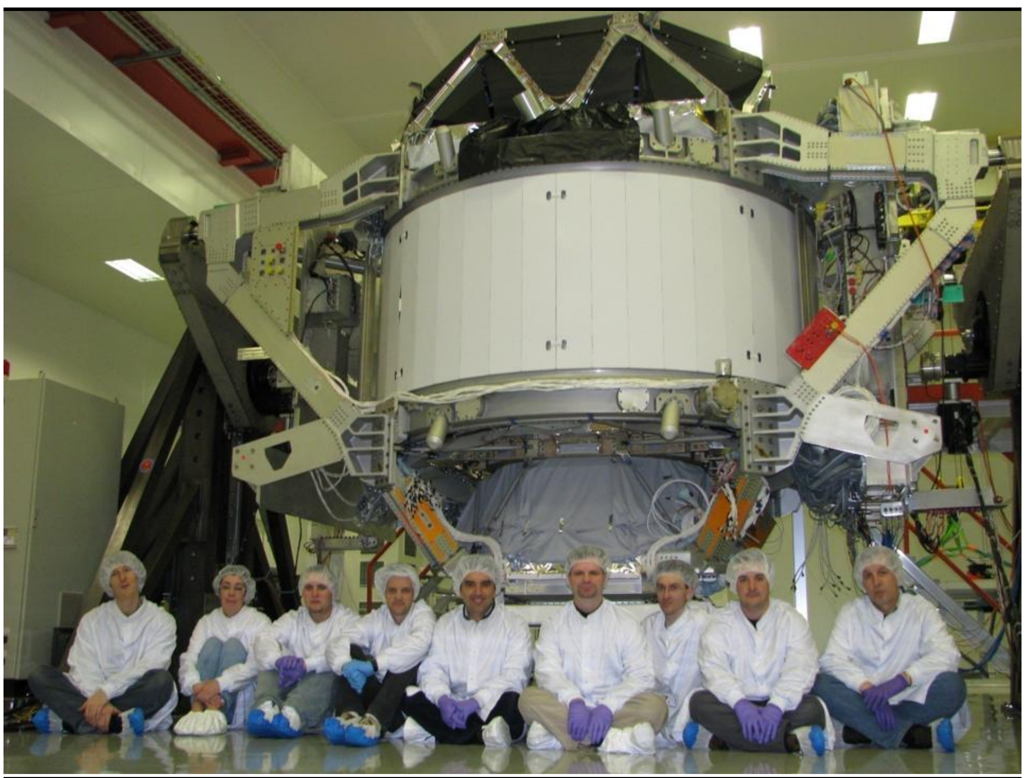
<u>Status:</u> Closed, final testing of new design of BD03/BD06 duct and burst disk design completed at Texas A&M University successfully.

SUPPORTING DOCUMENTATION: (follows)

Alpha Magnetic Spectrometer SFHe Tank Burst Disk Design Change

Prepared
10 August 2009

Prepared by
Trent Martin
NASA AMS Project Manager
281-483-3296
trent.d.martin@nasa.gov



History

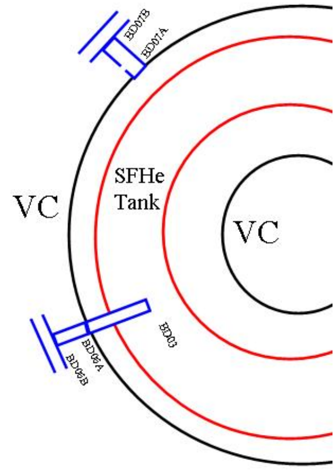
- AMS Phase II FSR was May 2007
- Data Package can be found at:
  - http://ams-02project.jsc.nasa.gov/html/SDP.htm
- Current design of AMS Dewar Burst Disks coordinated through numerous meetings with EP and PSRP over the last 8 years

Current Design

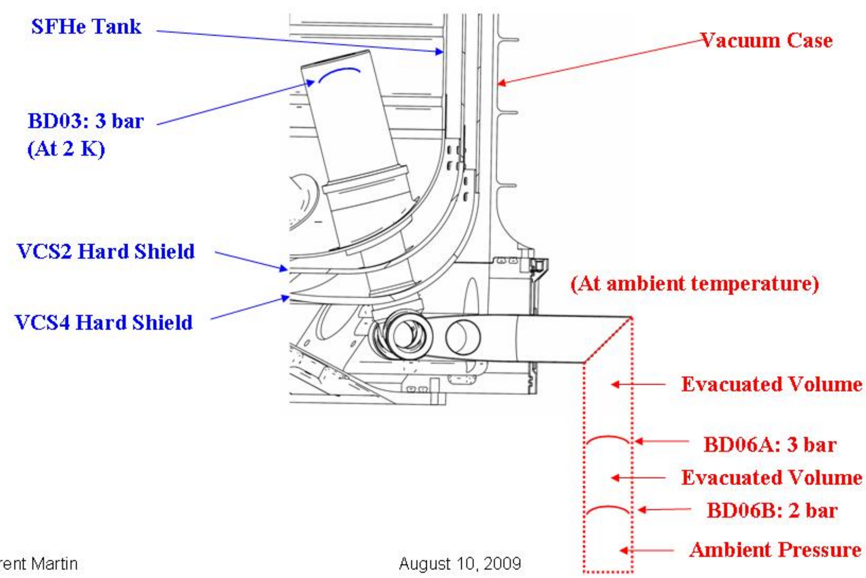
- Current design includes
  - Double 0.8 bar burst disk in series on Vacuum Case (BD07A and B) with the volume between them referenced to the surrounding atmosphere through a weep hole
  - Single 'cold' (2 K) 3 bar burst disk welded to SFHe Tank (BD03)
  - Ducted path from 'cold' to 'warm' (300 K)
  - Double 'warm' burst disk assembly with 3 bar burst disk (BD06A) at VC interface and 2 bar burst disk (BD06B) in series just outside of 3 bar disk. The space between BD06A and BD06B is evacuated and sealed.
  - Zero thrust vent outside of all burst disk assemblies

Current Burst Disks

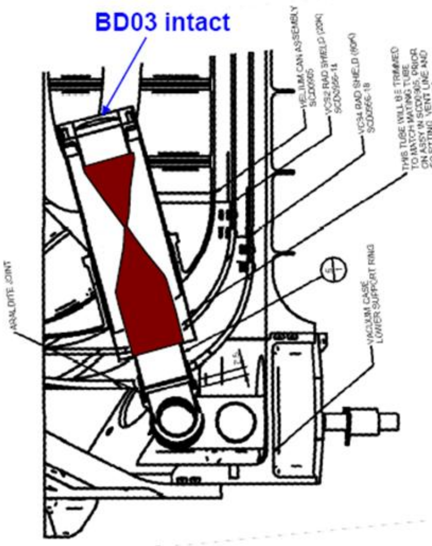
- The existing burst disks on the SFHe Tank and the VC have the following specifications:
  - BD03 on a re-entrant tube welded directly to the SFHe Tank: 3 bard +0/-10% at 1.8K (2.7 to 3.0 bard)
  - BD06A on the VC exterior at exit of ductwork from BD03, but referenced to VC vacuum space: 3 bard +0/-10% at 295K (2.7 to 3.0 bard)
  - BD06B on the VC exterior on the evacuated exit of BD06A: 2 bard +0/-10% at 295K (1.8 to 2.0 bard)
  - BD07A on the VC exterior to the vacuum space: 0.8 bard +0/-30% at 295K (0.56 to 0.80 bard)
  - BD07B on VC exterior at exit of BD07B but referenced to the external atmospheric pressure: 0.8 bard +0/-30% at 295K (0.56 to 0.80 bard)



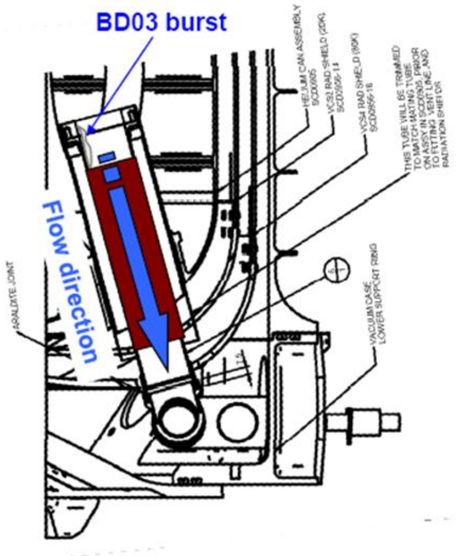
General Arrangement of BD03 and BD06A/B from the SFHe Tank through the VC



Existing Kapton Duct configuration



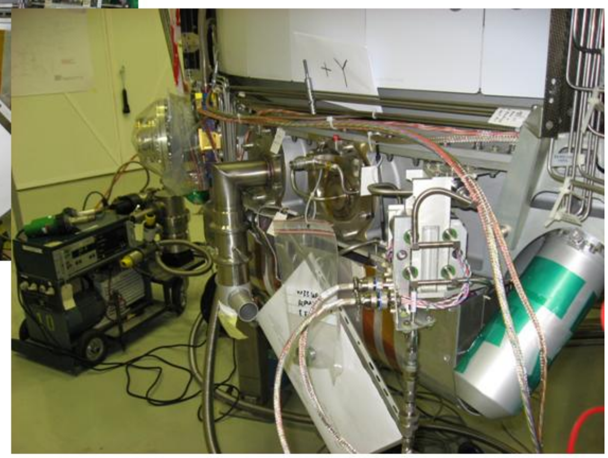
Kapton Vent Duct collapsed



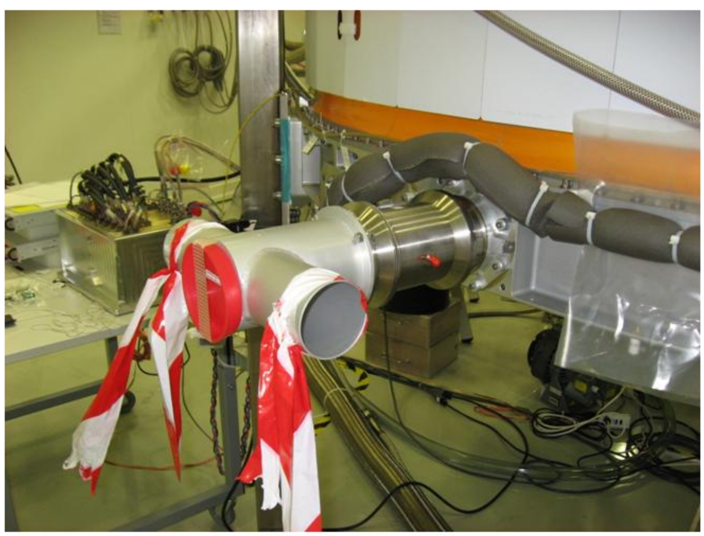
Kapton Vent Duct inflated

AMS Magnet

BD06 with Zero Thrust Vent



BD07 with Zero Thrust Vent



Design Considerations

- **Safety**
  - **Over Pressurization** - Option chosen must prevent the SFHe tank from being over pressurized (3 bard) while at the same time must prevent the VC from being over pressurized (0.8 bard)
  - **Flexibility** - Option chosen must be flexible enough to take the entire spectrum of transportation, differential thermal expansion/contraction, and launch deflections with one end at ~2K and the other at ~300K for the entire life of the cryostat
- **Mission Success**
  - **Thermal Conduction and Radiation** – Option chosen must minimize thermal conduction and radiation with one end at ~2K and the other at ~300K. This is in order to meet mission requirements for helium endurance
  - **Configuration Compatibility** - Option chosen must be compatible with the existing configuration of BD03 on the SFHe tank and the available ports on the VC as well as the configuration of the BD03 qualification tests that have already been performed
  - **Schedule** – Self explanatory, STS-134 scheduled for July 29, 2010
  - **Costs** - AMS Project resources are limited, and getting new contracts in place quickly is difficult

Testing on Existing Design

- All of the burst disks have gone through extensive testing
  - Acceptance testing (lot burst testing on individual burst disks and on assemblies if in series)
  - Vibration testing (on assemblies)
  - Leak testing (on individual burst disks and as assemblies)
- The existing flexible/collapsible Kapton duct configuration was tested extensively using a ~250 liter volume and a ball valve venting ‘rapidly’ via a 40 mm diameter transfer line ~3 meters long into a representative flexible/collapsed and offset duct partially submerged in liquid nitrogen (LN2)
  - This development test program took ~5 months to develop the configuration currently installed on the flight magnet
  - Although numerous failures were encountered during the development program, the final version was finally shown to work repeatedly with rapid pressurization to ~6 bard. ‘Rapid’ in this case means pressurization in a fraction of a second (~200 milliseconds). With these successful tests, the magnet developer installed this version into the flight magnet.

Testing of Existing Design, Cont.

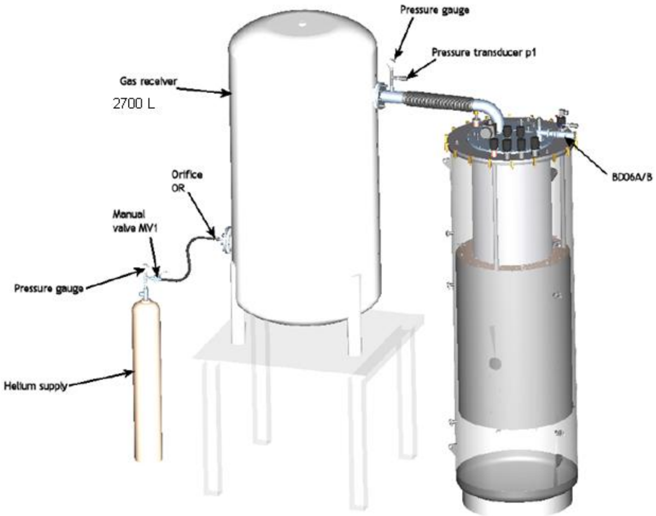
- While work progressed on the flight system, a test was prepared to test the final configuration as a complete assembly
- Previous successful tests of components within the assembly gave the magnet developer confidence that the final test would be successful

Trent Martin August 10, 2009 13

Development Tests of Kapton Tube

Trent Martin August 10, 2009 14

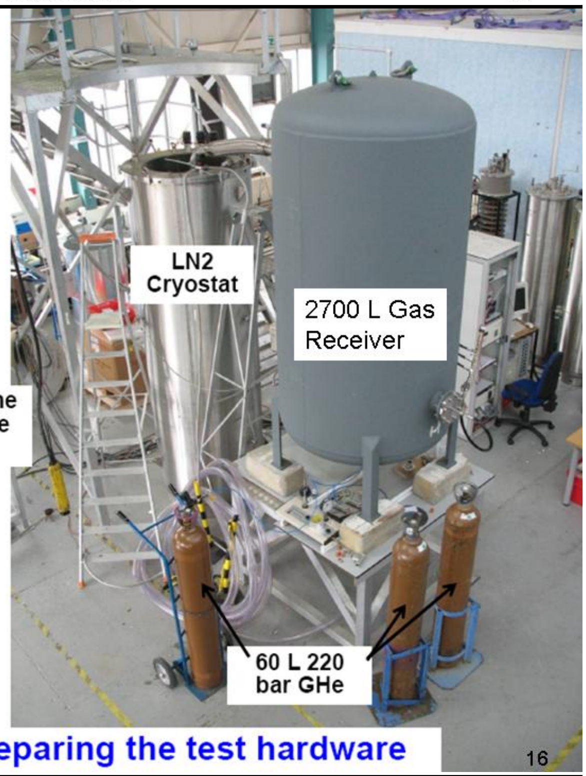
Test Setup for Existing Design



- A test rig was designed and constructed which allowed the flight spare disks to be mounted at the end of a 2.7 m3 volume which could be pressurized to 3 bar or higher.
- Gas in the system was warm, but a heat exchange with liquid nitrogen bath was included so that the inner disk (BD03) could be cooled to a temperature of 77K.

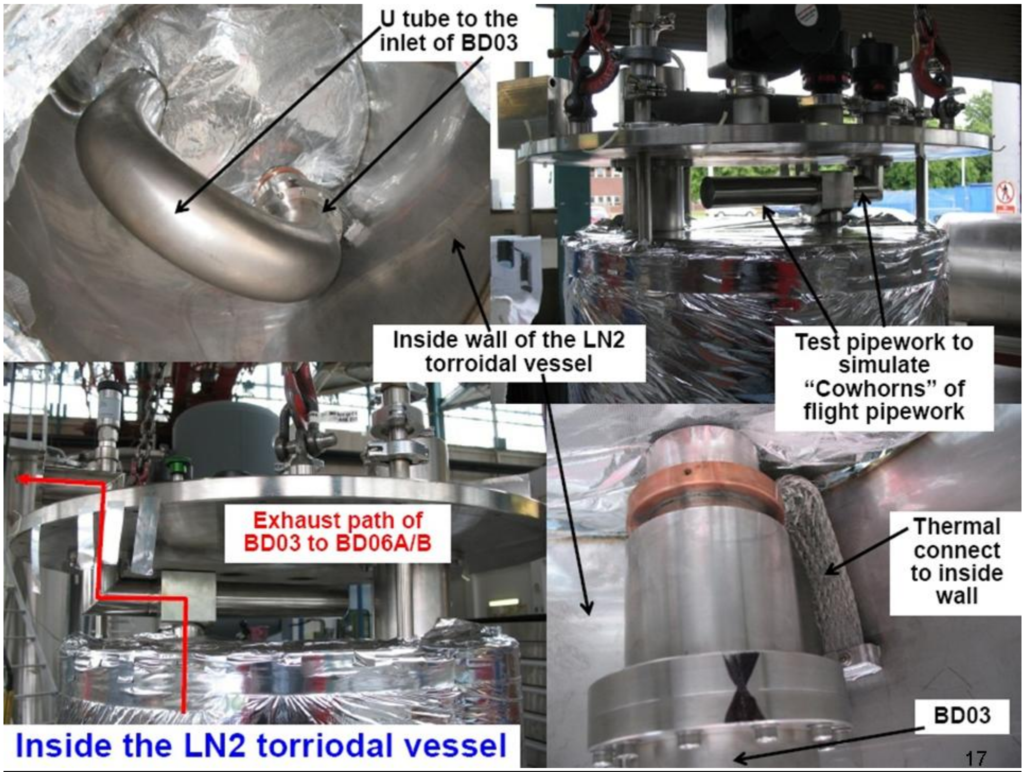
Trent Martin   August 10, 2009   15

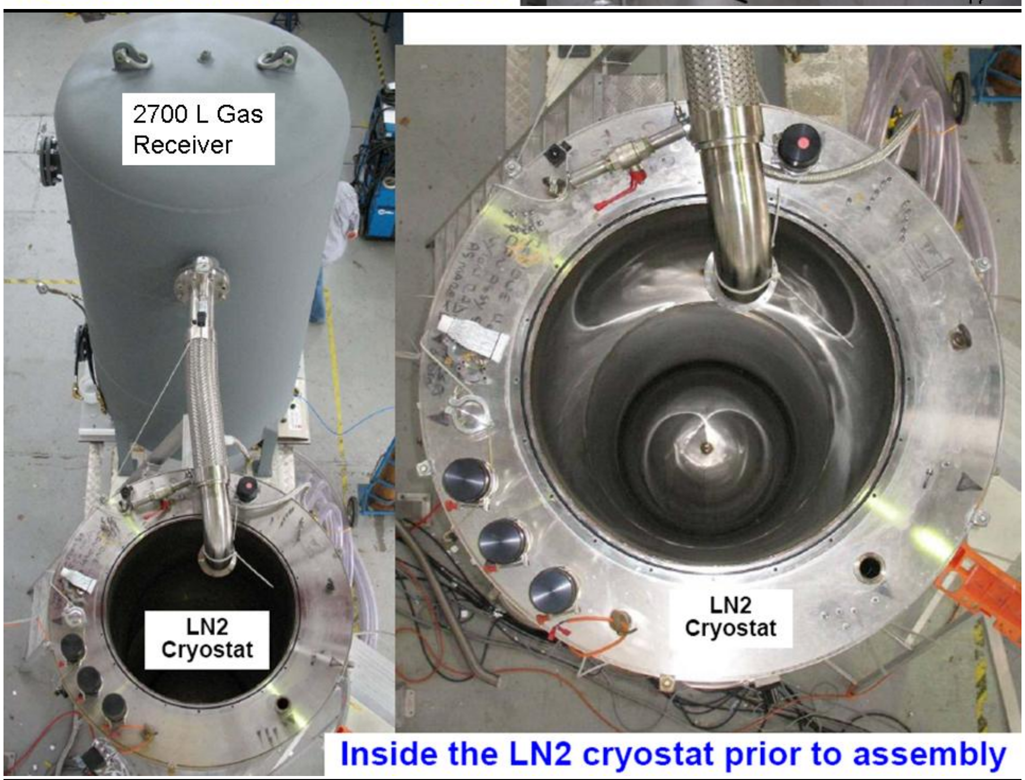
Installing the superinsulation around the LN2 torroidal vessel that surrounds the BD03/Kapton Tube assembly



Preparing the test hardware

16

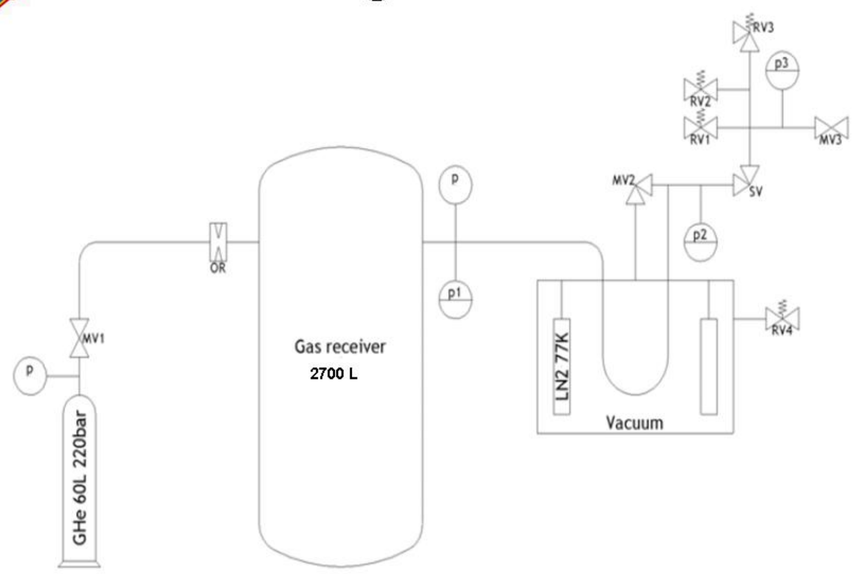

U tube to the inlet of BD03
Inside wall of the LN2 torroidal vessel
Test pipework to simulate "Cowhorns" of flight pipework
Exhaust path of BD03 to BD06A/B
Thermal connect to inside wall
BD03
Inside the LN2 torriodal vessel
17


2700 L Gas Receiver
LN2 Cryostat
LN2 Cryostat
Inside the LN2 cryostat prior to assembly

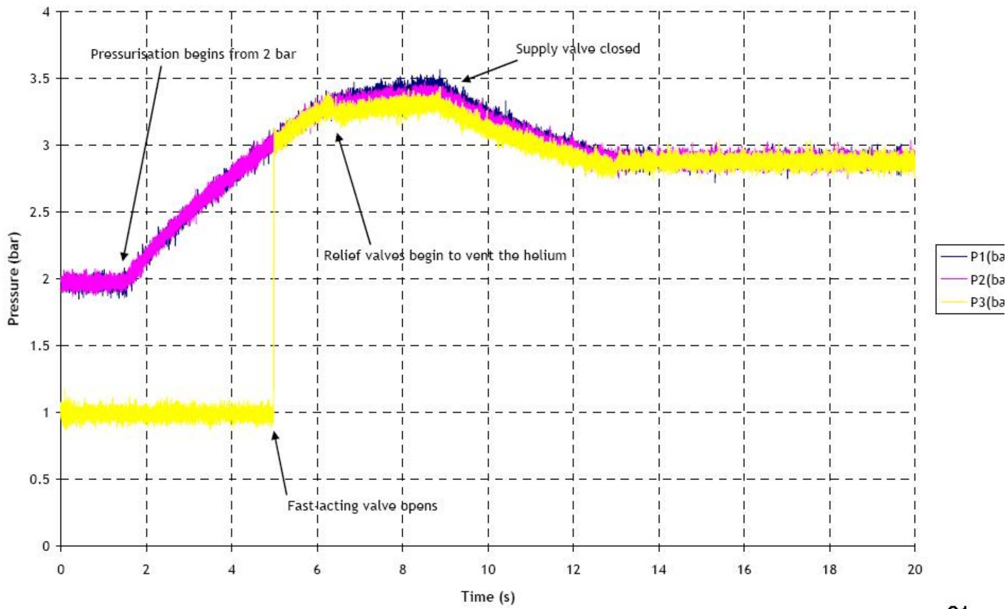
Test Rig Commissioning

- Due to limited number of spare burst disks, the test rig was first commissioned using relief valves.
- Main purpose of the commissioning was to determine how quickly the system could be pressurized to ensure that it match expected flight configuration
- Helium gas from the cylinder is allowed to fill the gas receiver.
- Flow rate is limited by an orifice.
- From receiver, helium also pressurized.
- When pressure in the receiver reaches 3 bar, a fast acting valve (SV on the diagram) opens to depressurize the system through a series of relief valves
- Preliminary tests showed that a single gas bottle was not sufficient to pressurize the receiver at a rate similar to expected flight magnet conditions. Also, a single bottle exhausted more completely than anticipated, so there was little driving pressure by the time the receiver reached 3 bar. For this reason, three gas bottles were connected in serious with a 5 mm orifice in the supply line to the receiver.
- The receiver was also slowly pressurized to 2 bar before the test rather than starting from vacuum.

Test Rig Schematic



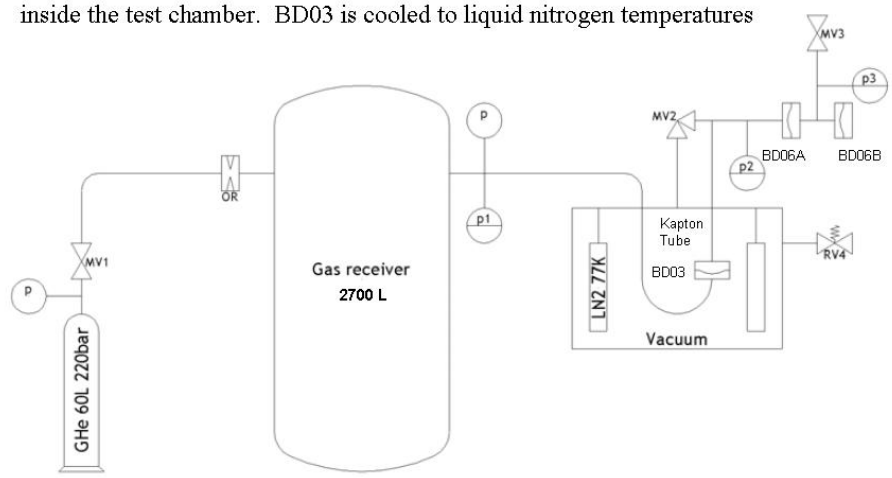
Test Rig Commissioning



21

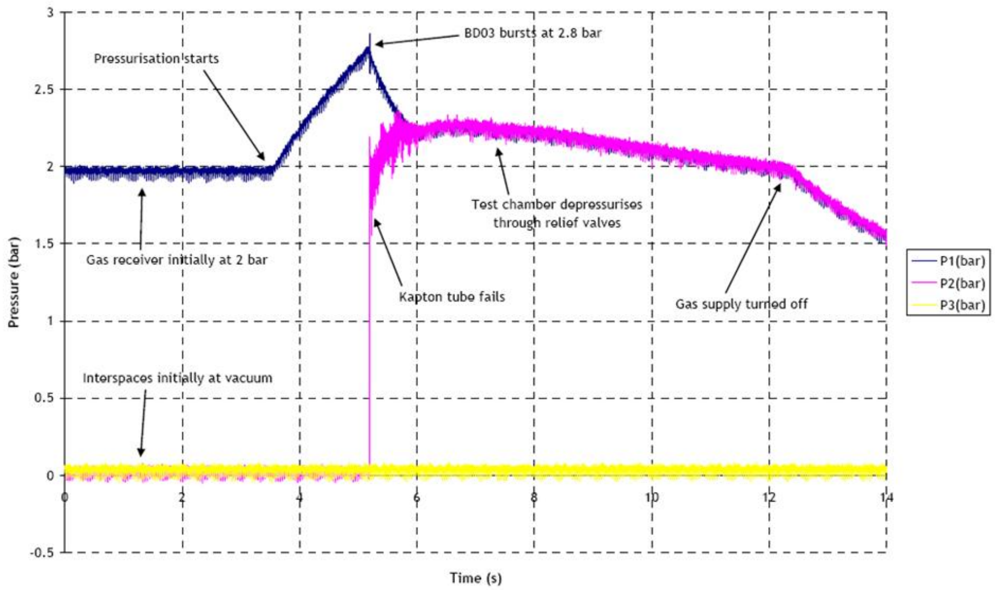
Burst Disk Test

- After commissioning, a set of spare flight burst disks were installed in the system and the arrangement was configured as shown here.
- In this configuration, a 4 inch line from the gas receiver now encounters BD03 inside the test chamber. BD03 is cooled to liquid nitrogen temperatures



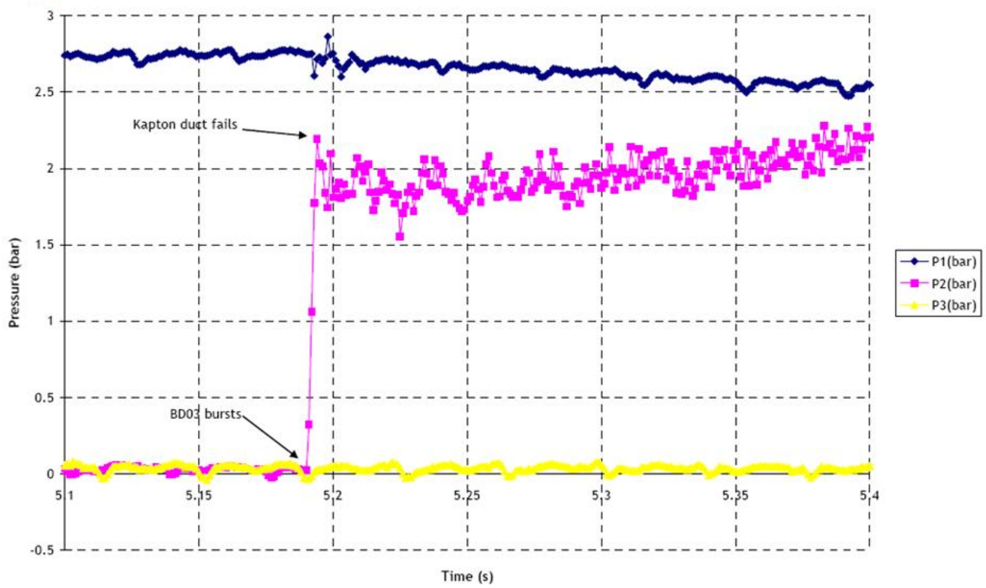
22

Burst Disk Assembly Test Results



Trent Martin August 10, 2009 23

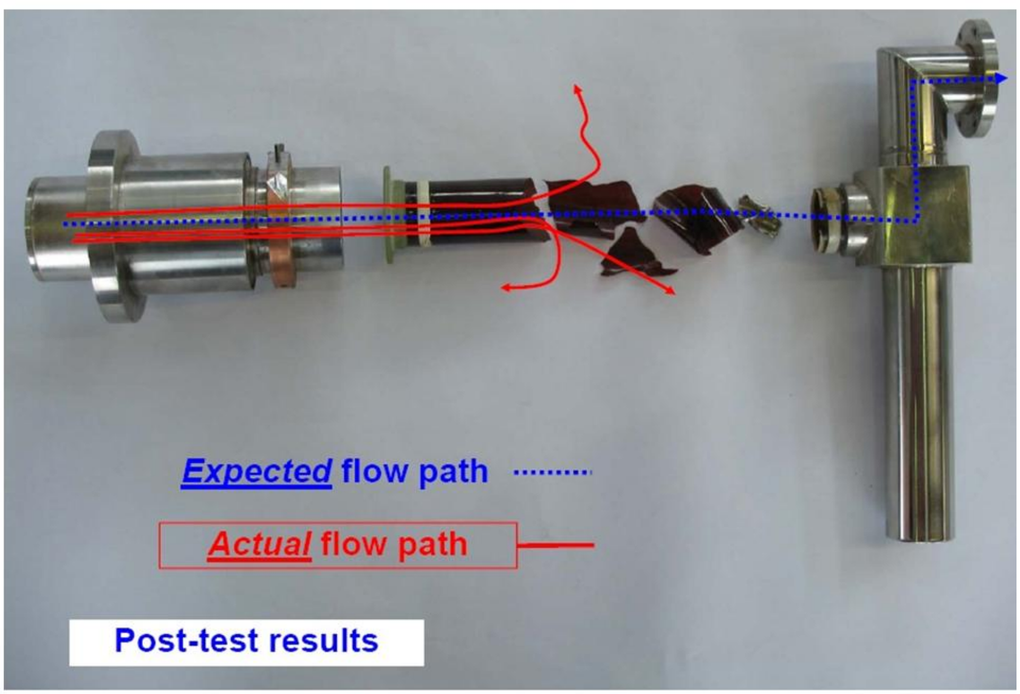
Burst Disk Assembly Test Results

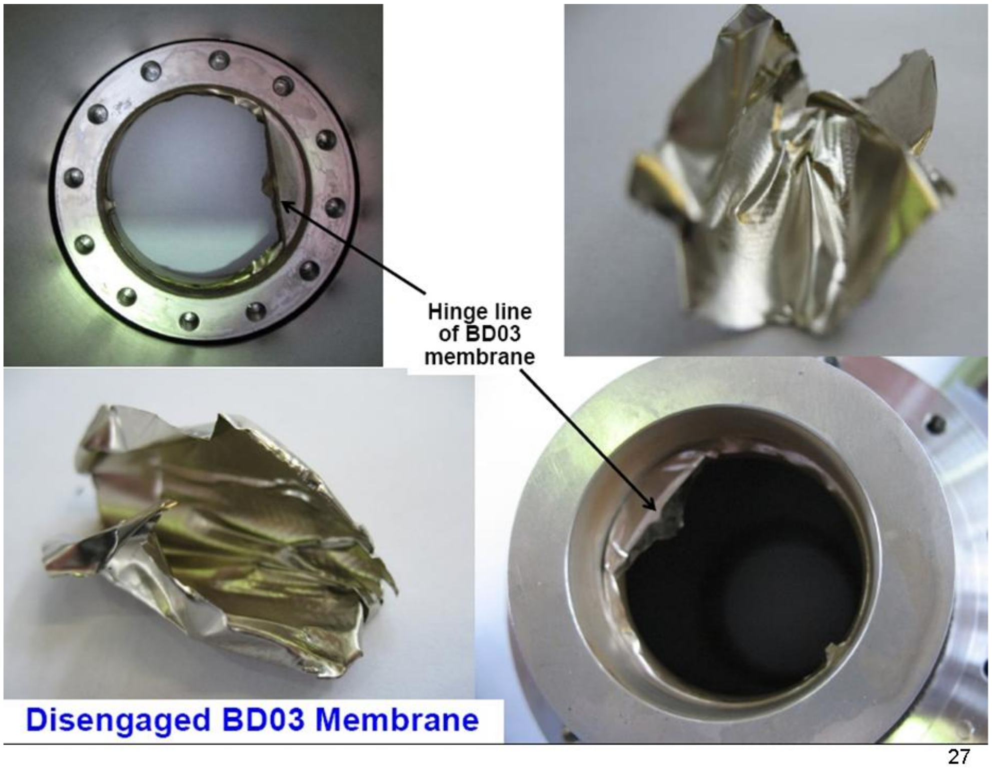


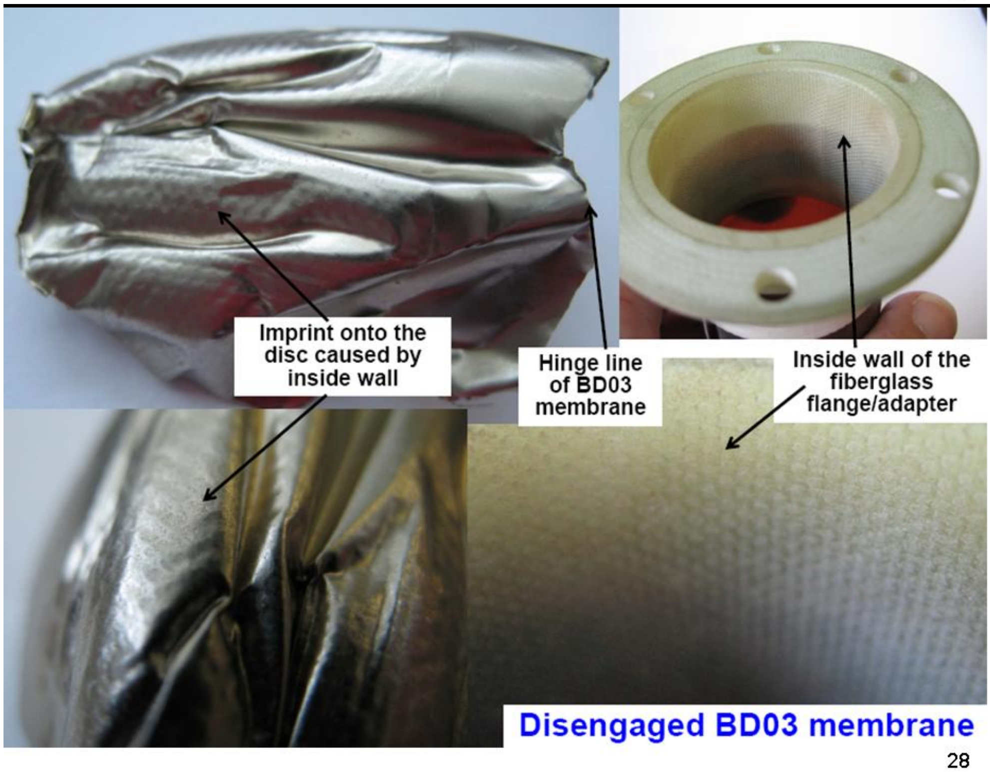
Trent Martin August 10, 2009 24

Test Failure

- Despite successful development tests of the Kapton tube, the tube experienced a failure during this ‘final’ test.
- The spare BD03 membrane disengaged during the test.
  - Although we have tested a large number of BD03, we have never experienced this failure mode in the past

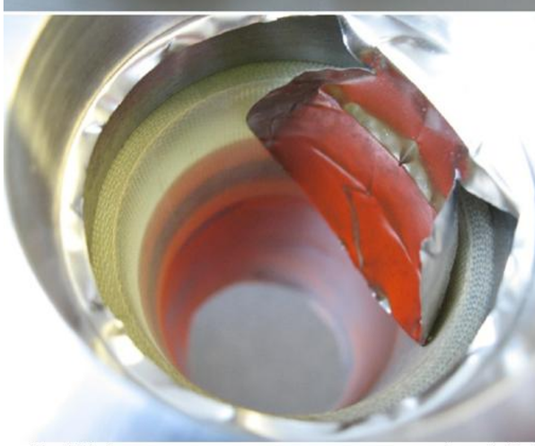


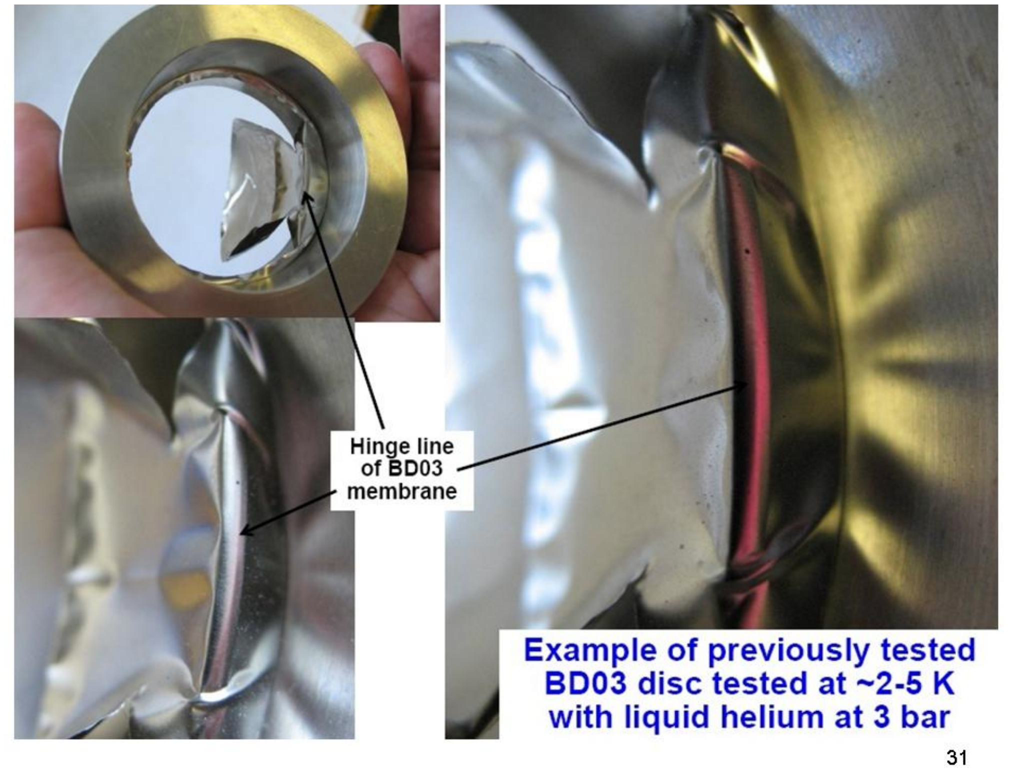

Hinge line
of BD03
membrane
Disengaged BD03 Membrane
27

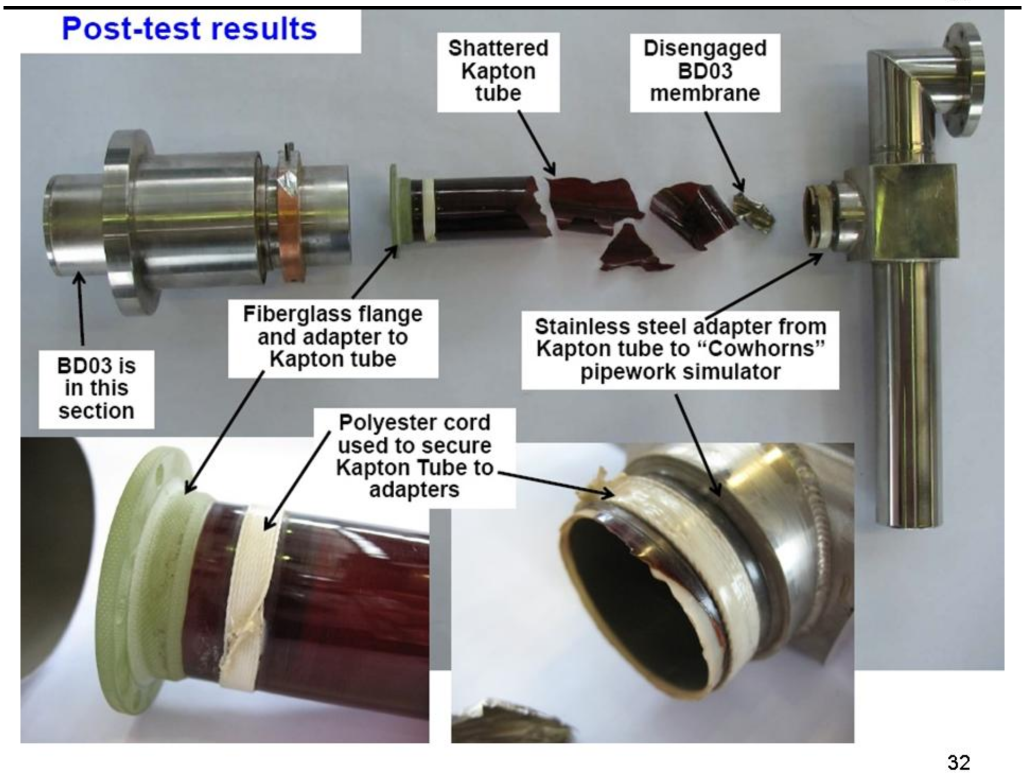

Imprint onto the
disc caused by
inside wall
Hinge line
of BD03
membrane
Inside wall of the
fiberglass
flange/adapter
Disengaged BD03 membrane
28

This membrane did not separate

Example of previously tested BD03 disc tested at ~2-5 K with liquid helium at 3 bar




Hinge line
of BD03
membrane
Example of previously tested
BD03 disc tested at ~2-5 K
with liquid helium at 3 bar
31


Post-test results
Shattered
Kapton
tube
Disengaged
BD03
membrane
BD03 is
in this
section
Fiberglass flange
and adapter to
Kapton tube
Stainless steel adapter from
Kapton tube to "Cowhorns"
pipework simulator
Polyester cord
used to secure
Kapton Tube to
adapters
32

Test Failure Investigation

- Since the test on July 9, 2009, the following has been determined
  - Failure of the burst disk membrane is believed to have been caused by a design flaw in the fiberglass flange used to attach the Kapton tube to the BD03 assembly. The flange, which was supposed to be at least the same diameter as the burst disk opening was actually 6.6 mm smaller diameter than the disk opening. This caused the membrane to impale itself onto the fiberglass flange, weakening the hinge line and causing the membrane to detach.
  - Kapton tube failure could have been cause by the disk membrane impact or by the difference in the dynamic burst mechanism. All original tests were conducted with a pressurization rate of about 0 to 3 bard in 200 milliseconds. The burst disk rupture pressurizes the Kapton tube in about 4 milliseconds. The dynamic impact of this difference could have been enough to rupture the Kapton tube.
  - A finding unrelated to the failure is that the original design had a heat load much higher than expected, and any new proposal should at least attempt to rectify this problem.

How do we proceed?

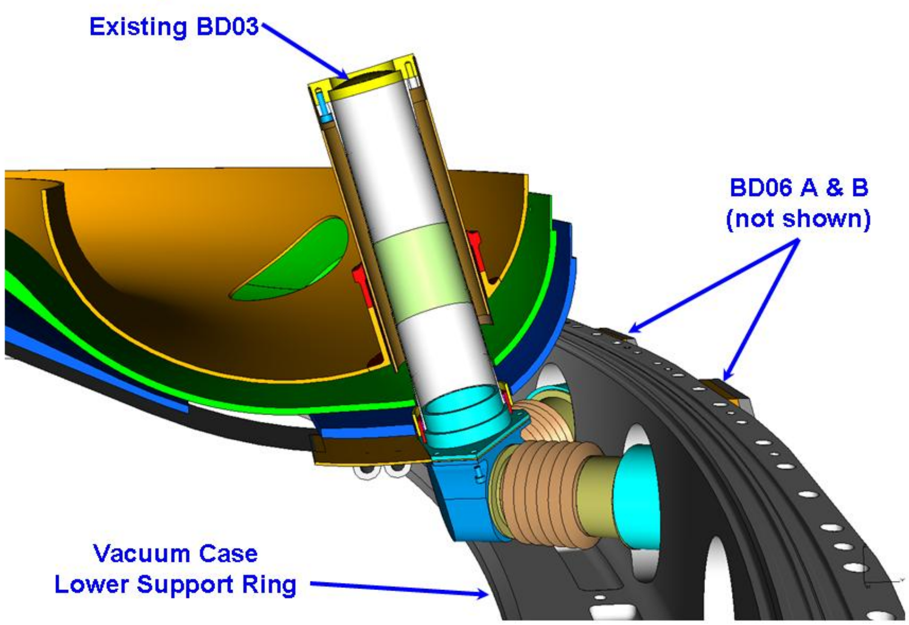
- After the test and investigation, the AMS team has developed a go-forward plan that we plan to prove:
  - meets all of the design requirements,
  - will be tested to be shown to be a robust safety system, and
  - can be built and installed into the existing flight system quickly.

New Design Proposal

- Eliminate the Kapton Tube as it has been the source of weakness in the design and we can not guarantee that we will not experience similar failure in subsequent tests
- Replace the Kapton Tube with a composite telescoping structure which should be much more robust
- Replace the existing internal T-Duct (Cow Horns) with a new T-Duct system that thermally isolates and provides redundant paths to new external burst disks
- Replace BD06A/B assembly with two larger lower burst pressure burst disk in parallel. Since BD07 has already been qualified and meets these criteria, several single BD07 assemblies have been ordered for testing and final flight configuration. Reducing the burst pressure on the external disks should only make the design more safe and doubling the number and diameter, thus increasing the vent area by a factor of ~4 of the external burst disks will help ensure adequate vent area. Testing has been performed to show that the burst disks do not leak, but additional testing can be performed to show that if they do leak the safety system will still function.
- Implement additional radiation barrier made of one layer of 0.3mm thick pure aluminum to help dramatically improve the thermal performance of the system
- Perform a series of tests to show that this new configuration functions properly even under or beyond worst case safety conditions

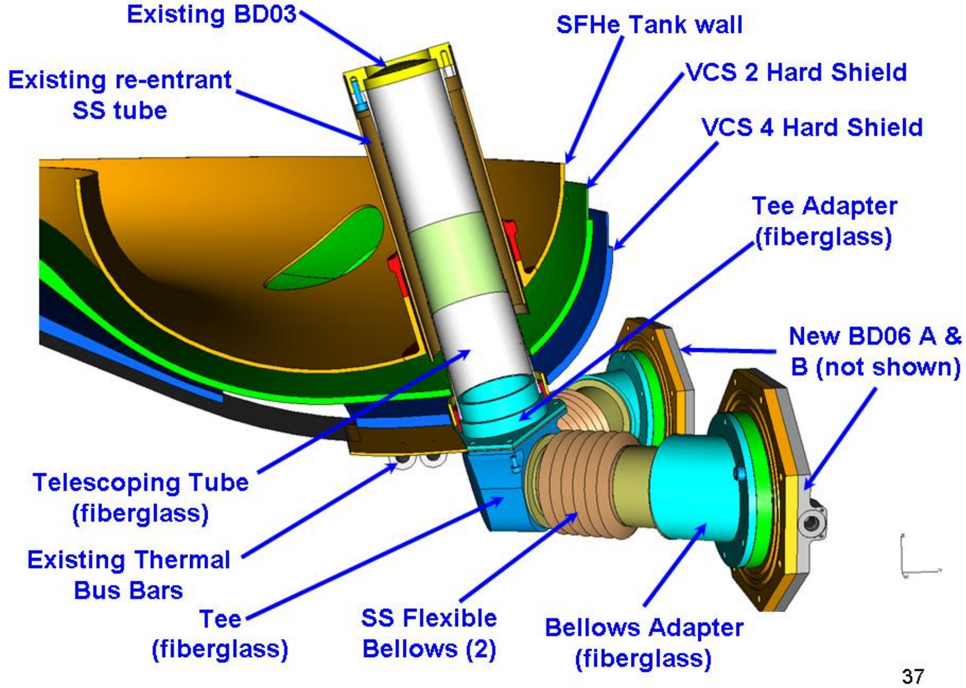
Trent Martin August 10, 2009 35

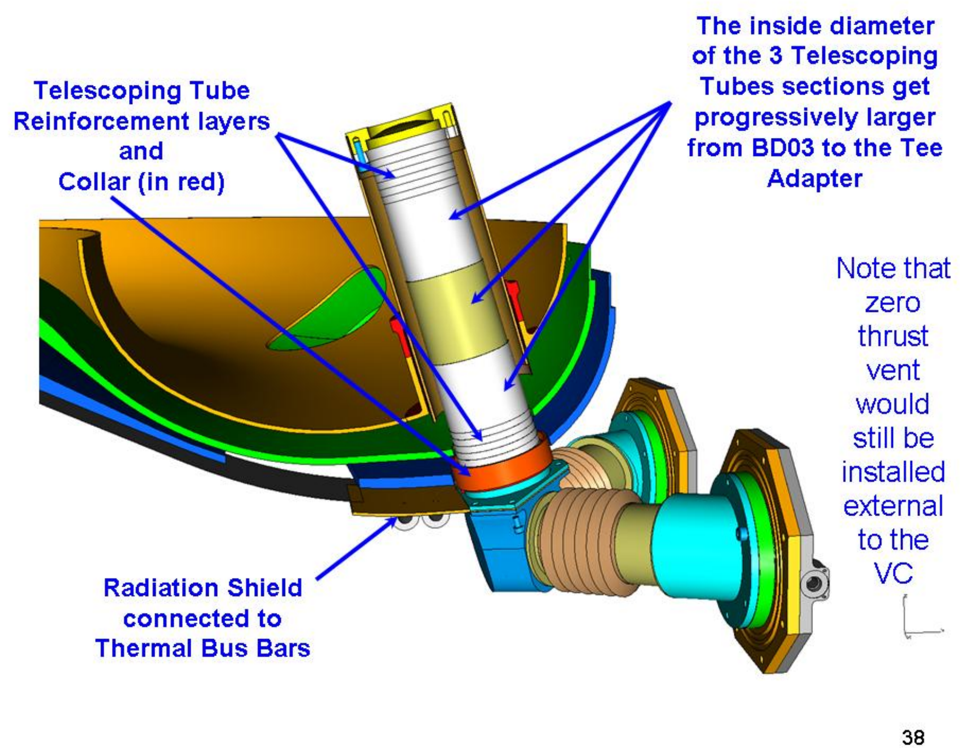
AMS Superfluid Helium Tank Burst Discs

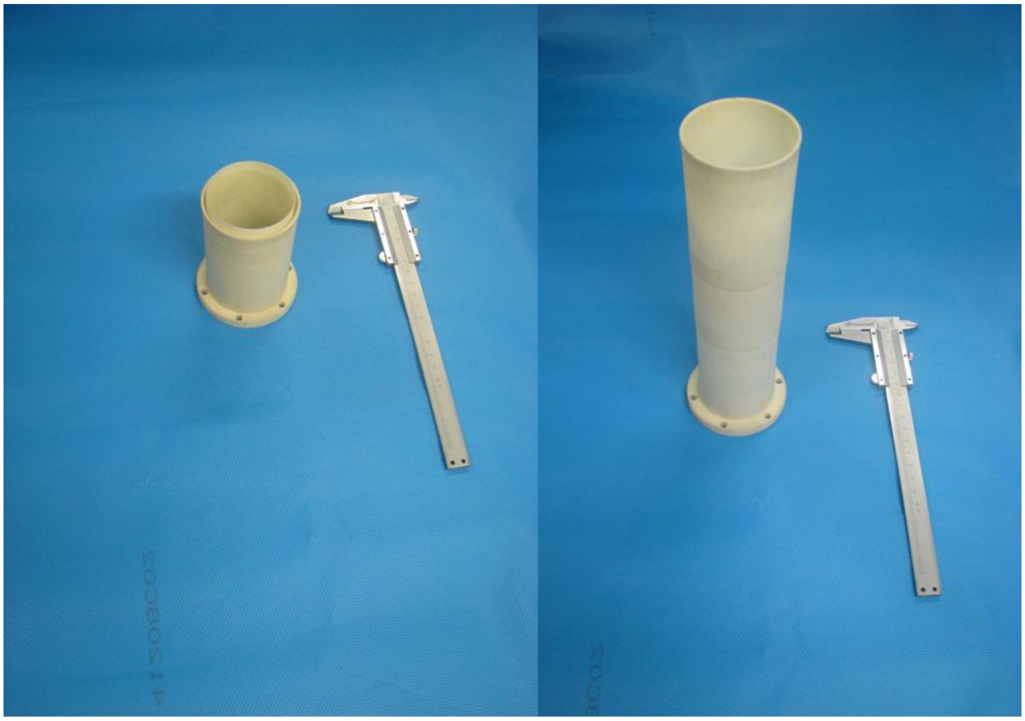


36

AMS Superfluid Helium Tank Burst Discs

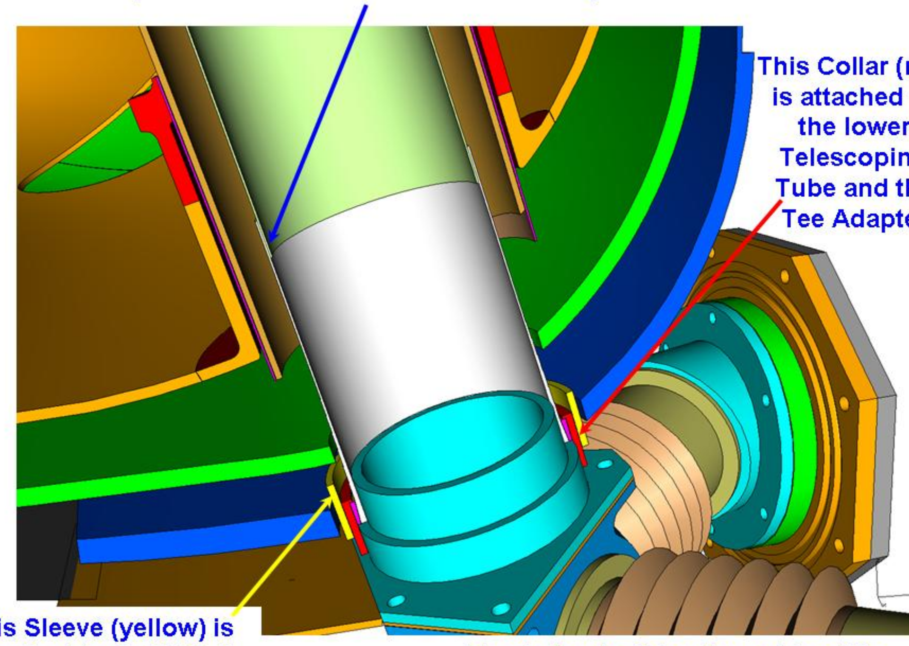




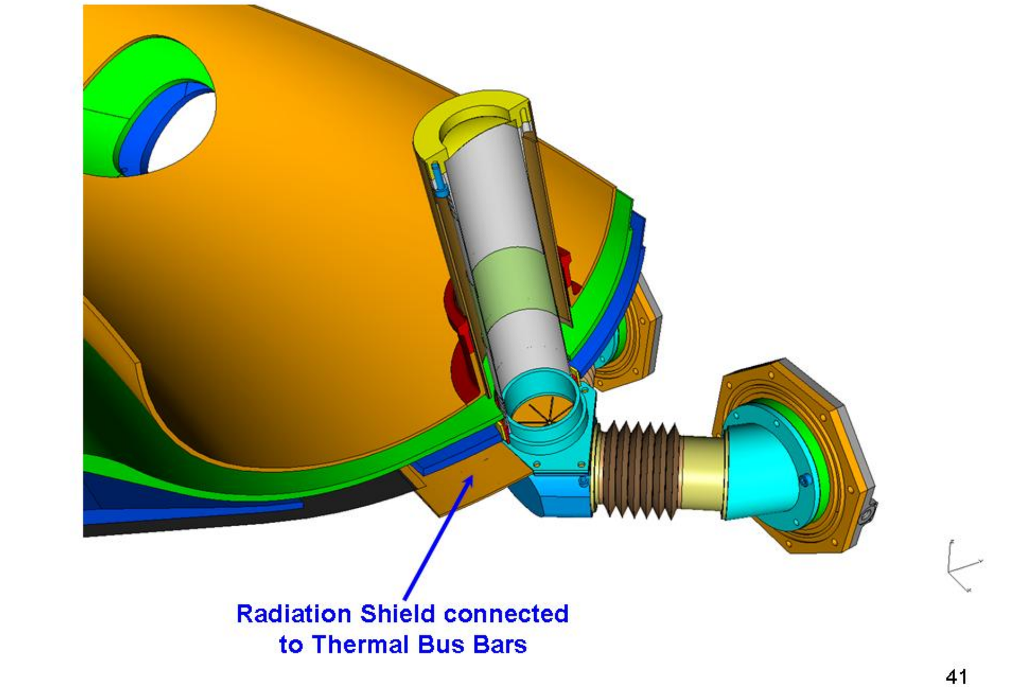


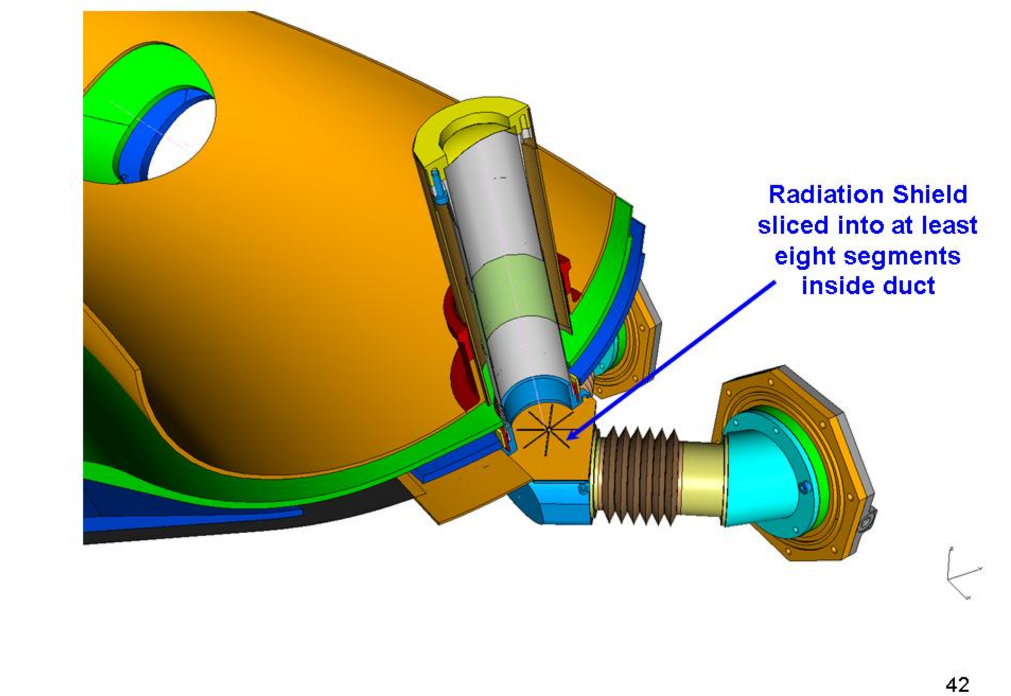
Trent Martin August 10, 2009 39

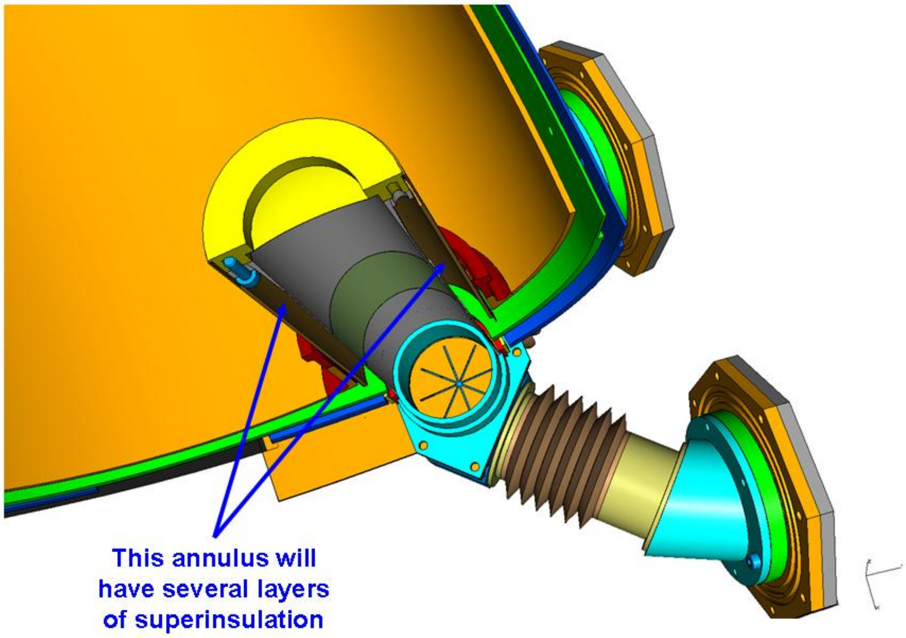
This joint is an interference fit that is also glued

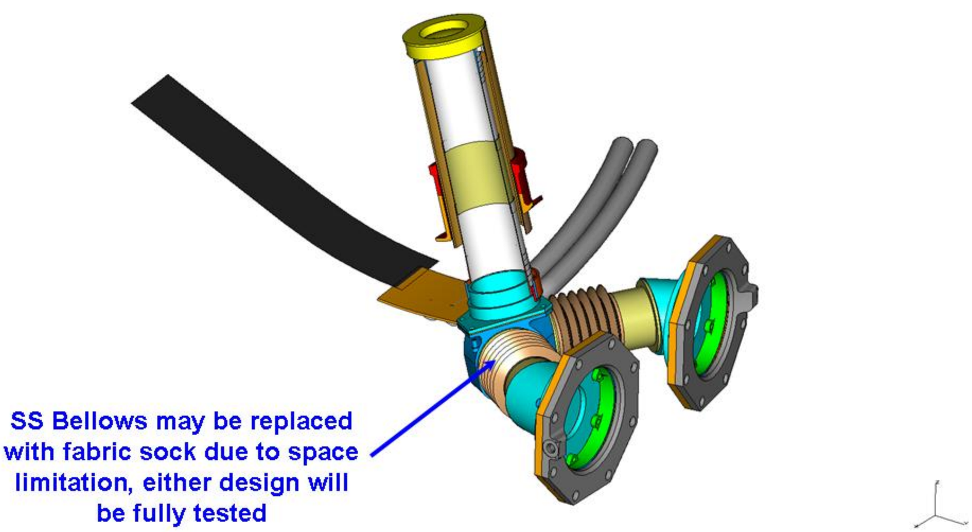


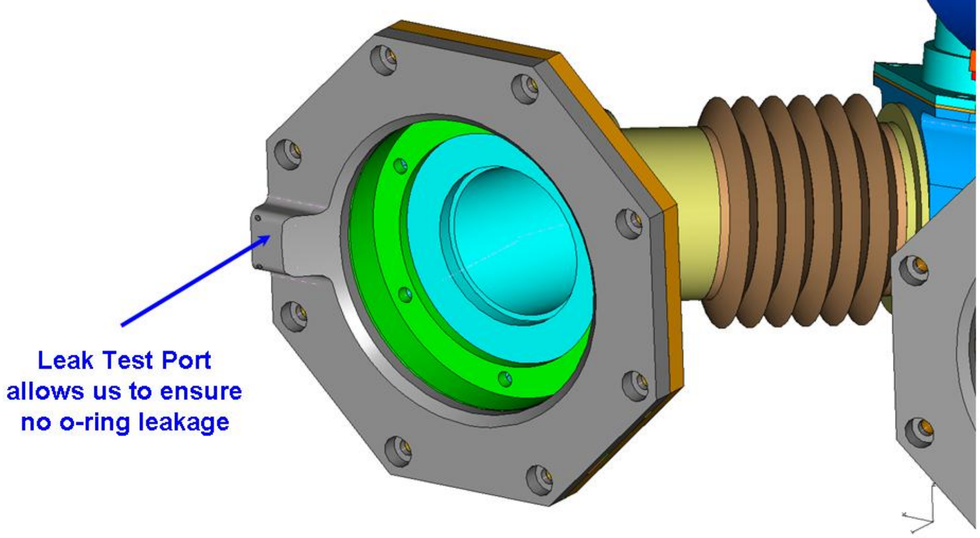
40


Radiation Shield connected
to Thermal Bus Bars
41


Radiation Shield
sliced into at least
eight segments
inside duct
42


This annulus will
have several layers
of superinsulation


SS Bellows may be replaced
with fabric sock due to space
limitation, either design will
be fully tested



Proposed New Testing

- At least 8 tests of this new configuration will be conducted
  1. Telescoping Tube Static Test - Rome
     - Purpose of this test is ensure that we have a positive margin of safety with a factor of safety of 2.0. The test has been completed, and the telescoping tube was taken to 11 bard without failure. Because the tube did not fail, we do not yet know the ultimate margin of safety, but we do know that it is well above zero.
  2. Telescoping Tube Cryogenic Static Test - Geneva
     - Similar to test 1, but performed in a nitrogen bath (77K).
  3. Stainless Steel Cryogenic Static test to failure - Geneva
     - Purpose of this test is to understand the margin of safety of the SS bellows. The ends of the bellows will be offset by the worst case expected flight deflection. The expansion of the bellows will be restricted along the central axis, as it will be in the flight configuration, and the bellows will be pressurized to failure in a nitrogen bath.
  4. Room Temperature Test of new Burst Disk Test Rig (BDTR) at Texas A&M
     - A new BDTR is being built at Texas A&M that will allow us to test the entire BD03 to BD06 system in a flight like configuration. In this test, a tank of liquid helium will be pressurized to the burst pressure of BD03 and all of the burst disks will be allowed to burst as they will in the flight system. This first test will be done at ambient temperatures but will include a test disk rated at 2.7 bard to simulate BD03 and two disks rated at 0.76 bard to simulate BD06A and BD06B. A complete set of the telescoping tube, Tee, Tee Adapter, two Stainless Steel bellows, two bellows adapters, and two intermediate flanges. The sleeve for VCS4 will be accurately modeled in the test. The BDTR will be designed such that the outlet for BD06A and BD06B are intentionally offset by the maximum expected flight deflections.

Proposed New Testing, Cont.

- At least 8 tests of this new configuration will be conducted

5. Cryogenic test of BDTR at Texas A&M
   - Same as test 4, but performed using liquid helium. This is an all up dress rehearsal for the flight like tests.
6. Flight Test #1 at Texas A&M
   - This is a cryogenic test with burst disk assembly attached to liquid helium tank. Test will utilized flight BD03 and one flight BD06. The second BD06 port will be blanked off. This will simulate the failure of one of the BD06s to open. The zero thrust T-vent will be installed for the test. Once successful, we will begin welding the flight VC closed and continue flight hardware processing.
7. Flight Test #2 at Texas A&M
   - This is the most severe and conservative test we will do. This test will be like Flight Test #1, but we will install both BD06A and BD06B. Zero thrust vents will be installed on both BD06A and B. During this test, we will attach the detached BD03 disk membrane from the failed test in July. This will intentionally act as 'shrapnel', so that we can be assured that even if the BD03 disk membrane breaks off on the flight system, the safety system functions properly.
8. Flight Test #3 at Texas A&M
   - This is our final flight test with BD03 and both BD06A and BD06B installed. Zero thrust vents will be installed on both outlets.

BD03/06 Telescoping Tube Tests

The tube was then placed in a small styrofoam dewar and connected to a 0-50 bar pressure gauge

BD03/06 Telescoping Tube Tests

Then the tube was pressurized from ~1 bar to ~36 bar in ~15 seconds. The last part was from ~30 bar to 35 **bar in ~2 seconds.**

Moments before failure…go Kerry go!

We only need 3 bar, and the test shows that the tube can withstand more than 35 bar.

49

BD03/06 Telescoping Tube Tests

The glued interface to the end cap for the test failed while the tube remained intact. When this is bolted to the BD03 flange, it will be a stronger joint.

NASA JSC
Payload Safety Review Panel
Alpha Magnetic Spectrometer-02
Burst Disk
Technical Interchange Meeting

Minutes of Meeting
August 13, 2009

1.0 INTRODUCTION

1.1 **General:** The Payload Safety Review Panel (PSRP), chaired by JSC/OE/M. Surber, met on August 13, 2009, with representatives of the JSC/Alpha Magnetic Spectrometer (AMS) Project Office, the Payload Organization (PO), at the Regents Park III Conference Facility for an AMS-02 Burst Disk Technical Interchange Meeting (TIM). JSC/NA2450/R. Rehm and K. Chavez, the supporting Payload Safety Engineers (PSEs), introduced the meeting and attendees (see Attachment 1).

1.2 **Background:** The PO has coordinated the current design of the AMS-02 Dewar Burst Disks (BDs) through numerous meetings with JSC/Pressure Systems and the PSRP. The PSRP held the following meetings on AMS-02:

- Helium Venting TIM, 4/20/00
- Phase 0/I Flight Safety Review (FSR), 1/16/01
- Vacuum Jacket Leakage Special Topic Meeting, 10/11/01
- Gauss Limit Special Topic Meeting, 10/16/01
- TIM, 1/17/03
- Phase II FSR, 5/21-25/07
- Hazard Report (HR) TIM, 10/10/07
- Non-compliance Report (NCR) TIM, 12/10/08

1.3 **Scope:** This meeting focused on the PO report of BD test results. The PSRP reviewed no previous action items (AIs) associated with this payload in this meeting.

1.4 **Conclusion:** No agreements and no AIs resulted from this meeting. The PSRP reviewed no HRs. The PSRP accepted the PO's proposed resolution and redesign of the BDs for the vent lines. The PSRP urged the PO to have all verification tracking log (VTL) items that are not associated with nominal ground processing for launch closed prior to the Phase III FSR. The PO also should include the assessments of the composite-over-wrapped pressure vessels (COPVs) and the WSTF review (visual inspection) of them in the Phase III Flight Safety Review (FSR).

2.0 SIGNIFICANT SAFETY DISCUSSION

2.1 **Science Overview:** The AMS-02 experiment is a state-of-the-art particle detector that will search for antimatter and dark matter in space and study galactic cosmic rays. The experiment will advance our knowledge of the universe and its origin.

The AMS-02 experiment uses a large cryogenic superfluid helium (SFHe) superconducting magnet (Cryomagnet or Cryomag) at 2°K to produce a strong, uniform magnetic field (~0.8 Tesla). Due to the differences in electrical charge, particles of matter will curve one way when they pass through the magnetic field, and antimatter particles will curve in the opposite direction. The mass of the particles determines the amount of curvature. Planes of detectors above, in the center of, and below the Cryomagnet record the unique particle signatures. The AMS-02 will collect data from the ISS for at least three years.

2.2 **Hardware Overview:** The PO conducted hardware inspections at Geneva, Switzerland, and at KSC. The Shuttle will ferry the AMS-02 experiment to the International Space Station (ISS) for installation on the external truss of the ISS. Due to limited Shuttle flights, AMS-02 will remain on the ISS indefinitely.

2.2.1 BDs: A BD is basically a highly reliable "fuse" for fluid lines. The BD design is single-fault tolerant to prevent leaking atmosphere into the helium system. BD07 protects the Dewar from venting helium into the payload bay.

2.2.2 Kapton Tube: The Kapton tube is used only for installation; it is fixed during operation. The telescoping Kapton tube is designed for thermal expansion and will withstand launch loads. Testing showed that the internal diameter (ID) of the Kapton tube was too small for the BD opening.

2.2.4 Radiation Shield: The PO will test the Radiation Shield.

2.2.5 Flange: The PO clarified that the flange that failed was a test article and not a flight unit.

2.2.6 Bellows or Fabric Sock: The PSRP inquired about the effect of air passing over the folds in the bellows at high velocity and whether this is a concern. The PO indicated that they are considering replacing the stainless steel bellows with a fabric sock for unrelated reasons.

2.3 **Burst Disk Test:** The PO conducted the following tests on the BDs:

- Acceptance testing on individual BDs and on assemblies, if in series
- Vibration testing on assemblies
- Leak testing on individual BDs and on assemblies

The spare BD03 membrane disengaged during the test on July 9, 2009. The failure was that the BD membrane tore loose completely, which had not occurred previously. Failure of the burst disk membrane is believed to have been caused by a design flaw in the fiberglass flange used to attach the Kapton tube to the BD03 assembly. The flange, which was supposed to be at least the same diameter as the BD opening, was actually 6.6 mm smaller in diameter than the disk opening. This caused the membrane to impale itself onto the fiberglass flange, weakening the hinge line and causing the membrane to detach. The Kapton tube failure could have been caused by the disk membrane impact or by the difference in the dynamic burst mechanism. The dynamic impact of this difference could have been enough to rupture the Kapton tube. The BD07 tests reported no leakage.

2.3.1 Anomalies during Testing/Assembly/Ground Processing: The PO found that the pressure dynamic load was much higher than expected, and any new design should attempt to accommodate this finding. This result was unusual because of the low pressure dynamic load that was seen in the testing conducted prior to this failure. Previous testing did not use Burst Disks, due to cost and availability, but rather valve opening.

2.4 **Failure Scenarios:**

2.4.1 BD on Launch: The PO analyzed various scenarios that might require a Trans-Atlantic Abort Landing. The PO said that it will monitor heat sources up to 9 minutes prior to launch (L-9) as a requirement for Launch Commit Criteria. The payload bay overpressurization concern is only credible between L+30 sec. and L+60 sec., not to include a launch abort scenario. The Space Shuttle Program office is aware of this and gave its approval to this assessment.

2.4.2 Variable Specific Impulse Magnetoplasma Rocket (VASIMR) Impacts: Both the AMS-02 and VASIMR payloads use large magnets. The AMS-02 PO reported that it has communicated with the VASIMR project management to determine whether VASIMR's strong magnetic flux could affect the operation and data quality of AMS-02. The PO found no hazards or mission success issues to report. VASIMR magnets are smaller than the AMS-02 Cryomagnet, and they only operate at times other than when AMS-02 will operate. Plasma concerns from VASIMR are still being evaluated to determine if they could affect AMS-02 science.

2.5 Design Changes Since the Non-compliance Report TIM (12/10/08):

2.5.1 Resolution: After the test and investigation, the AMS team developed a go-forward plan that will

- Eliminate the Kapton tube, replacing it with a more robust composite telescoping structure.
- Replace the existing internal T-Duct (Cow Horns) with a new T-Duct system that thermally isolates and provides redundant paths to new external BDs.
- Replace the BD06A/B assembly with two larger lower-burst pressure BDs in parallel. The result would be that there should be just one burst disk in each of the three vent lines. Reducing the burst pressure on the external disks should make the design safer and ensure adequate vent area. Since BD07 has already been qualified and meets these criteria, several single BD07 assemblies are on order for testing and final flight configuration. Tests show that the BDs do not leak, but additional testing is needed to demonstrate that, if they do leak, the safety system will still function. The PO plans to add a zero thrust vent to the burst disk in BD07.
- Implement an additional thermal radiation barrier made of one layer of 0.3 mm-thick pure aluminum to help improve the thermal performance of the system.
- Perform a series of tests to show that this new configuration functions properly, even under worst-case safety conditions.

2.5.2 Proposed New Testing: The PO proposed eight tests for the new configuration:

- Telescoping Tube Static Test (Rome)
- Telescoping Tube Cryogenic Static Test (Geneva)
- Stainless Steel Cryogenic Static test to failure (Geneva)
- Room Temperature Test of new Burst Disk Test Rig (BDTR) (Texas A&M University)
- Cryogenic test of BDTR (Texas A&M)
- Flight Test #1 (Texas A&M)
- Flight Test #2 (Texas A&M)
- Flight Test #3 (Texas A&M)

2.5.3 Discussion and PSRP Approval: The PO explained that JSC required it to provide three burst disks for two-fault tolerance to protect the Dewars from the hazard of backflow air leakage that might overpressurize the helium tank and cause it to leak into the payload bay. The PSRP said it believes that the original design was still single-fault tolerant. In fact, the PSRP concluded that multiple discs are actually less reliable than a single BD. In the test configuration, the PO removed one burst disc from the assembly as well as the 90-degree turn in the line that it believes caused the pressure shock that resulted in the burst disk failure. The two-BD testing configuration reduced pressure in the large tank following bursting. The PSRP concurred with the new design, which will include one BD with a single-thrust vent. The PSRP considered the design changes as meeting requirements for "failsafe."

2.5.4 Panel Poll: The PSRP polled its members to determine whether the solution to the BD anomaly is acceptable. The panel members replied as follows:

- Shuttle Integration—Acceptable, with high confidence based on extensive previous analysis.
- Mission Operations Directorate (MOD)—Acceptable, with no issues.
- Crew Office—Acceptable.
- PSEs—Acceptable.
- Executive Officer (XO)—Acceptable.
- Chair—Acceptable.
- Engineering—Acceptable.
- Extravehicular Activity (EVA)—Acceptable.
- Payload Engineering & Integration (PE&I)—Acceptable.
- Pressure Systems—Acceptable; the test failure was fail-safe.
- Mechanical Systems Working Group (MSWG)—Acceptable.

2.6 **Safety Assessment:**

2.6.1 Form 1428, Fire Detection and Suppression Reporting Form: *Not applicable to this hardware.*

2.6.2 Form 622, Reflown and Series Payload Hardware Reflight Assessment Reporting Sheet: *Not applicable to this hardware.*

2.6.3 Form 1114A, Certificate of Payload Safety Compliance: *Not discussed in the meeting.*

2.7 **Hazard Report Discussion:** *Not discussed in the meeting.*

3.0 **AGREEMENTS:** The PSRP made no agreements with the PO in this meeting.

Original signed by:
JSC/NA2450/R. Rehm
Payload Safety Engineer

Original signed by:
JSC/NA2450/A. Coleman
Technical Writer

Original signed by:
JSC/NA2450/K. Chavez
Payload Safety Engineer

Status of Hazard Reports Presented

The PSRP reviewed no HRs in this meeting.

Previous Action Item Status

The PSRP reviewed/assigned no previous AIs associated with this payload in this meeting.

ATTACHMENT 1

Payload Safety Review Attendance Log

Payload: AMS-02 Burst Disk TIM

Meeting Date: August 13, 2009

Mail Code	Name	Phone 281	X
CHAIRMAN			
OE	Surber, M.	483-4626	X
SUPPORT PERSONNEL			
CB	Rickard, J.	483-3760	X
DA8/USA	Knutson, D.	483-4405	X
EA441	Henning, G.N.	483-0533	X
MO2	Kunkel, S.	483-4356	X
NE14	Guidry, R.	244-5510	X
SM	Spann, R.	483-3807	X
NT	Nobles, D.	335-2129	X
EP4/Jacobs	Manha, W.	483-6439	X
ESCG/JACOBS	Ross, S.	461-5710	X
ESCG/JACOBS	Brown, G. A.	461-5435	X
Boeing/HB3-40	Miley, R. R.	226-4968	X
NA2450/GHG	Chavez, K.	335-2374	X
NA2450/GHG	Mensingh, P.	335-2363	X
NA2450/GHG	Rehm, R.	335-2364	X
NA2450/JES	Coleman, A.P.	335-2391	X
NA2450/JES	Stauffer, P. W.	335-2402	X

Name	Mail Code	Employer	Phone Number	Technical Discipline	Internet Address
Harvey, E. K.		Barrios/ ESCG	281-461-5509 JEI SA	Systems Safety Engineer	eric.harvey@escg.jacobs.com
Martin, T.	EA	NASA	281-483-3296	AMS Project Manager	trent.d.martin@nasa.gov
Hill, L.	4E	ESCG/ Bastion	281-461-5701	Safety	leland.hill@escg.jacobs.com
Tutt, C.		ESCG	281-461-5703	Project Management	john.tutt@escg.jacobs.com
Mott, P.		ESCG	281-461-5712	AMS Chief Engineer	phillip.mott@escg.jacobs.com

11. AMS-02-A11 – Fire in AMS-02 Battery Box During Ground Testing

Description of Event:
During testing, November 2006, of the AMS-02 Uninterruptible Power Supply (UPS) Engineering Development Unit at CSIST (Chung-shan Institute of Science and Technology) the battery assembly experienced a thermal runaway that resulted in a aggressive fire event that destroyed the UPS assembly.


Figure 11.1 – Engineering Development Unit (EDU) UPS after fire event.

Corrective Action: Upon review of the SYSU test set up and procedures, it was established that the charging system had not implemented the required controls to limit current or monitor battery performance that would have been enacted to compensate for the cell failure observed. Also at the time of the testing event, the testing engineers were absent. All remaining UPS units were returned to Yardney, the manufacturer of the cells and testing resumed at that location. See AMS-02-A12 for performance issues with remaining UPSs.

Safety Impact: Significant. The fire in a battery system that was designed to preclude such an event was taken as a significant safety event. It was not until it was established that the testing set up and process was not implemented in such a way to make use of the design features and the established protection protocols, that the battery design was eliminated as a cause of the fire. While the cell partial short was an anomaly in the cell, the BMS design within the UPS will detect and isolate this problem. The test configuration could not.

Status: Closed. Testing resumed in a new laboratory. See AMS-02-A12.

SUPPORTING DOCUMENTATION: (follows)

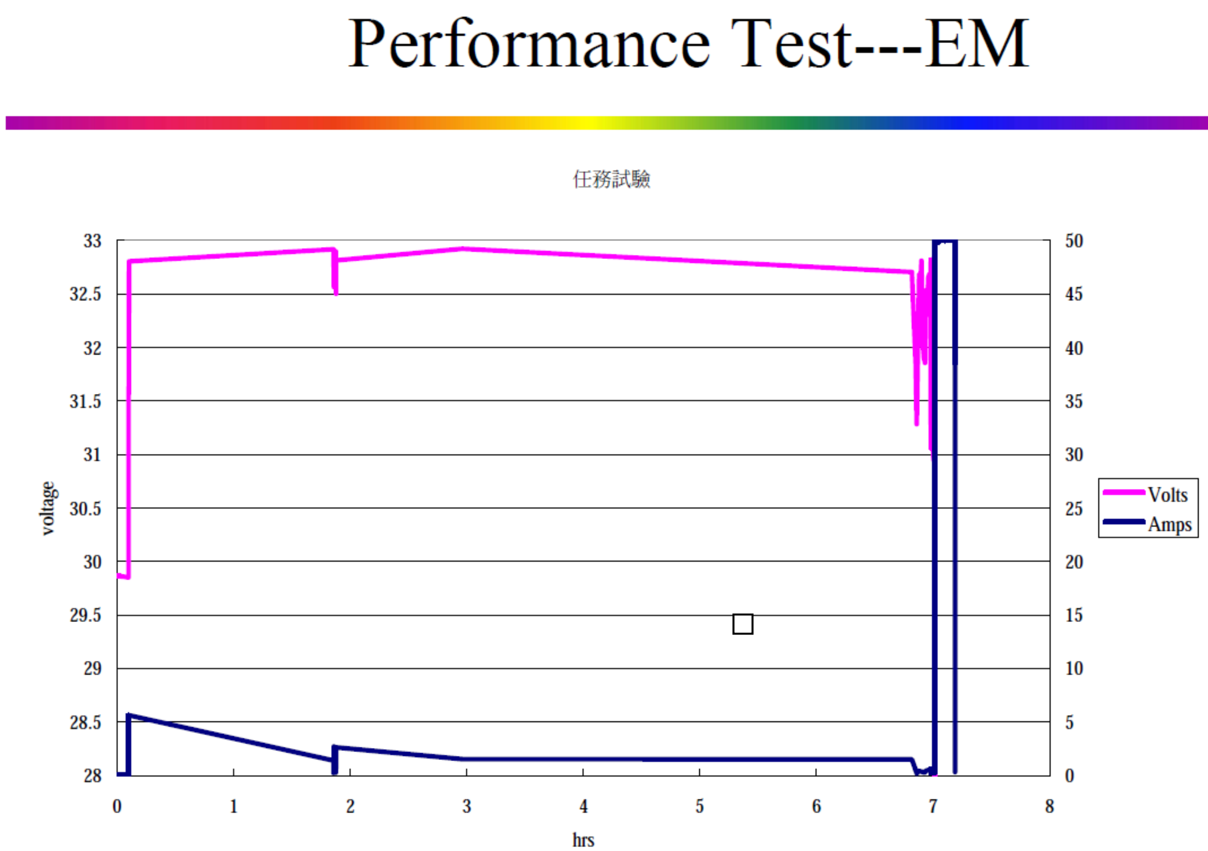


Figure 11-2 Performance Testing of UPS.

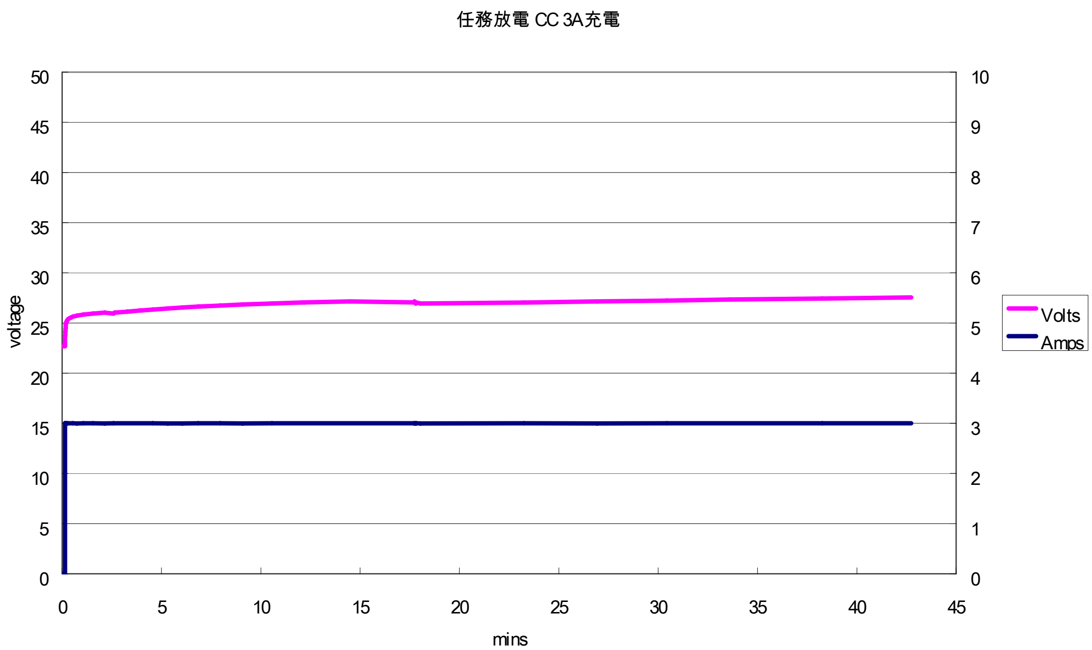
Notes of event:

EM UPS Testing

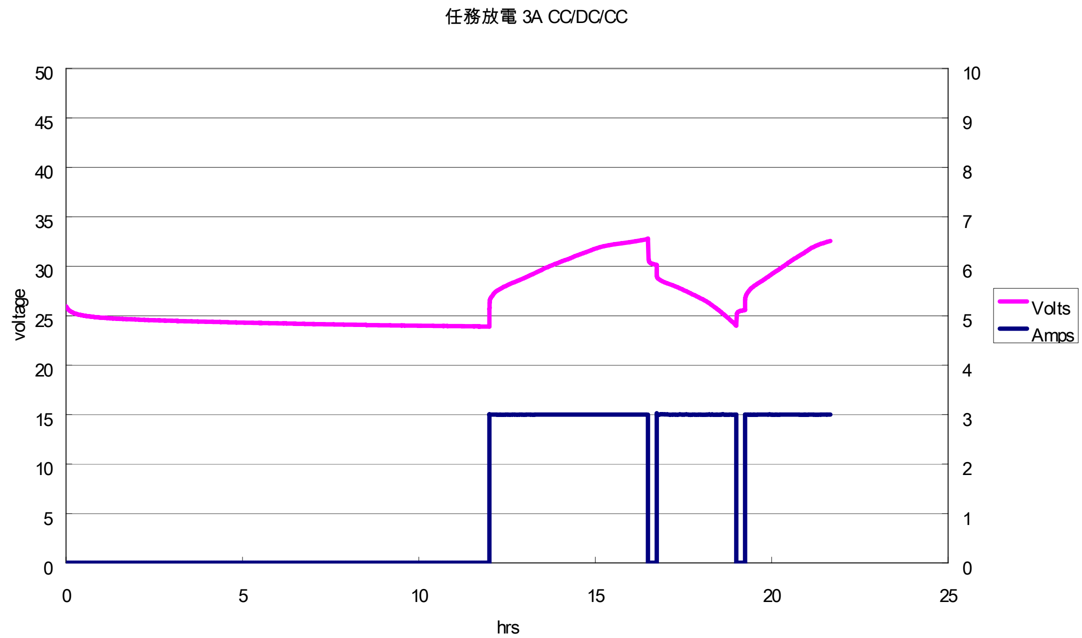
1. EM UPS was charged at 3 Amp constant current with Maccor S4000 Battery Tester for 43 minutes (Graph 1). After 12 hours Open Circuit, EM was charge/discharge/charge one cycle at 3 Amps (Graph 2). Battery Capacity is about 3 Amps x 3 hour=9 Amp-hrs.
2. EM was charged at 5.6 Amps for only 1.3 minutes (Graph 3) and stopped for take movie of EM UPS Testing.
3. EM was charged at 5.6 Amps for about 0.3 minutes then EM was charged at constant voltage for about 7 hours (Graph 4). We try to execute 4.1 Performance Test.
4. EM Battery had encountered partial short at about 1.9 hours (about 0.4 volts drift) and 6.9 hours (about 2 volts drift). After that battery voltage had been dropped to zero volts and the charge current had been

increased to 50 Amps to compensate the voltage setting of 32.8V during constant voltage charge. The maximum charging current of Maccor S4000 Battery Tester is 50 Amps.

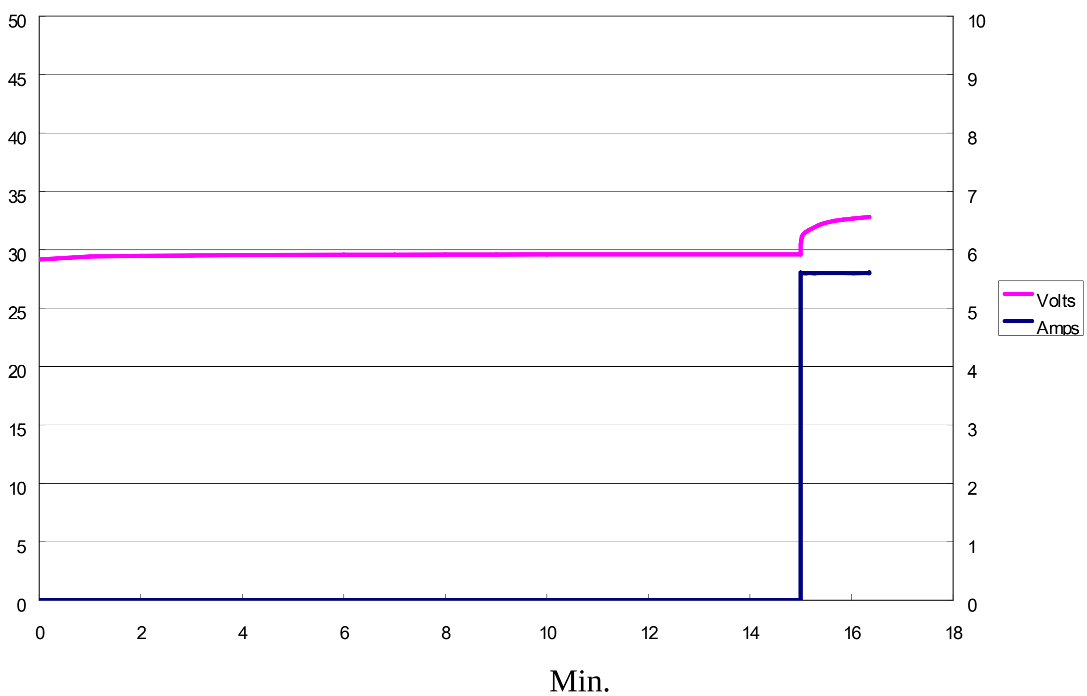
5. BMS charge enable signal was not implemented as an operational control. The charge enable signal from the BMS can not be used as an inhibitor or a disable for the External protection box we try to bought.
6. Parts of the top cover of UPS BOX had been melted due to high temperature (1759.0 deg. C) generated by battery short. J1 / J2 and two Test Connectors are all damaged. The equipment involved in this UPS EM charge failure event has not been tested or serviced following the event.



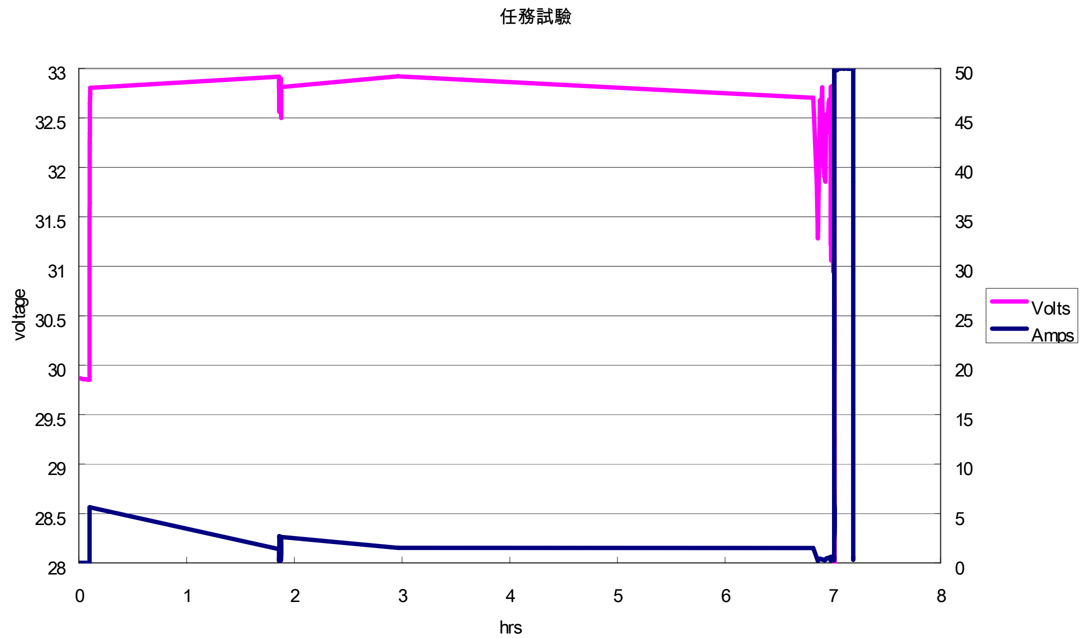
Graph 1: EDU was charged at 3 Amps for about 43 minutes.



Graph 2: Open circuit for 12 hours then EM was charge/discharge/charge at 3 Amps.

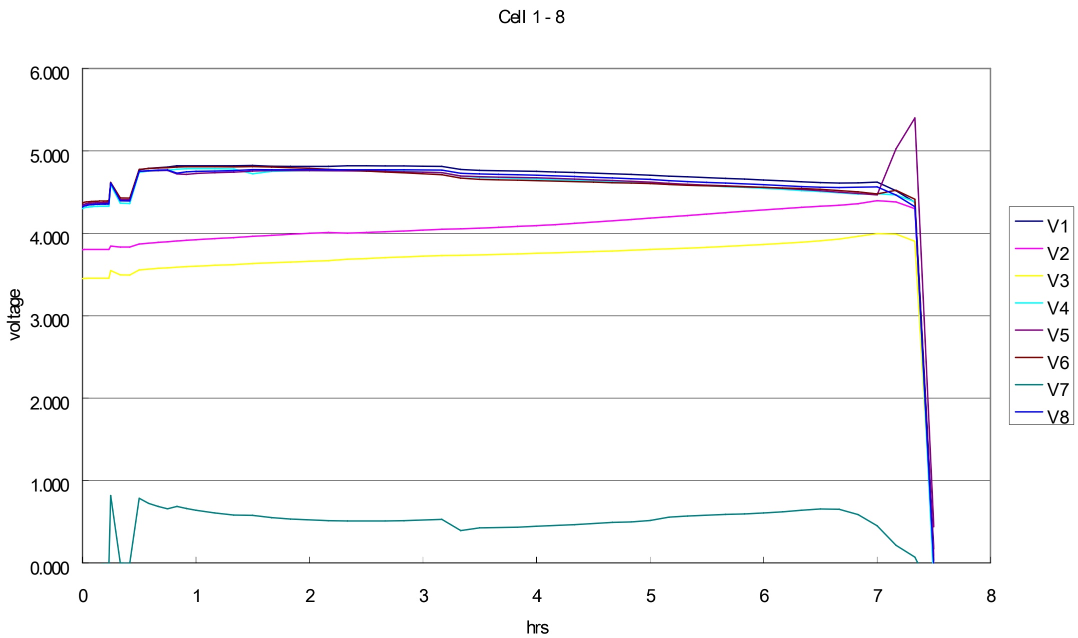


Graph 3: EM was charged at 5.6 Amps for about 1.3 minutes.



Graph 4: EM was charged at 5.6 Amps for about 0.3 minutes then EM was charged at constant voltage for about 7 hours.

7. Unfortunately, only individual cell data of Graph 4 (attached) was taken by Digital Recorder (Accuracy is ±0.01% of reading) due to restriction of the Recorder memory. Voltages of Cell 1 to Cell 8 are cited in Graph 5. At 15:53:02, voltage of Cell # 7 is -0.136 V and voltages of Cell # 2/#3 are3.801/3.450 V. The battery was not well balanced after 1st charge/discharge/charge cycle. Voltage of Cell # 7 was below 1 volt during the Constant Voltage charging period. Voltages of the health Cells #1/4/5/6/8 are above 4.67 V at 16:41:04.
8. At 23:22:58 Voltage of Cell #5 was 5.011 V. At 23:27:14 Voltage of Cell #5 was 5.850 V.
9. At 23:35:28, V5 dropped from 5.521 to -0.077 V; V3 dropped from 3.899 to 0.479 V; V7 dropped from 0.067 to-1.070 V.
10. At 23:43:08 all cells went to zero or negative volts and the temperature at cell #5 was 1759.0 deg. C.


Cell 1 - 8
6.000
5.000
4.000
3.000
2.000
1.000
0.000
voltage
0
1
2
3
4
5
6
7
8
hrs
V1
V2
V3
V4
V5
V6
V7
V8

Graph 5: Voltage of Cell 1 to Cell 8

Time	V	V1	V2	V3	V4	V5	V6	V7	V8	T4
15:53:02	29.02	4.342	3.801	3.450	4.300	4.340	4.367	-0.136	4.318	23.5
16:41:04	32.15	4.706	3.875	3.574	4.675	4.681	4.679	1.006	4.681	25.9
23:27:14	31.95	4.436	4.328	3.947	4.397	5.850	4.326	0.087	4.387	28.5
23:35:26	30.34	4.353	4.285	3.889	4.390	5.521	4.786	0.067	4.301	27.6
23:35:28	27.77	3.716	3.130	0.479	4.466	-0.077	4.806	-1.070	4.040	28.3
23:35:30	-0.83	-3.432	-0.830	-0.518	0.596	########	-1.660	-1.550	-0.674	50.4
23:43:08	0.26	0.136	0.098	0.013	-0.261	0.435	0.029	-0.353	-0.047	1759.0

12. AMS-02-A12 – UPS Battery Cell Undervoltage

Description of Event: During UPS level testing at Yardney, the battery cell manufacturer, it was discovered that some cells in all 4 UPSs exhibited low charge voltages and higher than normal discharge rates. This was seen after the UPSs had been returned from Taiwan (SYSU) due to other testing process related issues (See AMS-02-A11). It is assumed that the cells suffered damage due to improper handling and storage while in the care of SYSU.

Corrective Action: The UPSs were tested and the cells within were attempted to be recovered through conditioning, successfully recovering the performance specifications of some cells. However there were sufficient "bad" and weak cells that it was decided that the UPS compliment of cells needed to be reorganized. The UPSs were disassembled at Yardney and from all of the remaining "good" cells the cell manufacturer assembled two units for further use at CERN during integration and testing. It was decided that, since there were not enough "good" cells to populate a set of flight spares, Yardney would remanufacture sufficient new cells to populate 4 UPSs (2 Flight, 2 Flight Spare). These cells were to be identical to the existing cells and undergo limited testing, including PHYSICAL AND ELECTROCHEMICAL CHARACTERISTICS, FLIGHT SCREENING OF CELLS, TVT .and Vibe Testing.

Safety Impact: None. The original UPSs were tested and shown to have sufficient power with a small margin to accomplish the Watch Dog Timer function that they are provided for, to power a controlled ramp down of the AMS-02 Cryomagnet's power in the even that power or communications are lost from the ISS for a period in excess of 8 hours. As the true source of the diminished cells was not established, it was unsure how the performance over time would be for the UPSs with the "bad" cells. So new cells with full performance compliance were desired so that the original design's margin was restored.

Status: Closed. Cell testing is complete and the Flight and Spare UPSs are under construction.

SUPPORTING DOCUMENTATION: (follows)

13. AMS-02-A13 – Excessive Helium Consumption in Pilot Valves to Cold Weka Valves

Description of Event: During initial cryogenic testing of the AMS Cryosystem and Magnet at CERN, the original Hoerbinger pilot valves installed to actuate the AMS cold and warm Weka valves were found to use excessive amounts of helium.

Corrective Action: A market search was conducted and Clippard valves were chosen to replace the Hoerbinger valves. Pressure, leak, thermal, EMI, vibration, and magnetic field testing was conducted to assure the new valves were suitable. A new Pilot Valve Vacuum Vessel (PVVV) housing the new Clippard valves was developed. A new electrical interface to the Cryomagnet Avionics Box (CAB), modified electrical harnesses, piping manifolds, and brackets for connecting and mounting the pilot valves were also developed. These components all meet the same design requirements as the originals.

Safety Impact: None, this only had a potential impact on mission success based on rate of warm helium consumption.

Status: Closed

SUPPORTING DOCUMENTATION: (follows)

14. AMS-02-A14 – Unreliable Cryosystem Pressure Sensors

<u>Description of Event:</u> During initial cryogenic testing of the Cryosystem and magnet at CERN, the temperature and pressure readings were found to be inconsistent. Research indicated that the leads of the pressure sensors were significantly effected by the temperature, creating variences in the resistance of the lead wires so that depending on the temperature of the sensor, there was an offset imposed.

<u>Corrective Action:</u> It was established that the temperatures sensors were far more effective than low pressure sensors for determining the health and pressure of the Superfluid helium dewar. Nominally the pressure of the tank is at or near vacuum, so pressure variances are small and temperature was more accurate, even as pressure elevated.

<u>Safety Impact:</u> Minimal, pressure sensors are not used to monitor the trends of the Cryosystem, multiple temperature exclusively is used.

<u>Status:</u> Closed.

SUPPORTING DOCUMENTATION: (follows)
None

15. AMS-02-A15 – DDRS-02 Error during EMI Testing

<u>Description of Event:</u> DDRS-02 USB RS422 Assembly malfunctioned and was non functional during the 180.8 – 192.0 MHz section of the RS103 radiated electrical field testing in JSC Building 14 EMI chamber. The purpose of the test was to establish if a susceptibility in the DDRS-02 hardware would propagate and damage the GFE A31p laptop. After the exposure the USB RS422 was properly recognized and functioning, having recovered all function. There was no threat at any time to the GFE hardware.

<u>Corrective Action:</u> Deviation was made to test setup to re-perform a portion of the RS testing in which the EUT was susceptible. In original test configuration, EUT was not fully concealed (not grounded, acted as aerials). Connections TXD, RXD, TXC and RXC were left open and created a path for radiated electric field to enter enclosure. In deviation configuration, loopback cables were connected from TXD to RXD and TXC to RXC. Under retest the DDRS-02 USN RS422 Assembly passed the previously failed range.

<u>Safety Impact:</u> None

<u>Status:</u> Closed

SUPPORTING DOCUMENTATION: (follows)
None – EMI testing report on file.

16. AMS-02-A16 – Leakage of Explosively Bonded Bimetallic Joint in Cryosystem

Description of Event: The AMS-02 Main Helium Tank has four plumbing feedthroughs which contain an explosively-bonded bimetallic joint to connect the steel plumbing lines with the aluminum tank. These joints were all tested as individual units and found to be leak-tight. After the units were welded into the helium tank, two of the four units were found to have developed leaks during integrated tank testing at Hans Bieri Engineering. The most likely cause of the new leaks was overheating of the bimetallic joint during welding operations.

Corrective Action: The two leaking units were removed and two replacement units fabricated and retested. The welding procedure was revised to include additional levels of thermal protection to limit the heat rise at the joint itself. After installation, both replacement units were retested and found to be leak tight.

Safety Impact: Leakage into the interior of the Vacuum case would have been detected long before AMS-02 integration would have progressed on the ground, there is no safety impact with the corrective action in place.

Status: Closed.

SUPPORTING DOCUMENTATION: (follows)

Figure A16-1 Replaced Bimetallic Joint in Place.

17. AMS-02-A17 – Warm Helium Gas Supply Regulator Divergence

<u>Description of Event:</u> During operations at CERN, the Warm Helium Gas Supply pressure regulator was found to diverge from it's nominal setting of 6 bar to a consistent 6.9 bar.

<u>Corrective Action:</u> The nominal operating pressure of the system has increased slightly, but the MDP (8 bar) of the Warm Helium Gas Supply low pressure side (regulated by the anomalous device) is actually set by pressure relief valves set to open at 7.5 bar (8 bar full flow). The consistency of the regulator in operations has shown that while the value is an excursion, it does not impact the operation or the safety of the Warm Helium Gas Supply.

<u>Safety Impact:</u> None- MDP remains consistent and the operating pressure increases slightly.

<u>Status:</u> Closed.

SUPPORTING DOCUMENTATION: (follows)

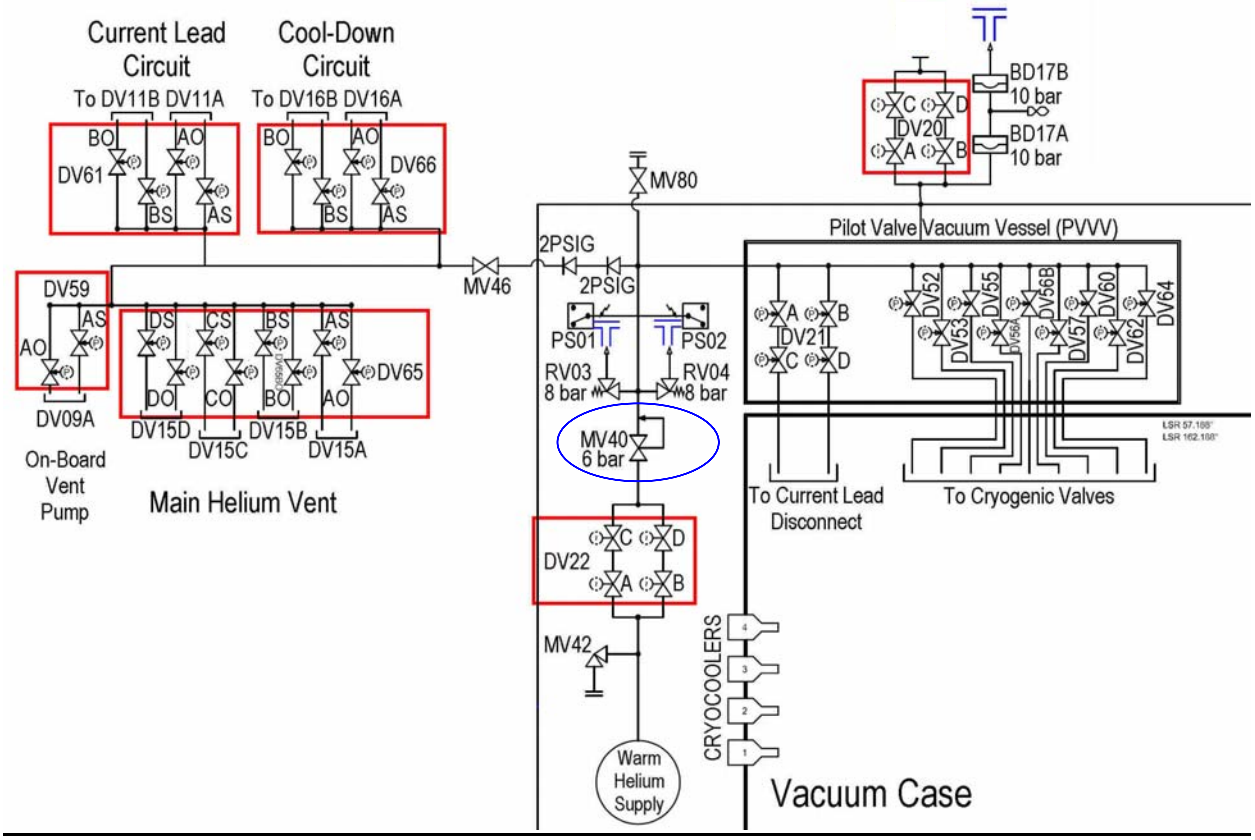


Figure A17-1 Warm Helium Gas Supply (Blue Circle indicates anomalous regulator)

18. AMS-02-A18 – Bubbles in Radiator Heaters

Description of Event: Post-installation inspection of heaters mounted on the back of the Main and Tracker Radiators revealed several small bubbles. Though few and small, these bubbles could possibly lead to localized debonding and overheating of the Kapton foil heaters and eventually heater failure.

Corrective Action: All Kapton foil heaters on the Main and Tracker Radiators were covered with an aluminum tape, which will spread the heat evenly and eliminate any localized hot spots on the heater. In addition, the tape provides additional attachment to the radiator, reducing risk of total debonding.

Safety Impact: Minimal - Bubbles in Kapton foil heaters could have caused localized debonding, localized hot spots, and eventual heater failure. Corrective action was implemented to eliminate these concerns.

Status:

SUPPORTING DOCUMENTATION: (follows)

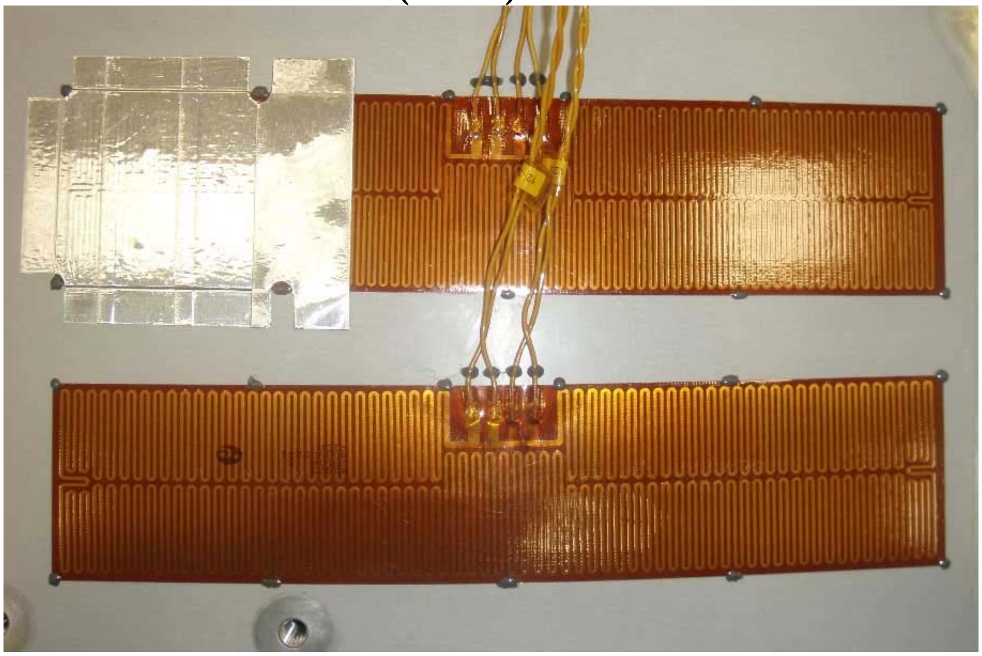


Figure A18-1 Example of covering heater with Kapton Foil Tape (Process incomplete for photo.)

19. AMS-02-A19 – Cleanliness of inside of the Superfluid Helium Tank

Description of Event: During the final cleaning of the Superfluid Helium Tank, higher than expected particulate count was found inside the tank. Although the plan was to clean out the inside of the tank only a few times using clean isopropyl alcohol, the cleaning process took 40 flushes

Corrective Action: Flush the tank with isopropyl alcohol until the particulate count was within the specification. Review this process and results with outside experts, Lou Salerno and Peter Kittel, from NASA Ames Research Center.

Safety Impact: None

Status: Closed

SUPPORTING DOCUMENTATION: (follows)

Memorandum

SCIENTIFIC MAGNETICS

To:	Conference Call Participants	**From:**	Robin Stafford Allen
Ref No.:	Issue 2	**Date:**	12th June 2007
Re:	Cleaning of helium vessel	**CC:**	Stephen Harrison, Trent Martin, Ken Bollweg, Chris Tutt

The helium vessel for the AMS program has to be sufficiently clean for reliable operation of the valves and porous plug. The discussion to date has been as to whether the specification set for cryogenic system components is adequate when the large volume (2500 litres) of the helium vessel is considered.

Cleaning has been underway over some weeks. The cleaning initially was done using washes of 50 – 70 litres of filtered IPA fluid at a time. This wetted the outer skin well and rinsed much of the vessel as the vessel was rotated around its axis, and at the same time perpendicularly to this axis. There is clear audible splashing and sloshing due to this process and the many pockets in the central ring may have carried IPA up into the upper parts of the vessel before allowing it to drain down over the inner skin but it was felt that this might not have washed the entire inner surface of the vessel. To make sure of rigorous cleaning it was agreed that some washes with larger volumes would be undertaken. These have been performed.

The fill required to touch the inner skin with the axis horizontal is around 400 litres. The vessel support jig was given extra support and loaded with 450 litres of IPA and confirmation that the inner skin was around 50 mm into the fluid was made.

The vessel was then rotated around its horizontal axis, as the axle was supported at both ends on stands. The through-tubes could clearly be heard causing turbulence and significant splashing of the IPA. This 450 Litre process has now been completed seven times to date.

The process of loading the fluid and unloading has been established and the results over the first 14 washes showed a significant reduction in the particle count. The assessment process was taken over during the usual engineer's absence and the results between wash 14 and 32 have been discarded as unreliable. From wash 32 onwards the results are felt to be representative. Several changes to the process have been made to ensure that the environmental contamination of the samples is reduced. The sample is taken at a suitable point during the emptying of the fluid, usually at about half-way empty, and the sample is immediately sealed into container and transferred into the lamina flow clean-room area. The air drawn back into the vessel as the fluid is removed is now also filtered.

The fluid sample is passed through a 47mm diameter, 0.45 micron, 'grid' filter paper and the paper examined under a microscope. Initially 100 mls. of fluid was filtered and examined and 5 squares of the paper counted (of the 100 squares of the full area of the filter paper). With the large number of particle this was a very time consuming process. The sample results were multiplied by a factor of 20 to give a comparison with the Cleaning Specification. As the number of particles has dropped the amount of fluid has

now been increased to 250 mls. and the number of squares counted increased to 10. The results are then only multiplied by factor of 4 to compare with specification (100mls, 100 squares).
The results are tabulated below and show the number of particles in the cleaning fluid normalised to the 100 mls of the Cleaning Specification. They show a reduction over the 40 IPA cleaning cycles so far.
To make a summary chart a weighted system has been used. This turns a particle size and frequency spectrum into a single number for comparison. It was felt that the smallest particles were the most concerning and so the weighting was defined as follows

Larger than 100 micron	x1
Less than 100 micron	x2
Less than 50 micron	x4
Less than 25 micron	x8
Less than 10 micron	x16

The weighted total is then divided by 31.
Employing this weighting calculation, the AMS particle Specification level comes out at 27. The chart on the last page shows the examination of the repetitive washes of the vessel and the improvements in the cleanliness can be seen.
The comparison dark blue bars on the bar chart are at the Cleaning Specification value of 27 units. The recent samples are around or below this level in this weighted system. No clear and significant change, only a slight transient rise, in the particle evaluation occurred when switching from 70 litres to 450 litre washes.
Control samples are examined. The control samples are samples of the fluid as it is pumped through the filters into the vessel. The results have been helpful in improving the process of reducing contamination, and the control samples are showing very similar profile of particles to the fluid now coming out of the vessel.
Mark Gallilee has now had an opportunity to examine the last two filter papers. He had performed all the examinations up #33 but he was unavailable for the last washes. His examination produces slightly higher particle count, but this may be due to sampling different 10 squares on the paper, which were chosen at random, or the fact that the filter paper had been stored in a plastic zip-lock bag for some days before being re-examined, which gave the opportunity for a low level of contamination. In any event the levels of contamination found were of the same order as the first examination. His figures have been added to the tables.

End-of-rinse fluid assessment.

Toward the end of the fluid pump-out, the last 30 – 50 litres is again washed around the vessel and as quickly as is practical allowed to flow out of the vessel into a catch-pot. The debris that settles in this catch-pot is observed rather subjectively. This has reduced from a significant quantity per Ken's original photographs to a few dozen particles. The amount it probably one or two orders of magnitude less in quantity than in the early washes. This has been consistent with the dropping in the particle count of the fluid samples.
The vessel cleaning has been developed as it has progressed. However with the equipment and the environment in which the cleaning is progressing, we appear to be almost at the limit of what can be achieved. A decision is required as to whether the vessel needs to be any cleaner for functional purposes.

Porous Plug Assessment
The porous plug has a diameter of 20 mm, so an area of 314 mm^2.
At the Cleaning Specification level of 39 particles of 10 micron diameter per 100 mls, throughout a volume of 2,500 litres, and assuming all particles are 10 micron by 10 micron (0.01 x 0.01 mm) the area covered by all these particles would be 97.5 mm^2.
This is approximately one third of the porous plug area in this worse-case analysis.
The charts are attached.

RCSA.

Specification per 100 mls of wash	39	15	3	1	0	
Specification per 1000 mls of wash	390	150	30	10	3	1
	1	2	3	4	5	
Sample item	5-10micron	11-25micron	26-50micron	51-100micron	>100micron	>200 micron
sample 4	780	440	240	80	120	
sample 5	500	280	140	20	160	
sample 6	480	120	260	40	100	
sample 7	260	220	140	20	120	
sample 8	140	100	40	100	80	
sample 9	280	60	60	20	180	
Sample 10	140	60	120	80	60	
Sample 11	300	160	120	60	100	
Sample 12	120	60	20	0	120	
Sample 13	140	80	20	60	80	
Sample 14	260	120	20	20	60	
Sample 32	60	0	20	40	0	
Sample 33 450L	80	20	20	0	20	
Sample 35 450L	112	10	0	8	14	
Sample 36 450L	72	6	0	6	4	
Sample 37	12	16	0	0	0	
Sample 38	21	14	21	7	14	
Sample 39	4	8	4	0	8	
Sample 40	8	12	0	0	0	
Sample 39 (re-examined by Mark Gallilee)	20	12	12	16	12	
Sample 40 (re-examined by Mark Gallilee)	32	24	12	4	4	
Control sample 39 (fluid entering vessel)	4	4	8	4	4	
Control sample 40 (fluid entering vessel)	8	4	0	0	4	

Sample Particle count corrected to 100 mls for comparison with the Cleaning Specification (top line numbers)

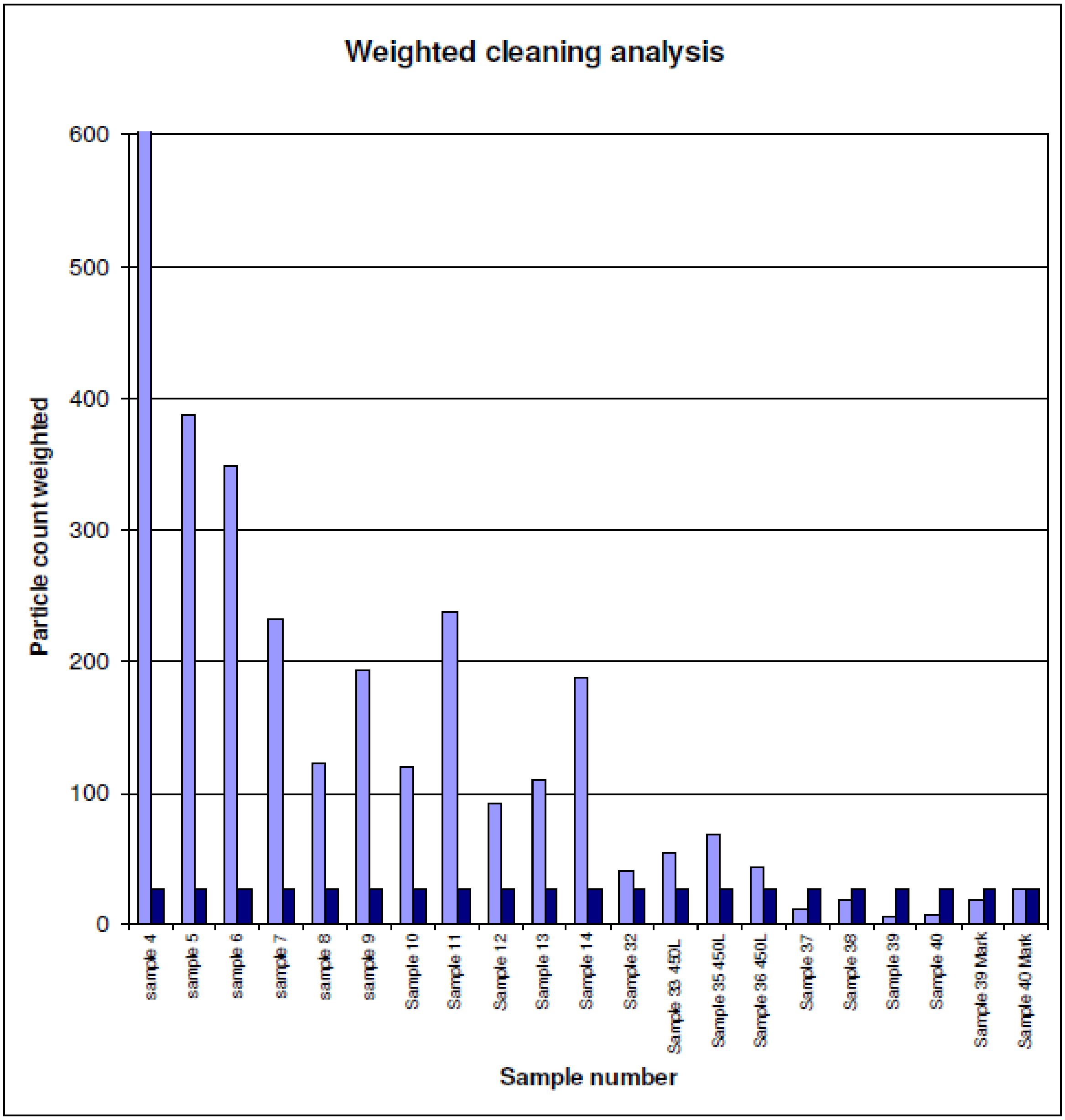


Chart of the 'weighted' particle size count against the IPA cleaning cycle number, showing the improvement in particle count as the cleaning cycles progress.
The dark blue bars show the Cleaning Specification requirement 'weighted' value of 27 units.
The rightmost two values show the re-examination of sample filter papers by Mark Gallilee.

EMAIL Correspondence between project team and the cryogenics experts from NASA Ames Research Center:

-----Original Message-----
From: Louis Salerno [mailto:Louis.J.Salerno@nasa.gov]
Sent: Tuesday, June 12, 2007 8:50 AM
To: Robin Stafford Allen; Tutt, John C. (JSC-EA2)[ESCG]; 'Peter Kittel'; Martin, Trent D. (JSC-EA2); 'Steve Harrison'; Bollweg, Kenneth (JSC-EA2)
Cc: 'Mark Gallilee (SM)'
Subject: RE: Cleaning of Helium Vessel Summary

All,

Thanks to Robin and the entire SM Team for this. I continue to feel that we have achieved the cleanest condition possible using the current methods and that this is acceptable.

Lou

At 06:04 AM 6/12/2007, Robin Stafford Allen wrote:
> To all,
>
>I have updated my report with the details of the 'Control Fluid'
>analysis (ref the email below) and the re-check of the original #39 and
>#40 filter papers conducted by Mark to make sure we have some consistency in readings.
>Mark's results are slightly higher than when I viewed the filter
>papers, and this could be due to contamination of the papers with the
>passing of time (although they were bagged in the clean room) or some
>other factor, or it could be a genuine slight difference. However
>Mark's analysis does show that using the "weighted" specification level
>that the last two rinses are still within requirement.
>
>On the conference call on Monday we agreed to continue with the drying
>and vacuum-pumping of the vessel and the flushing of the
>heat-exchangers. This is on-going.
>
>Regards
>
>Robin...
>
>-----Original Message-----
>From: Robin Stafford Allen [mailto:rstaf@scientificmagnetics.co.uk]
>Sent: 08 June 2007 09:36
>To: 'Tutt, John C'; 'Peter Kittel'; 'Martin, Trent D. (JSC-EA2)';
>'Louis Salerno'; 'Steve Harrison'; 'Bollweg, Kenneth (JSC-EA2)'
>Cc: 'Mark Gallilee (SM)'
>Subject: RE: Cleaning of Helium Vessel Summary
>
>Chris,
>
>To answer Peter's and your questions:-
>

>1) Yes I should have labelled the last four washes as 450 L. My
>apologies for this confusion. We have now completed a total of seven
450L washes.
>
>2) I agree that the calculation was very simplistic but it was purely
>to relate the cleanliness to an understandable parameter of the porous
plug.
>
>3) The control fluid samples put through the same procedure produced
>numbers as follows
>
>   <10   <25   <50   <100   >100
>Control 40   2   1   0   0   1
>Control 39   1   1   2   1   1
>
>When multiplied up to normalise to 100 mls and the full squares count
>these become
>
>Control 39   4   4   8   4   4
>Control 40   8   4   0   0   4
>
>And the effective index using the same weighting system
>
>Control 39   5
>Control 40   6
>
>As you can see these numbers are quite similar to the measurements of
>the fluid coming from the vessel and are part of the reason that I
feel
>we are in the diminishing returns of the process. To achieve low
counts
>I am using the cleanest part of our cleanroom for the counting and
have
>fully gowned and gloved before opening samples. I found that if
samples
>of fluid are left in the open for even a few minutes, the number of
>dust particles collected is significant and produce distorted readings
>at these low count levels. The filter papers are even more obviously
>affected by even one or two airborne dust particles.
>
>There is also our old friend Weibull and statistics. When looking at
>small numbers nearing zero there is a probability distribution and
>always some variability. I feel that the few 100 micron bits from wash
>37 fall in this category as there were no significant change in the
>process that I can identify between 36 and 38.
>
>We are setting up to dry the vessel, and I am actually quite pleased
>that we have 'tested' this process by drying it after wash 33 last
>weekend and not seeing a significant increase in particles afterwards.
>We are drawing air from the cleanest area of the clean-room and
ducting
>it into the Porous plug opening through the vessel to enable the IPA
to
>evaporate in the vessel and be carried away out of the burst-disc port.
>It appears to take about 3 shifts to dry out the gross IPA content,
and

>it would be good to do this over the weekend. We will then do another electrical check.
>
>When we have unanimous agreement that we have achieved the technical
>goal and can stop cleaning the vessel we will move on to the drying.
>
>Any questions, do ask.
>
>Robin...
>
>
>
>-----Original Message-----
>From: Tutt, John C [mailto:John.Tutt@escg.jacobs.com]
>Sent: 07 June 2007 22:34
>To: Peter Kittel; Martin, Trent D. (JSC-EA2); Louis Salerno; Robin
>Allen; Steve Harrison; Bollweg, Kenneth (JSC-EA2)
>Subject: RE: Cleaning of Helium Vessel Summary
>
>Obviously, I'll defer to the experts on whether or not a 1/3 blockage
>of the porous plug would be a mission success issue or not. But I
>think that Robin hit on the key point that we seem to have reached the
>practical limit of what we can do with the current method.
>
>I am curious what happened between sample 37 and sample 38. Whatever
>it was, it seemed to shake loose a large number of particles. That
may
>be worth investigating in case it's something that we might do again
>during normal operations.
>
>Regards,
>Chris
>
>Chris Tutt
>Project Manager
>Engineering and Science Contract Group
>Jacobs Sverdrup
>2224 Bay Area Blvd M/C B2SC
>Houston, TX 77058
>(281) 461-5703
>
>
>-----Original Message-----
>From: Peter Kittel [mailto:pkittel@mail.arc.nasa.gov]
>Sent: Thursday, June 07, 2007 2:35 PM
>To: Martin, Trent D. (JSC-EA2); Louis Salerno; Robin Allen; Steve
>Harrison; Tutt, John C; Bollweg, Kenneth (JSC-EA2)
>Subject: Re: Cleaning of Helium Vessel Summary
>
>Trent,
>
>The figure and table attached to Robin's report does not label the
>last 4 washes as being 450 l. From the text I assume they were.
>Also, I do not see mention of the control - the particle count of IPA
>not used as a wash but otherwise treated the same as the other samples.
>Since the control sample had some particles, The actual particle count
>is probably less than stated in the report.

>
>The estimate of the blocked area of the porous plug is probably high.
>
>Particles larger than 10um are likely to loosely accumulate on the
>surface and not interfere with the operation of the porous plug.
>
>Particles smaller than 10 um, especially the very small particles, may
>penetrate into the porous plug. Alternative calculation might be the
>fraction of the void volume of the porous plug that is blocked.
>
>Overall, I am optimistic that the tank is sufficiently clean.
>
>Peter
>
>
>On Jun 7, 2007, at 10:33 AM, Martin, Trent D. (JSC-EA2) wrote:
>
>> Please review and comment.
>>
>> -----Original Message-----
>> From: Robin Stafford Allen [mailto:rstaf@scientificmagnetics.co.uk]
>> Sent: Thursday, June 07, 2007 11:38 AM
>> To: 'Stephen Harrison'; Martin, Trent D. (JSC-EA2); Bollweg, Kenneth
>> (JSC-EA2); Tutt, John C. (JSC-EA2)[ESCG]
>> Subject: Cleaning of Helium Vessel Summary
>>
>>
>> Attached is a summary of the situation as it is today, Thursday 7th
>> June. We have completed more cleaning cycles at 450 Litres and I
have
>> added these data points to the tables. I feel they are very
>> encouraging.
>>
>> Please review and do comment
>>
>> Robin...
>>
>>
>> Robin C Stafford Allen
>> Scientific Magnetics,
>> Building E1,
>> Culham Science Centre,
>> Culham,
>> Abingdon,
>> Oxfordshire OX14 3DB
>> Tel: +44 (0)1865 409210.
>> Fax: +44 (0)1865 409222.
>> Mobile: +44 (0)7834 629131
>> mailto:rstaf@scientificmagnetics.co.uk
>>
****
>> *
>
>> *
>>
>> The information contained in this message is confidential and is

>> intended for the addressee only. If you have received this message
in
>> error or there are any problems please notify the originator
>> immediately. The unauthorised use, disclosure, copying or alteration
>> of this message is strictly forbidden. Space Cryomagnetics Ltd. will
>> not be liable for direct, special, indirect or consequential damages
>> arising from alteration of the contents of this message by a third
>> party or as a result of any virus being passed on.
>>
>> Space Cryomagnetics Ltd. Company No. 3950388. Registered in England
>> and Wales at registered office: Building E1, Culham Science Centre,
>> Culham, Abingdon, Oxfordshire OX14 3DB England. Tel: +44 (0)1865
>> 409200. Fax:
>> +44
>> (0)1865 409222. http://www.scientificmagnetics.com/
>> <Cleaning measurements memo.doc>
>
>
>

Louis J. Salerno
Technical Authority and
Group Leader for Cryogenics
NASA Ames Research Center
M/S 244-10
Moffett Field, CA 94035-1000
Phone: (650) 604-3189
FAX: (650) 604-0673 Note new FAX number

"Having top people is NASA's good fortune. The privilege of working
with the best is mine." -- Louis J. Salerno

---

20. AMS-02-A20 – Deviation from documented procedure for Installation of MLI Pins

<u>Description of Event:</u> During installation of MLI pins on the AMS-02 lower USS-02, the process for removing anodization on aluminum surfaces was altered due to the difficulty using documented process. Rather than a slow abrading process a sharp implement was used to "score" the area in a grid-like pattern.

<u>Corrective Action:</u> This revised process is based on the process used on the EuTEF payload, however as this was a deviation from AMS-02 documentation, it was required by the AMS-02 Safety Engineer that each pin be validated to be properly secured with this process (20 pins) to qualify this process on the prepared AMS-02 anodized surface.

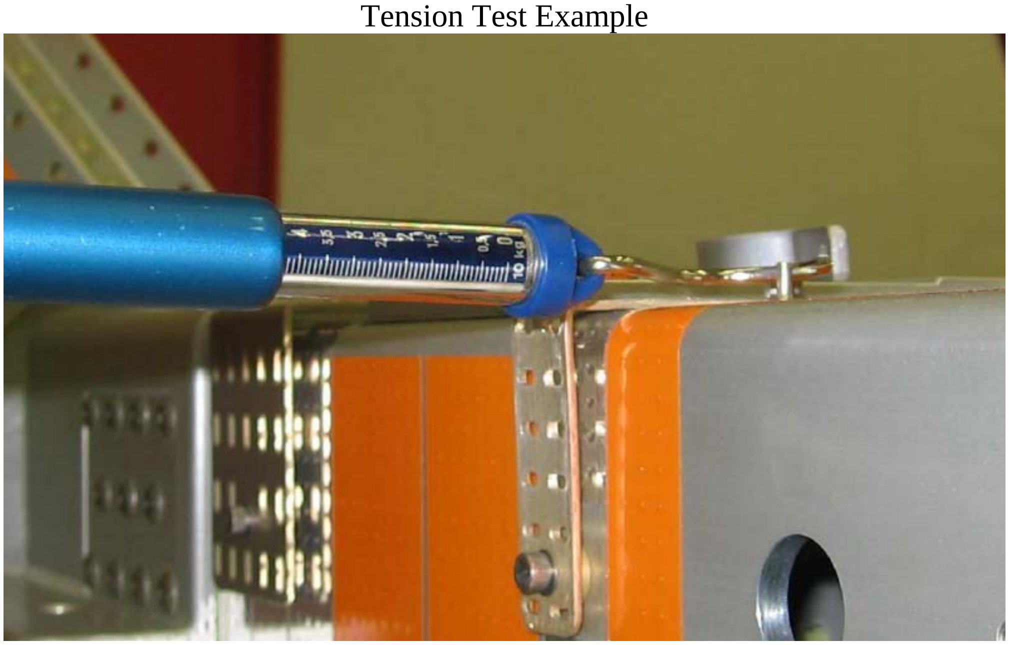
Calculated load on a pin from the installed MLI blanket was established to be no more than 2 kg per pin with a 2.0 factor of safety applied. Testing loads for tensile and shear testing was established from this number to be 4 kg of load to assure that the pins are well secured. Previous qualifications for these pins adhered to an alodined surfaces were shown good to a 10 kg load, but this greatly exceeds the need of the AMS-02 application so testing to this level again was no deemed necessary.

<u>Safety Impact:</u> Potentially the adhesion of the MLI pins would be inadequate to secure the MLI to the AMS-02. With testing, no issue.

<u>Status:</u> Closed. Wednesday November 28, 2007 the pull test on all twenty installed pins were made to a minimum loading of 4 kg in tension (along the axis of the pin) and shear (a lateral force applied to the pin above the adhesion plane). All installed pins passed this test and were deemed adequately installed. This test was considered evidence that any future installation of pins that may support MLI loading per pin of 2kg or less based on a 10g acceleration condition would be enveloped and acceptable using this installation technique.

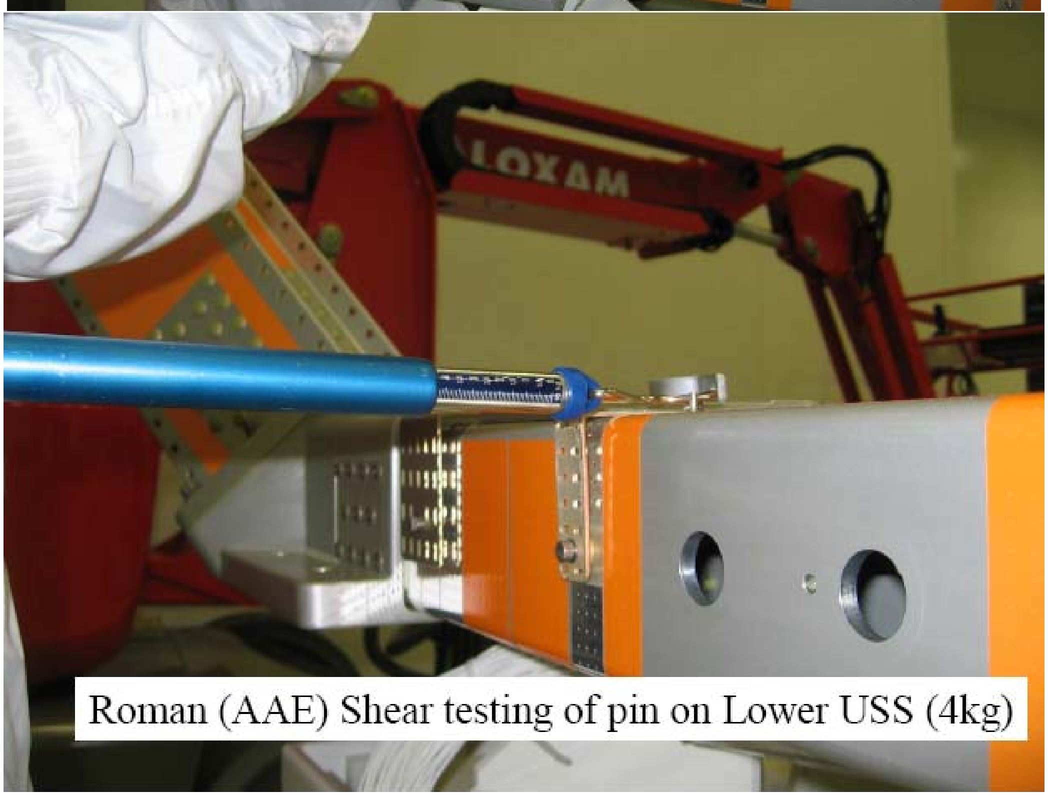
SUPPORTING DOCUMENTATION: (follows)

Tension Test Example



Shear Testing Example


Pull testing pin. All 20 pins successfully passed at 4kg.


Roman (AAE) Shear testing of pin on Lower USS (4kg)

APPENDIX C: LIST OF TECHNICAL OPERATING PROCEDURES (TOPS)

APPENDIX D: ACAS TEST

APPENDIX E: POPIT TEST

AMS-02 POPIT Test Plan

Revision: 3

Date: 4-Oct-07

Front Matter

1.1 Table of Contents

1.2 List of Figures

1.3 List of Tables

2 Introduction

This document provides the test designs for the AMS-02 Pad Ops Preliminary Interface Test (POPIT). This test provides a verification that the systems designed to provide the data supporting the Payload Safety Review Panel required launch commit criteria are fully understood, adequate to task, and available for use. The timing of this test requires it be done when it is possible to rectify any design issues with AMS-02 J-Crate hardware should the test expose them.

2.1 Terminology

Mobile Launch Platform (MLP). This is the portion of the launch platform onto which the STS stack is assembled within the Vehicle Assembly Building (VAB). STS on the MLP is rolled out to the launch pad by the crawler.

Tail Service Mast (TSM). The TSM provides avionics (and other) connections between the MLP and the STS. These connections are withdrawn from STS just moments prior to liftoff.

STS simulator (STS-SIM). This is an AMS02-APO provided medium fidelity mockup of the electrical wire within the shuttle over which the signals travel from the payload bay up to the mid deck panels and then down to the tail service mast connections. This includes various lengths of twinax cabling, connectors, 1553 couplers, and a Computer Interface Panel (CIP).

TSM-Breakout Connector. A KSC provided adapter providing breakout cables for the TSM connections.

Digital Data Recording System 02 (DDRS02). This is the laptop system flown on the aft flight deck to provide recordings of the AMS-02 RS422 high rate data stream.

USB422. The AMS-02 developed USB interface to high rate RS422.

DDRS02-MLP. This is DDRS02 derived software operating on an industrial PC located in compartment 10A of the MLP and attached to AMS-02 via T-0 connections.

DDRS02-JMDC. This is DDRS02 derived software operating on an industrial PC located on the launch pad deck of the MLP and attached to STS-SIM and hence to the TSM. This provides a simulated RS422 data stream for testing.

AMS02-RT. Provides a low fidelity simulation of the AMS-02 payload 1553 Remote Terminal interface. Also called the AMS-02 Payload Simulator.

AMS02-BC. Provides a low fidelity simulation of the ISS Payload MDM.

AMS02-BM. Provides an application specific 1553 bus monitor for the AMS-02 system.

2.2 Software Configuration

POPIT is baselined on the AMS-02 standard Fedora Core 6 installation (AMS-FC6_20070622_DVD.iso) and AAL release aal_20070814.tgz with the following exceptions:

- The 1553 system has been modified to operate in real time mode – see patches to bu_lib.c
- The standard AAL drivers have been neutralized by the following file system change: mv /lib/modules/2.6.20-1.2948.fc6/kernel/driver/ams02 /lib/modules/2.6.20-1.2948.fc6/kernel/driver/ams02-nodriversplease
- The testing directory ~ams/POPIT must be created and must be populated with the following two files: big.dat and file_id.cfg
- The networking topology has been hand changed to use fixed IPs of the form 192.168.1.xxx where xxx is the nn in PCAALnn.

2.3 MLP Test Setup Drawing

The drawing below shows the POPIT MLP test setup. Note: while shown as distinct machines for clarity in fact AMS02-BM and DDRS02-MLP will be the same computer.

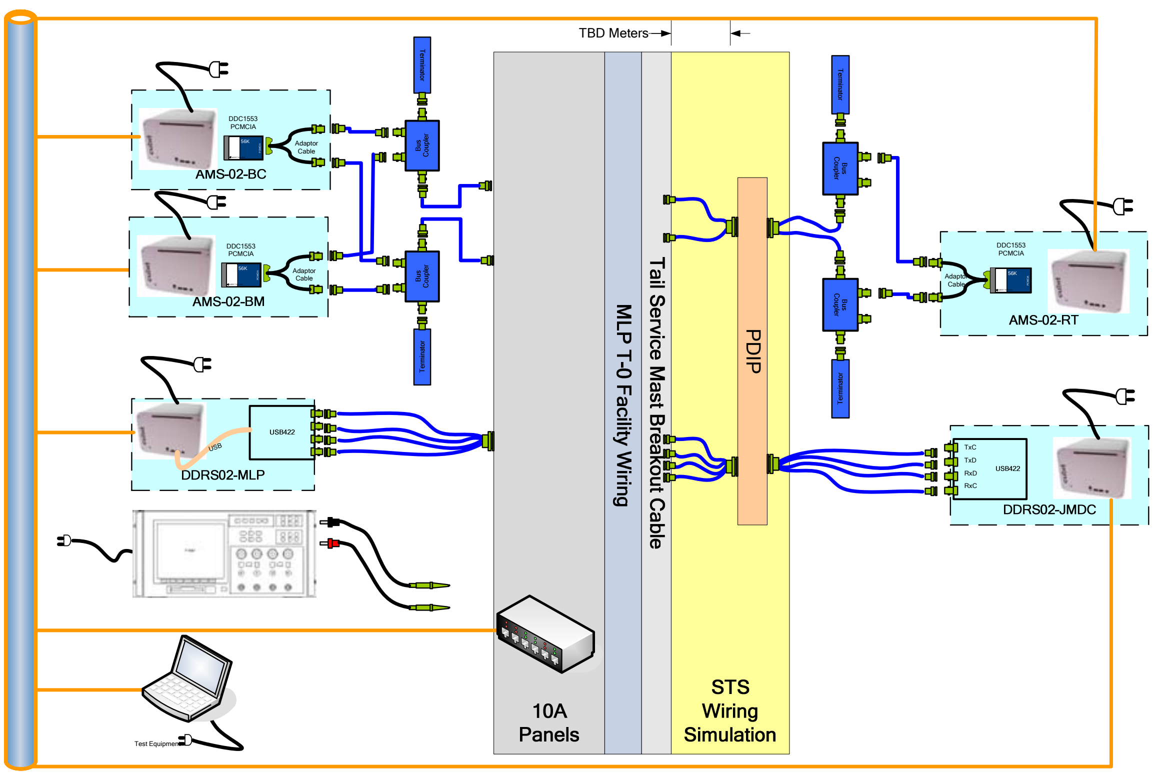


Figure 2-1 MLP Test Setup Drawing

2.4 PRCU Pre-Test Setup Drawing

The drawing below shows the POPIT PRCU pre-test setup.

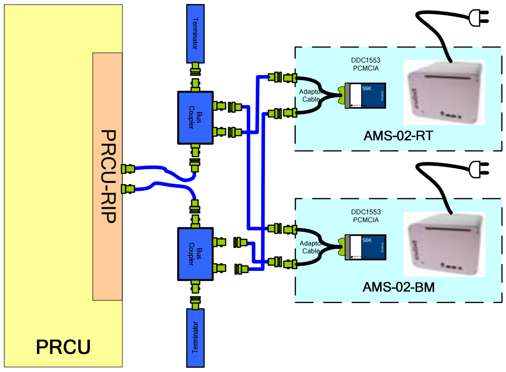


Figure 2-2 PRCU Test Setup Drawing

2.5 PRCU 1553 Pre-Test Calibration

The PRCU 1553 Pre-Test Calibration run will be used as a reference to which to compare the MLP session tests. This test will also assure the procedures themselves are meaningful and valid.

2.6 1553 Test Background

The 1553 tests will document that the MLP interface wiring for 1553 is correctly understood, that all appropriate cables are fabricated correctly, and the services selected adequate to carry to appropriate signals. The tests consist of engineering studies of the signal integrity using an oscilloscope as well as bit error testing

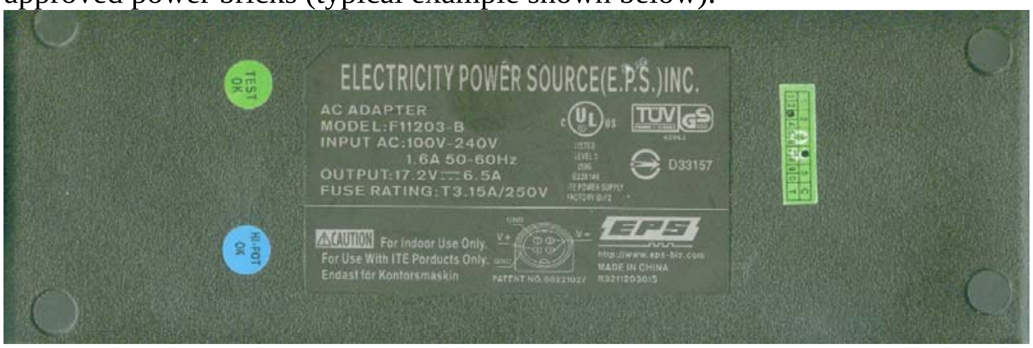
2.7 RS422 Test Background

The RS422 tests will document that the MLP interface wiring for RS422 is correctly understood, that all appropriate cables are fabricated correctly, and the services selected adequate to carry to appropriate signals. The tests consist of engineering studies of the signal integrity using an oscilloscope as well as bit error testing at various data rates to confirm operations.

2.8 Safety Data

This section provides input to the safety review process for the customer provided equipment involved in the POPIT tests.

1. Tests are performed with Electrical Ground Support Equipment (EGSE) built from unmodified Commercial Of The Shelf (COTS) PCs with commercial interfaces installed being utilized for the purpose for which they where designed.
2. The single exception to COTS is the RS422 interface designed for flight which receives 5vdc 500ma via a USB interface. This unit is much like commercial USB serial port converters – just faster.
3. Other then standard 120vac power no voltages in the test exceeds 20vdc.
4. In all cases the customer provided equipment receives operational power via UL approved power bricks (typical example shown below).



5. All customer provided cables and harness are either COTS or fabricated to NASA standards – service class details can be provided.
6. Standard lab breakout connections are utilized for Oscilloscope studies.
7. No Mechanical GSE or moving equipment is involved.
8. No customer provided equipment weighs more the 20lbs.
9. There are not operation restrictions or safeties for customer provided equipment.

Based on this assessment it is suggested that this document and a table top safety walk down just prior to test could be utilized in lieu of a formal ground safety package.

2.9 RS422 Bit Error Rate Computation

Each RS422 test calculates a Bit Error Rate (BER) approximation as follows:

(FinalError – InitialErrors) / ((FRAMES*4080*8) / ElapseSeconds)

This is a rather poor approximation as it assumes a single error detected by DDRS02 equates to a bit error. It may in fact represent many bit errors.

2.10 RS422 Data Rate Table

The following table provides the data rate generated for various transmit clock divider parameters.

TX_DIV	Bits/sec	Frames/s
0	15,000,000	459.1
1	7,500,000	229.6
2	5,000,000	153.0
3	3,750,000	114.8
4	3,000,000	91.8
5	2,500,000	76.5
6	2,142,857	65.6
7	1,875,000	57.4
8	1,666,667	51.0
9	1,500,000	45.9
10	1,363,636	41.7
11	1,250,000	38.3
12	1,153,846	35.3
13	1,071,429	32.8
14	1,000,000	30.6
15	937,500	28.7

TX_DIV	Bits/sec	Frames/s
16	882,353	27.0
17	833,333	25.5
18	789,474	24.2
19	750,000	23.0
20	714,286	21.9
21	681,818	20.9
22	652,174	20.0
23	625,000	19.1
24	600,000	18.4
25	576,923	17.7
26	555,556	17.0
27	535,714	16.4
28	517,241	15.8
29	500,000	15.3
30	483,871	14.8
31	468,750	14.3

Table 2-1 DDRS02 Transmit Clock Divider Data Rates

3 RS422 Setup Validation

This test validates that the RS422 test setup environment is functioning as expected. This test is performed on two DDRS02 systems (DDRS02-MLP and DDRS02-JMDC) cabled together with short (less then 20 feet) Twinax RS422 cables.

3.1 Connection Detail

Connections are made per the following table:

DDRS02-MLP	DDRS02-JMDC
RxD	TxD
RxC	TxC
TxD	RxD
TxC	RxC

Table 3-1 RS422 Setup Validation Connection Detail

3.2 Procedure

3.2.1 Test Uplink

Perform procedure as documented in Appendix A – RS422 Operations Procedures using DDRS02-MLP as the transmitter and DDRS02-JMDC as the receiver. Perform the following substitutions:

[test] = 3U.n (Where n is a sequence number starting at 0 for restarts or reruns)
[txdiv] = 7
[rate] = 57.3

3.2.2 Test Downlink

Perform procedure as documented in Appendix A – RS422 Operations Procedures using DDRS02-JMDC as the transmitter and DDRS02-MLP as the receiver. Perform the following substitutions:

[test] = 3D.n (Where n is a sequence number starting at 0 for restarts or reruns)
[txdiv] = 7
[rate] = 57.3

4 RS422 MLP Nominal Operation

This tests the RS422 path on the MLP functioning at the design speed. This test is performed on two DDRS02 systems (DDRS02-MLP and DDRS02-JMDC). DDRS02-MLP is attached to the appropriate connections on the panels in compartment 10A and DDRS02-JMDC (STS-SIM) is attached to the TSM.

4.1 Connection Detail

Connections are made per the following table:

DDRS02-MLP	DDRS02-JMDC
RxD	TxD
RxC	TxC
TxD	RxD
TxC	RxC

Table 4-1 RS422 Nominal MLP Connection Detail

Assuming limited cable availability the procedures are design to be split between uplinks and downlinks.

4.2 Procedure

4.2.1 Test Uplink

Perform procedure as documented in Appendix A – RS422 Operations Procedures using DDRS02-MLP as the transmitter and DDRS02-JMDC as the receiver. Perform the following substitutions:

[test] = 4U.n (Where n is a sequence number starting at 0 for restarts or reruns)
[txdiv] = 7
[rate] = 57.3

4.2.2 Test Downlink

Perform procedure as documented in Appendix A – RS422 Operations Procedures using DDRS02-JMDC as the transmitter and DDRS02-MLP as the receiver. Perform the following substitutions:

[test] = 4D.n (Where n is a sequence number starting at 0 for restarts or reruns)
[txdiv] = 7
[rate] = 57.3

5 RS422 MLP Data Rate 3.0 Mbit/sec

This tests the RS422 path on the MLP functioning at 3.0Mbits/sec. This test is performed on two DDRS02 systems (DDRS02-MLP and DDRS02-JMDC). DDRS02-MLP is attached to the appropriate connections on the panels in compartment 10A and DDRS02-JMDC is attached to the STS-SIM which is attached to the TSM.

5.1 Connection Detail

See Section 4.1 Connection Detail

5.2 Procedure

5.2.1 Test Uplink

Perform procedure as documented in Appendix A – RS422 Operations Procedures using DDRS02-MLP as the transmitter and DDRS02-JMDC as the receiver. Perform the following substitutions:

[test] = 5U.n (Where n is a sequence number starting at 0 for restarts or reruns)
[txdiv] = 4
[rate] = 91.8

5.2.2 Test Downlink

Perform procedure as documented in Appendix A – RS422 Operations Procedures using DDRS02-JMDC as the transmitter and DDRS02-MLP as the receiver. Perform the following substitutions:

[test] = 5D.n (Where n is a sequence number starting at 0 for restarts or reruns)
[txdiv] = 4
[rate] = 91.8

6 RS422 MLP Data Rate 1.5 Mbit/sec

This tests the RS422 path on the MLP functioning at 1.5Mbits/sec. This test is performed on two DDRS02 systems (DDRS02-MLP and DDRS02-JMDC). DDRS02-MLP is attached to the appropriate connections on the panels in compartment 10A and DDRS02-JMDC is attached to the STS-SIM which is attached to the TSM.

6.1 Connection Detail

See Section 4.1 Connection Detail

6.2 Procedure

6.2.1 Test Uplink

Perform procedure as documented in Appendix A – RS422 Operations Procedures using DDRS02-MLP as the transmitter and DDRS02-JMDC as the receiver. Perform the following substitutions:

[test] = 6U.n (Where n is a sequence number starting at 0 for restarts or reruns)
[txdiv] = 9
[rate] = 45.9

6.2.2 Test Downlink

Perform procedure as documented in Appendix A – RS422 Operations Procedures using DDRS02-JMDC as the transmitter and DDRS02-MLP as the receiver. Perform the following substitutions:

[test] = 6D.n (Where n is a sequence number starting at 0 for restarts or reruns)
[txdiv] = 9
[rate] = 45.9

7 RS422 MLP Data Rate 1.25 Mbit/sec

This test may optionally be omitted if satisfactory results have been obtained at higher data rates.

This tests the RS422 path on the MLP functioning at 1.25Mbits/sec. This test is performed on two DDRS02 systems (DDRS02-MLP and DDRS02-JMDC). DDRS02-MLP is attached to the appropriate connections on the panels in compartment 10A and DDRS02-JMDC is attached to the STS-SIM which is attached to the TSM.

7.1 Connection Detail

See Section 4.1 Connection Detail

7.2 Procedure

7.2.1 Test Uplink

Perform procedure as documented in Appendix A – RS422 Operations Procedures using DDRS02-MLP as the transmitter and DDRS02-JMDC as the receiver. Perform the following substitutions:

[test] = 7U.n (Where n is a sequence number starting at 0 for restarts or reruns)
[txdiv] = 11
[rate] = 38.3

7.2.2 Test Downlink

Perform procedure as documented in Appendix A – RS422 Operations Procedures using DDRS02-JMDC as the transmitter and DDRS02-MLP as the receiver. Perform the following substitutions:

[test] = 7D.n (Where n is a sequence number starting at 0 for restarts or reruns)
[txdiv] = 11
[rate] = 38.3

8 RS422 MLP Data Rate 1.0 Mbit/sec

This test may optionally be omitted if satisfactory results have been obtained at higher data rates.

This tests the RS422 path on the MLP functioning at 1.0Mbits/sec. This test is performed on two DDRS02 systems (DDRS02-MLP and DDRS02-JMDC). DDRS02-MLP is attached to the appropriate connections on the panels in compartment 10A and DDRS02-JMDC is attached to the STS-SIM which is attached to the TSM.

8.1 Connection Detail

See Section 4.1 Connection Detail

8.2 Procedure

8.2.1 Test Uplink

Perform procedure as documented in Appendix A – RS422 Operations Procedures using DDRS02-MLP as the transmitter and DDRS02-JMDC as the receiver. Perform the following substitutions:

[test] = 8U.n (Where n is a sequence number starting at 0 for restarts or reruns)
[txdiv] = 14
[rate] = 30.6

8.2.2 Test Downlink

Perform procedure as documented in Appendix A – RS422 Operations Procedures using DDRS02-JMDC as the transmitter and DDRS02-MLP as the receiver. Perform the following substitutions:

[test] = 8D.n (Where n is a sequence number starting at 0 for restarts or reruns)
[txdiv] = 14
[rate] = 30.6

9 RS422 MLP Data Rate 0.75 Mbit/sec

This test may optionally be omitted if satisfactory results have been obtained at higher data rates.

This tests the RS422 path on the MLP functioning at 0.75Mbits/sec. This test is performed on two DDRS02 systems (DDRS02-MLP and DDRS02-JMDC). DDRS02-MLP is attached to the appropriate connections on the panels in compartment 10A and DDRS02-JMDC is attached to the STS-SIM which is attached to the TSM.

9.1 Connection Detail

See Section 4.1 Connection Detail

9.2 Procedure

9.2.1 Test Uplink

Perform procedure as documented in Appendix A – RS422 Operations Procedures using DDRS02-MLP as the transmitter and DDRS02-JMDC as the receiver. Perform the following substitutions:

[test] = 9U.n (Where n is a sequence number starting at 0 for restarts or reruns)
[txdiv] = 19
[rate] = 23.0

9.2.2 Test Downlink

Perform procedure as documented in Appendix A – RS422 Operations Procedures using DDRS02-JMDC as the transmitter and DDRS02-MLP as the receiver. Perform the following substitutions:

[test] = 9D.n (Where n is a sequence number starting at 0 for restarts or reruns)
[txdiv] = 19
[rate] = 23.0

10 PRCU Pre-Test 1553 Calibration

10.1 Connection Detail

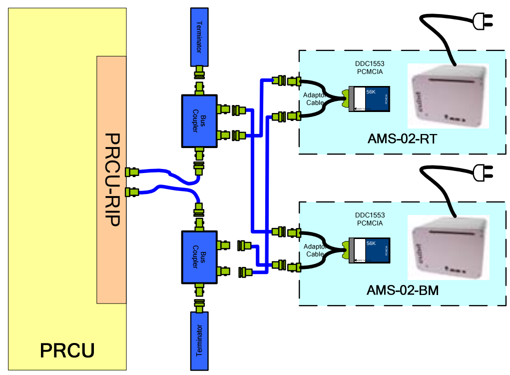


Figure 10-1 PRCU Pre-test 1553 Calibration Connection Details

Note: Connection at RIP or under floor ISPR in control room both acceptable.

10.2 Procedure

Activate PRCU per KSC procedure _________________.

Activate the AMS-02 payload polling on RT _____________

10.2.1 Test Bus A

Perform procedure as documented in Appendix C – 1553 Software Operations following PRCU notations and using the following substitutions:

[bus] = A
[test] = 10A.n (Where n is a sequence number starting at 0 for restarts or reruns)

10.2.2 Test Bus B

Perform procedure as documented in Appendix C – 1553 Software Operations following PRCU notations and using the following substitutions:

[bus] = B
[test] = 10B.n (Where n is a sequence number starting at 0 for restarts or reruns)

10.2.3 Test Termination

Deactivate PRCU per KSC procedure ____________.

Remove customer equipment.

11 Offline 1553 Test Verification

This test validates that the 1553 test setup environment is functioning as expected. This test is performed on AMS02-BC and AMS02-RT systems cabled together with external 1553 couplers and short (less then 10 feet) bus and stub cables.

11.1 Connection Detail

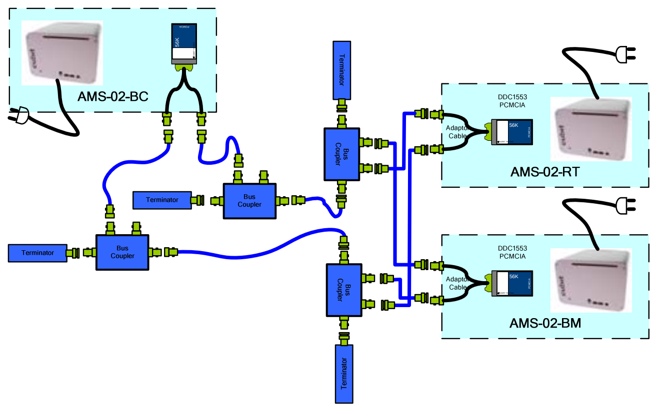


Figure 11-1 Offline1553 Test Connection Detail

11.2 Procedure

11.2.1 Test Bus A

Perform procedure as documented in Appendix C – 1553 Software Operations NOT following PRCU notations and using the following substitutions:

[bus] = A
[test] = 11A.n (Where n is a sequence number starting at 0 for restarts or reruns)

11.2.2 Test Bus B

Perform procedure as documented in Appendix C – 1553 Software Operations NOT following PRCU notations and using the following substitutions:

[bus] = B
[test] = 11B.n (Where n is a sequence number starting at 0 for restarts or reruns)

12 1553 MLP Nominal Operation

This tests the nominal operation of 1553 over the MLP and STS-SIM wiring. AMS02-BC and AMS02-BM are located in MLP compartment 10A and AMS02-RT at the base of the TSM.

12.1 Connection Detail

Utilize the connection detail provide in Appendix E – 1553 Detailed Drawings.

12.2 Procedure

12.2.1 Test Bus A

As required adjust cable connections to Bus A.

Perform procedure as documented in Appendix C – 1553 Software Operations NOT following PRCU notations and using the following substitutions:

[bus] = A
[test] = 12A.n (Where n is a sequence number starting at 0 for restarts or reruns)

12.2.2 Test Bus B

As required adjust cable connections to Bus B.

Perform procedure as documented in Appendix C – 1553 Software Operations NOT following PRCU notations and using the following substitutions:

[bus] = B
[test] = 12B.n (Where n is a sequence number starting at 0 for restarts or reruns)

Appendix A – RS422 Operations Procedures

	√	Task	Notes
1		Verify connections are per this test section's diagram above. Enter [test], [txdiv] date, and time in Notes.	test: ________ txdiv: ________ Date: ________ Time: ________
2		On each DDRS02-MLP and DDR02-JMDC: cd ~/aal/usb422	
3		Activate the DDRS02 transmitter with the following command line: **~ams/aal/usb422/ddrs02-usb –s –a 999 --clock [txdiv] --prefix [test]**	
4		Activate the DDRS02 receiver with the following command line: **~ams/aal/usb422/ddrs02-usb –s –a 999 --clock [txdiv] --prefix [test]**	
5		On both DDRS02-MLP and DDRS02-JMDC verify no data is being transmitted or received.	
6		On the DDRS02 receiver o Press 'R' o Verify Receive continuous: On.	
7		On the DDRS02 transmitter o Press 'G' o Verify Generate continuous: On o Note time.	time: ________
8		Verify the DDRS02 transmitter is transmitting frames at around [rate] per second.	
9		Note number of initial errors for each of DDRS02 transmitter and receiver.	Tx: ________ Rx: ________
10		Allow data to flow for not less then 30 minutes.	

	√	Task	Notes
11		On DDRS02 transmitter o Press 'G' o Verify Generate continuous: Off o Note time.	time: ________
12		Note number of errors for each DDRS02 transmitter and receiver. There should be no additional errors on either unit.	Tx: ________ Rx: ________
13		On both DDRS02 transmitter record total frames transmitted and on receiver total frames received.	Tx: ________ Rx: ________
14		Calculate and record the Rx bit error rate (BER) approximation as defined above.	BER: ________
15		On DDRS02 transmitter: o Press 'G' o Verify Generate continuous: On	
16		Attached the Oscilloscope to each of the RxD and RxC, lines just at DDRS02 receiver's USB-422 box. Capture and save indicative copies of the signals display at this point. Record signal observations.	
18		On both DDRS02 transmitter and receiver exit DDRS02 using the 'q' keystroke.	

Appendix B – 1553 Operations Procedures

	√	**Task**	**Notes**
1		Verify connections are per this test section's diagram. Enter [test], date, and time in Notes.	Test: ________ Date: ________ Time: ________
2		On each AMS02-RT, and AMS02-BC, and AMS02-BM: Verify Appendix D – System Startup Procedures have been performed and current working directory is POPIT for each main and secondary window.	
3		*PRCU: Omit* On the main window for AMS02-BC activate a bus controller with the following command line: **sudo `~ams/aal/1553/bc iss 8`**	
4		On the main window for AMS02-RT activate a remote terminal with the following command line: **sudo `~ams/aal/1553/rt iss 8`**	
5		On the main window for AMS02-BM activate a bus monitor with the following command line: **sudo ~ams/aal/1553/`bm`**	
5a		*PRCU: Activate AMS02*	
6		On AMS02-BM verify BC is actively polling.	
7		*PRCU: Select bus, verify CHD.* On the main window of AMS02-BC: o Press 'a' or 'b' to select the [bus] under test. o Record bus under test in notes. o Press 'p' and verify CHD is valid (hex values 0x1111 0x2222 0x3333 0x4444 0x5555 starting in 16-bit word 15).	Bus: ________
8		On the secondary window of AMS02-RT initialize the test file with the	

	√	Task	Notes
		following command: **cp big.dat test0701.dat**	
9		*PRCU: Omit* On the secondary window of AMS02-BC remove any existing target file with the following command: **rm test701.txt**	
10		On the main window of AMS02-RT start file transfer as follows: o Press ‘w’ then ‘1’	
11		On the main window of AMS02-BC verify file transfer from RT to BC has started.	
12		On the main window of AMS02-RT verify file transfer has started.	
13		The test file is 2.4MB and takes about 9 minutes to transfer. One or two restarts are acceptable. If more the test must be rerun.	
14		*PRCU: Omit* On the main window of AMS02-BC verify number of blocks transferred is 4882.	
15		On the main window of AMS02-RT verify number of blocks transferred is 4882.	
16		*PRCU: Omit* On the secondary window of AMS02-BC: o Enter: **ls –la** o Verify file test701.txt is 2,499,134 bytes long	
16a		On the main window of AMS02-BM press ‘?’ and record the number of errors.	Errors: _________ Errors: _________ Errors: _________
17		On the secondary window of AMS02-RT: o Enter: **rm test0701.dat** o Enter: **ls –la** o Verify file is deleted	
18		On the main window of AMS02-RT: o Enter: ‘r’ then ‘1’	
19		Verify on each main window that the transfer has started	

	√	Task	Notes
20		On the secondary window of AMS02-RT: o Enter: **ls –la** o Verify file big.dat and test0701.dat are the same size o Enter: **diff big.dat test0701.dat** o Verify no errors reported	
21		Repeat steps 6-20 for a total count of 3 times.	
22		Attach Oscilloscope breakout box to 1553 Bus under test near AMS02-BC. Capture indicative signal. Enter comments on signal quality.	
23		(Optional) Attach Oscilloscope breakout box to 1553 Stub under test near AMS02-BC. Capture indicative signal. Enter comments on signal quality.	
24		Attach Oscilloscope breakout box to 1553 Bus under test near AMS02-RT. Capture indicative signal. Enter comments on signal quality.	
25		(Optional) Attach Oscilloscope to 1553 Stub under test near AMS02-RT. Capture indicative signal. Enter comments on signal quality.	
26		On each main window terminate AMS02-RT, AMS02-BC, and AMS02-BM.	

Appendix C – 1553 Software Operations Notes

BC Operations Notes

Invoked with ./bc OIU|STS|ISS|MDM|PLMDM|TEST|TST addr bus PP

Where first argument defines protocol to use, second RT address, third bus A or B, and fourth is the polling period.

Once running keystrokes can modify operation as follows:

0	opt_0	Print lost interrupts
1		Set RT 10
2		Set RT 28
4		Set RT 4
A		Set bus A
B		Set bus B
C	!opt_C	Send “command”
D	!opt_D	Print int status
L	!opt_L	Print detailed status
N	!opt_N	Short OIU status
P	!opt_P	Print HK frame (single shot)
Q		Quit
W	!wc_inc	File xfer test
I	!opt_I	File xfer debug

RT Operations Notes

Invoked with ./rt OIU|STS|MDM|PLMDM|ISS addr

Where first argument defines the protocol to use and the second the RT address.

Once running keystrokes can modify operation as follows:

L	!opt_L	Print status at each frames sync
M	!opt_M	Print more detail at each frame sync
Q		Exit
S	!opt_S	Create and send fake HK and CHD
T	!opt_T	Print BC time
X	opt_x = 1	Exit on 10^{th} frame sync
Z		Zero the error counts
C		Cancel file transfer
I		Print file transfer info
R		Set file transfer direction BC->RT

W		Set file transfer direction RT-BC
0:5		Start file transfer of file id 700 + id
6:9		Start file transfer of file id 7000 + id

BM Operations Notes

Invoked with ./bm

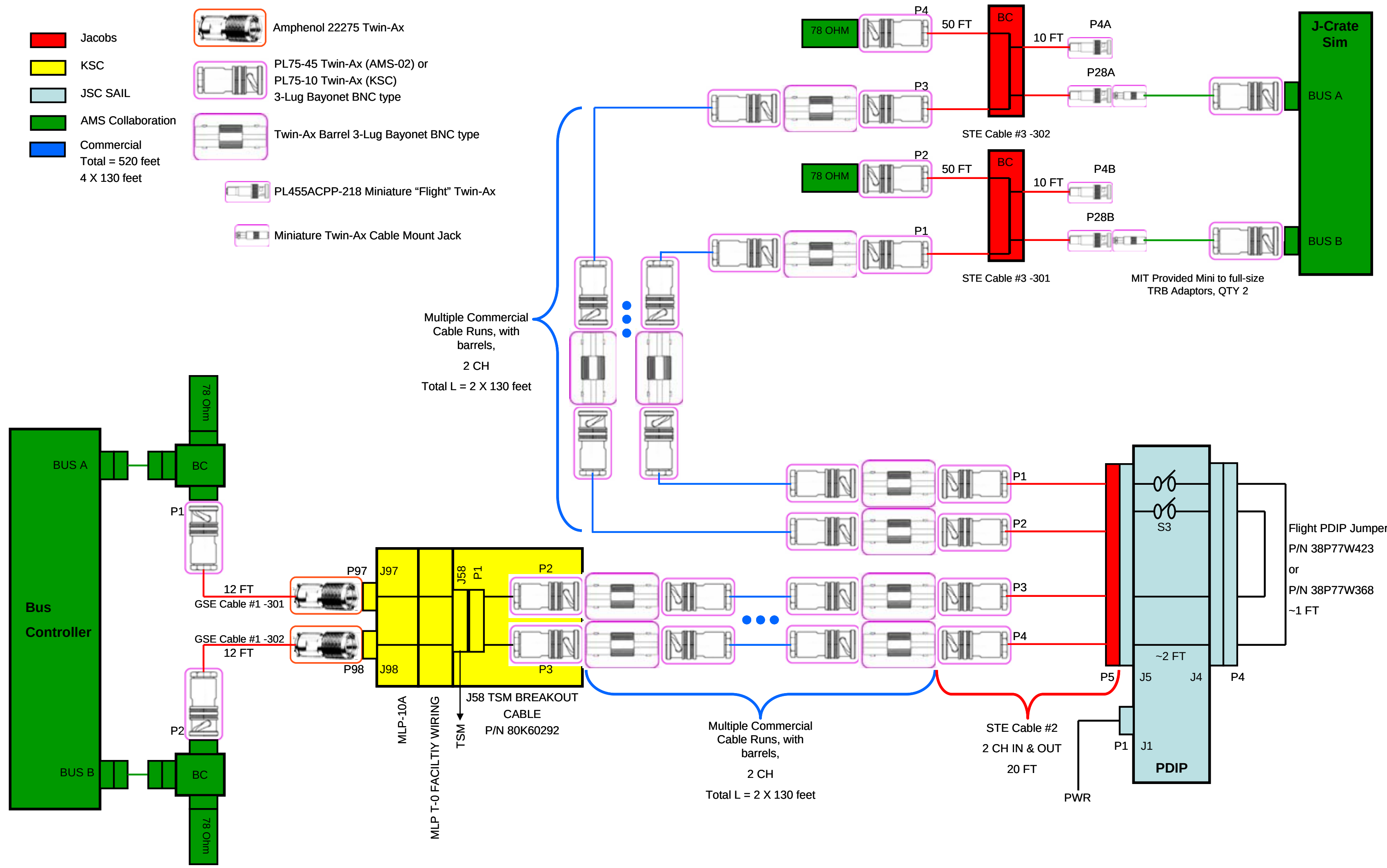
Once running keystrokes can modify operations as follows:

?		Print statistics and status
+ | -		Increase | decrease number lines of data displayed
C	!opt_C	Commands
D	!opt_D	Data
E	!opt_E	Errors
F	!opt_F	Fill frames
M	!opt_M	CHD (Monitor)
P	opt_P = 1	Print next frame
Q		Exit program
Z		Zero error count

Appendix D – System Startup Procedures

	√	Task	Notes
1		Power on system and allow normal boot	
2		Use TELNET or SSH to log in remotely to system as user "ams". This is the main test window.	
3		Force X off the system by entering: **sudo init 3**	
4		cd POPIT	
5		Use TELNET or SSH to open a second logon window as user "ams". This is the secondary test window.	
6		cd POPIT	

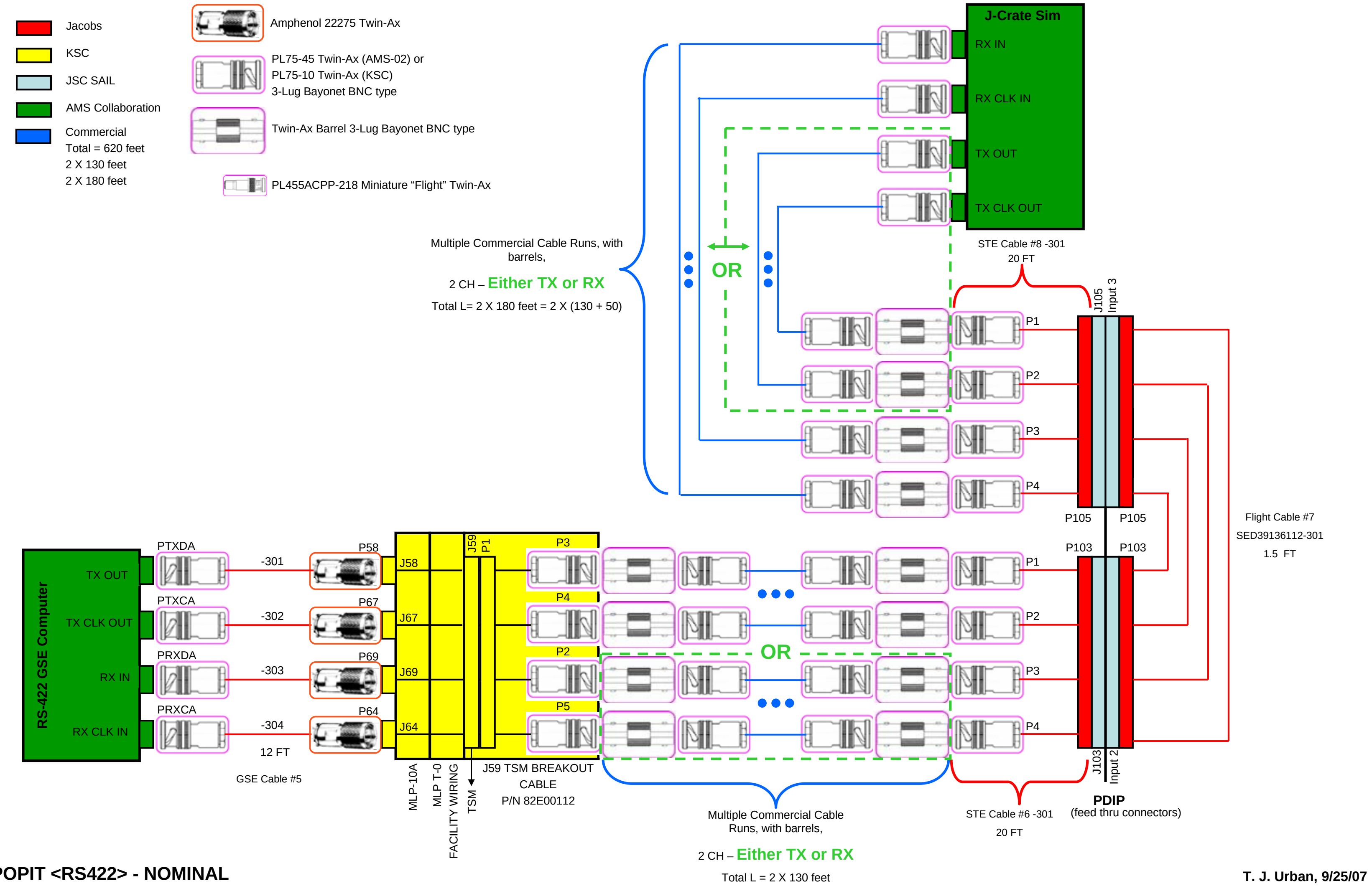
Appendix E – 1553 Detailed Drawings



POPIT <1553, Config 1> - NOMINAL

T. J. Urban, 9/25/07

Appendix F – RS422 Detailed Drawings



Appendix G – Bill Of Material

Part	Part Number	Quantity	Provider	Transport	Notes
Twinax commercial data cables, 60M Length		8	MIT	Shipped	Shipped from CSIST
Twinax Barrels		10	MIT	Hand carry	
Twinax Barrels		10	PADSOFT	Hand carry	
78 ohm twinax terminators		4	MIT	Hand carry	
78 ohm twinax terminators		4	PADSOFT	Hand carry	
Hoojum computer, power brick & US cord		2	MIT	Hand carry	No KVM
Hoojum computer, power brick & US cord		2	PADSOFT	Hand carry	No KVM
Laptop		1	PADSOFT	Hand carry	Control computer - ssh or telnet
Laptop		1	MIT	Hand carry	
1553 twinax stub cables		6	PADSOFT	Hand carry	4-20 ft
100bt 5-port network switch		1	PADSOFT	Hand carry	
CAT5 250' cable		1	KSC	Shipping	APO will bring if KSC does not confirm
CAT5 10' cable		6	MIT	Hand carry	
DDC 1553 PCMCIA with twinax adapter		2	MIT	Hand carry	"new" cards please
DDC 1553 PCMCIA with twinax adapter		2	PADSOFT	Hand carry	

Part	Part Number	Quantity	Provider	Transport	Notes
USB-422 box with USB cable		2	MIT	Hand carry	
USB-422 box with USB cable		2	PADSOFT	Hand carry	
GSE #1 -301	SED38120333-301	1	APO	Shipping	Length 12
GSE #1 -302	SED38120333-301	1	APO	Shipping	Length 12
Class III #2	Class III #2 TPS No.	1	APO	Shipping	Length 20
Class III #3 -301	Class III #3 TPS No. 1	1	APO	Shipping	Length 60
Class III #3 -302	Class III TPS No. 2	1	APO	Shipping	Length 60
GSE #4	SED38120332-301	1	APO	Shipping	Length 1
GSE #5 -301	SED38120333-301	1	APO	Shipping	Length 12
GSE #5 -302	SED38120333-301	1	APO	Shipping	Length 12
GSE #5 -303	SED38120333-301	1	APO	Shipping	Length 12
GSE #5 -304	SED38120333-301	1	APO	Shipping	Length 12
Class III #6	Class III #6 TPS No.	1	APO	Shipping	Length 20
FLT #7	SED39136112-301	1	APO	Shipping	Length 1.5
FLT #7	SED39136112-301	1	APO	Shipping	Length 1.5
Class III #8	Class III #8 TPS No.	1	APO	Shipping	Length 20
Class III #9, QTY 2	Class III #9 TPS No.	1	APO	Shipping	Length 1
Payload Data Interface Panel	N/A	1	APO	Shipping	Class III
PDIP Jumper	38P77W423 or 38P77W368	1	APO	Shipping	Class III
PDIP Power Cable		1	APO	Shipping	Class III
J58 TSM Breakout Cable	80K60292	1	KSC	N/A	
J59 TSM Breakout Cable	82E00112	1	KSC	N/A	

Part	Part Number	Quantity	Provider	Transport	Notes
MLP Room 10A 110 VAC & power strips		1	KSC	N/A	8 outlets
MLP Deck 110 VAC & power strips		1	KSC	N/A	8 outlets
28 VDC power supply for PDIP on MLP deck		1	KSC	N/A	
Oscilloscope w/probes and recording to USB		1	KSC	N/A	
Twinax breakout box for Oscilloscope		2	MIT	Hand carry	
Twinax to mini-twinax j-crate cable		2	APO	Shipping	Adapts twinax to J-Crate mini-trb
Loose twinax cable end connectors		4	MIT	Hand carry	TBD if needed to shorten CSIST TVT cables

APPENDIX F: KSC SUPPLIED GSE

Processing Requirements

Payload: Alpha Magnetic Spectrometer
Flight: ULF6

Facilities

Requirement Number	Requirement	Specifications	Qty	Units	Processing Activity	Launch From	Launch To
AMS-??-????-001	Laboratory, General	AMS integration and checkout.	3000	Sq. feet	OFFLINE	L-120	L-60

Ascent/ Descent	Location	KSC Commit	Commit Source	KSC Commit Info	Use	Facility	Room	Comments
Ascent	KSC	TBD			H/W			SSPF Footprint 7

Requirement Number	Requirement	Specifications	Qty	Units	Processing Activity	Launch From	Launch To
AMS-??-????-002	Office Space	AMS team officespace.	30	Occupants	OFFLINE	L-120	L-0

Ascent/ Descent	Location	KSC Commit	Commit Source	KSC Commit Info	Use	Facility	Room	Comments
Ascent	KSC	TBD			H/W			SSPPF Mezzanine

Requirement Number	Requirement	Specifications	Qty	Units	Processing Activity	Launch From	Launch To
AMS-??-????-003	Laboratory, General	ELC Rotation Stand & CEWS on-line checkout.	3000	Sq. feet	ONLINE	L-60	L-50

Ascent/ Descent	Location	KSC Commit	Commit Source	KSC Commit Info	Use	Facility	Room	Comments
Ascent	KSC	TBD			H/W			N/A

Processing Requirements

Payload: Alpha Magnetic Spectrometer
Flight: ULF6

Facilities

Requirement Number	Requirement	Specifications	Qty	Units	Processing Activity	Launch From	Launch To
AMS-??-????-004	Laboratory, General	Payload monitor & cryoservicing.	3000	Sq. feet	OFFLINE	L-50	L-20

Ascent/ Descent	Location	KSC Commit	Commit Source	KSC Commit Info	Use	Facility	Room	Comments
Ascent	KSC	TBD			H/W			CEWS in footprint 7.

Requirement Number	Requirement	Specifications	Qty	Units	Processing Activity	Launch From	Launch To
AMS-??-????-005	Testing User Room	POCC	15	Occupants	OFFLINE	L-120	L-60

Ascent/ Descent	Location	KSC Commit	Commit Source	KSC Commit Info	Use	Facility	Room	Comments
Ascent	KSC	TBD			H/W			N/A

Requirement Number	Requirement	Specifications	Qty	Units	Processing Activity	Launch From	Launch To
AMS-??-????-006	Testing User Room	POCC	15	Occupants	ONLINE	L-60	L+1

Ascent/ Descent	Location	KSC Commit	Commit Source	KSC Commit Info	Use	Facility	Room	Comments
Ascent	KSC	TBD			H/W			N/A

Processing Requirements

Payload: Alpha Magnetic Spectrometer
Flight: ULF6

Facilities

Requirement Number	Requirement	Specifications	Qty	Units	Processing Activity	Launch From	Launch To
AMS-??-????-007	Power Requirements, Special	Total electrical power of vacuum pump system (consist of two pumps): 73 kW, 400V, 50 Hz, 105 A	2	Each	OFFLINE	L-120	L-60

Ascent/ Descent	Location	KSC Commit	Commit Source	KSC Commit Info	Use	Facility	Room	Comments
Ascent	KSC	TBD			H/W			SSPF

Requirement Number	Requirement	Specifications	Qty	Units	Processing Activity	Launch From	Launch To
AMS-??-????-008	Storage Requirements, Special	Payload shipping fixtures, GSE crates and payload support stand require long term storage (~1000 sq. ft. for 4 months).	1	Each	OFFLINE	L-120	L+10

Ascent/ Descent	Location	KSC Commit	Commit Source	KSC Commit Info	Use	Facility	Room	Comments
Ascent	KSC	TBD			H/W			N/A

Requirement Number	Requirement	Specifications	Qty	Units	Processing Activity	Launch From	Launch To
AMS-??-????-009	Launch Support Room	Launch Control Center console to support Launch Commit Criteria.	2	Occupants	OFFLINE	L-120	L-20

Ascent/ Descent	Location	KSC Commit	Commit Source	KSC Commit Info	Use	Facility	Room	Comments
Ascent	KSC	TBD			H/W			N/A

Processing Requirements

Payload: Alpha Magnetic Spectrometer
Flight: ULF6

Facilities

Requirement Number	Requirement	Specifications	Qty	Units	Processing Activity	Launch From	Launch To
AMS-??-????-010	Power Requirements, Special	Require use of TCMS CD power suppy (on uninterruptible power supply) in MLP Room 10A up to L-9M.	1	Each	ONLINE	L-20	L+1

Ascent/ Descent	Location	KSC Commit	Commit Source	KSC Commit Info	Use	Facility	Room	Comments
Ascent	KSC	TBD			H/W			N/A

Requirement Number	Requirement	Specifications	Qty	Units	Processing Activity	Launch From	Launch To
AMS-??-????-011	Launch Support Room	Launch Control Center console to support Launch Commit Criteria.	1	Occupants	ONLINE	L-20	L+1

Ascent/ Descent	Location	KSC Commit	Commit Source	KSC Commit Info	Use	Facility	Room	Comments
Ascent	KSC	TBD			H/W			N/A

Requirement Number	Requirement	Specifications	Qty	Units	Processing Activity	Launch From	Launch To
AMS-??-????-012	Power Requirements, Special	Total electrical power of vacuum pump system (consist of two pumps): 73 kW, 400V, 50 Hz, 105 A	2	Each	ONLINE	L-20	L-3

Ascent/ Descent	Location	KSC Commit	Commit Source	KSC Commit Info	Use	Facility	Room	Comments
Ascent	KSC	TBD			H/W			PCR

Processing Requirements

Payload: Alpha Magnetic Spectrometer
Flight: ULF6

Facilities

Requirement Number	Requirement	Specifications	Qty	Units	Processing Activity	Launch From	Launch To
AMS-??-????-013	Power Requirements, Special	Total electrical power of vacuum pump system (consist of two pumps): 73 kW, 400V, 50 Hz, 105 A	2	Each	ONLINE	L-60	L-20

Ascent/ Descent	Location	KSC Commit	Commit Source	KSC Commit Info	Use	Facility	Room	Comments
Ascent	KSC	TBD			H/W		SSPF	

Processing Requirements

Payload: Alpha Magnetic Spectrometer
Flight: ULF6

Equipment

Requirement Number	Requirement	Specifications	Qty	Units	Processing Activity	Launch From	Launch To
AMS-??-????-001	General tools	AMS will checkout and return general tools from KSC cribs (wrenches, sockets, screwdrivers, pliers, torque wrenches, drills, etc) - both metric and SAE.	1	Each	OFFLINE	L-120	L-1

Ascent/ Descent	Location	KSC Commit	Commit Source	KSC Commit Info	Use	Facility	Room	Comments
Ascent	KSC	TBD			H/W			SSPF & PCR

Requirement Number	Requirement	Specifications	Qty	Units	Processing Activity	Launch From	Launch To
AMS-??-????-002	Oxygen sensors	Helium compatible	4	Each	OFFLINE	L-120	L-0

Ascent/ Descent	Location	KSC Commit	Commit Source	KSC Commit Info	Use	Facility	Room	Comments
Ascent	KSC	TBD			H/W			SSPF & PCR

Requirement Number	Requirement	Specifications	Qty	Units	Processing Activity	Launch From	Launch To
AMS-??-????-003	Electrical test equipment	AMS will checkout and return electrical test equipment from KSC cribs (DVMs, Oscilloscope [Dual channel 100mhz with probes and recording (prefer USB)], etc).	1	Each	OFFLINE	L-120	L-0

Ascent/ Descent	Location	KSC Commit	Commit Source	KSC Commit Info	Use	Facility	Room	Comments
Ascent	KSC	TBD			H/W			SSPF & PCR.

Processing Requirements

Payload: Alpha Magnetic Spectrometer
Flight: ULF6

Equipment

Requirement Number	Requirement	Specifications	Qty	Units	Processing Activity	Launch From	Launch To
AMS-??-????-004	ODA Simulator Cable	ODA Simulator Cable (ODA G073-520114 vs. GW73-520008) nominal checkout	1	Each	OFFLINE	L-120	L-100

Ascent/ Descent	Location	KSC Commit	Commit Source	KSC Commit Info	Use	Facility	Room	Comments
Ascent	KSC	TBD			H/W			SSPF

Requirement Number	Requirement	Specifications	Qty	Units	Processing Activity	Launch From	Launch To
AMS-??-????-005	ODA Simulator Cable	ODA Simulator Cable (ODA G073-520114 vs. GW73-520008) contingency STS interface	1	Each	ONLINE	L-20	L-3

Ascent/ Descent	Location	KSC Commit	Commit Source	KSC Commit Info	Use	Facility	Room	Comments
Ascent	KSC	TBD			H/W			PCR

Requirement Number	Requirement	Specifications	Qty	Units	Processing Activity	Launch From	Launch To
AMS-??-????-006	ELC rotation stand	Payload PVGF installation	1	Each	OFFLINE	L-60	L-58

Ascent/ Descent	Location	KSC Commit	Commit Source	KSC Commit Info	Use	Facility	Room	Comments
Ascent	KSC	TBD			H/W			SSPF Footprint TBD

Processing Requirements

Payload: Alpha Magnetic Spectrometer
Flight: ULF6

Equipment

Requirement Number	Requirement	Specifications	Qty	Units	Processing Activity	Launch From	Launch To
AMS-??-????-007	ELC rotation stand	ISS IVT: PAS & UMA mechanical fit check and UMA electrical checkout, EBCS Camera Alignment	1	Each	ONLINE	L-58	L-50

Ascent/ Descent	Location	KSC Commit	Commit Source	KSC Commit Info	Use	Facility	Room	Comments
Ascent	KSC	TBD			H/W			SSPF Footprint TBD

Requirement Number	Requirement	Specifications	Qty	Units	Processing Activity	Launch From	Launch To
AMS-??-????-008	ACASS	ISS IVT: PAS & UMA mechanical fit check and UMA electrical checkout	1	Each	ONLINE	L-58	L-50

Ascent/ Descent	Location	KSC Commit	Commit Source	KSC Commit Info	Use	Facility	Room	Comments
Ascent	KSC	TBD			H/W			SSPF Footprint TBD

Requirement Number	Requirement	Specifications	Qty	Units	Processing Activity	Launch From	Launch To
AMS-??-????-009	UMA "medusa" adaptor cable	Early ISS Interface testing	1	Each	OFFLINE	L-120	L-90

Ascent/ Descent	Location	KSC Commit	Commit Source	KSC Commit Info	Use	Facility	Room	Comments
Ascent	KSC	TBD			H/W			SSPF Footprint 7

Processing Requirements

Payload: Alpha Magnetic Spectrometer
Flight: ULF6

Equipment

Requirement Number	Requirement	Specifications	Qty	Units	Processing Activity	Launch From	Launch To
AMS-??-????-010	PRCU	Early ISS Interface testing: 1. Health and status data 2. Critical health data (CHD) 3. PLMDM file transfer	1	Each	OFFLINE	L-120	L-90

Ascent/ Descent	Location	KSC Commit	Commit Source	KSC Commit Info	Use	Facility	Room	Comments
Ascent	KSC	TBD			H/W			SSPF

Requirement Number	Requirement	Specifications	Qty	Units	Processing Activity	Launch From	Launch To
AMS-??-????-011	PRCU	UMA electrical functional test: 1553 LRDL and Fiberoptic HRDL, bi-directional: 1. Health and status data 2. Critical health data (CHD) 3. PLMDM file transfer	1	Each	ONLINE	L-58	L-50

Ascent/ Descent	Location	KSC Commit	Commit Source	KSC Commit Info	Use	Facility	Room	Comments
Ascent	KSC	TBD			H/W			SSPF

Requirement Number	Requirement	Specifications	Qty	Units	Processing Activity	Launch From	Launch To
AMS-??-????-012	CEWS	Hold the payload during final payload component integration, monitor and cryo-servicing	1	Each	OFFLINE	L-50	L-20

Ascent/ Descent	Location	KSC Commit	Commit Source	KSC Commit Info	Use	Facility	Room	Comments
Ascent	KSC	TBD			H/W			SSPF Footprint 7

Processing Requirements

Payload: Alpha Magnetic Spectrometer
Flight: ULF6

Equipment

Requirement Number	Requirement	Specifications	Qty	Units	Processing Activity	Launch From	Launch To
AMS-??-????-013	CEWS	Hold the payload during on-line PRCU ISS IVT	1	Each	ONLINE	L-45	L-40

Ascent/ Descent	Location	KSC Commit	Commit Source	KSC Commit Info	Use	Facility	Room	Comments
Ascent	KSC	TBD			H/W			SSPF Footprint 7

Requirement Number	Requirement	Specifications	Qty	Units	Processing Activity	Launch From	Launch To
AMS-??-????-014	PRCU	ISS IVT: 1553 LRDL and Fiberoptic HRDL, bi-directional: 1. Health and status data 2. Critical health data (CHD) 3. PLMDM file transfer	1	Each	ONLINE	L-45	L-40

Ascent/ Descent	Location	KSC Commit	Commit Source	KSC Commit Info	Use	Facility	Room	Comments
Ascent	KSC	TBD			H/W			SSPF

Processing Requirements

Payload: Alpha Magnetic Spectrometer
Flight: ULF6

Equipment

Requirement Number	Requirement	Specifications	Qty	Units	Processing Activity	Launch From	Launch To
AMS-??-????-015	UMA "medusa" adaptor cable	ISS IVT: 1553 LRDL and Fiberoptic HRDL, bi-directional: 1. Health and status data 2. Critical health data (CHD) 3. PLMDM file transfer	1	Each	ONLINE	L-45	L-40

Ascent/ Descent	Location	KSC Commit	Commit Source	KSC Commit Info	Use	Facility	Room	Comments
Ascent	KSC	TBD			H/W			SSPF footprint 7

Requirement Number	Requirement	Specifications	Qty	Units	Processing Activity	Launch From	Launch To
AMS-??-????-016	Payload Canister	Payload transportation to the pad, including power system and additional cooling: ¿ 120 VAC canister power has 2-20 amp circuit breakers (3&4) available ¿ I&CS will provide voltage only monitoring of the canister 120 VAC at all times. It is currently set to trigger an alarm at 118 VAC or less. The voltage limit can be adjusted. ¿ Provide fan cooling directly to the zenith radiator (canister can provide 71+/-6 F, <60% humidity) ¿ Option 1 - Fan provided on the AFT bulkhead ¿ Option 2 - Deflectors on the duct heads ¿ Need requirements for minimum flow ¿ Transporter has 2- 20 amp circuit breakers	1	Each	ONLINE	L-24	L-20

Ascent/ Descent	Location	KSC Commit	Commit Source	KSC Commit Info	Use	Facility	Room	Comments
Ascent	KSC	TBD			H/W			N/A

Processing Requirements

Payload: Alpha Magnetic Spectrometer
Flight: ULF6

Equipment

Requirement Number	Requirement	Specifications	Qty	Units	Processing Activity	Launch From	Launch To
AMS-??-????-017	Payload Change-out Room AMS CGSE arm	Provide support in mounting a payload provided pneumatically operated articulating arm which will be used in payload cryo-servicing.	1	Each	ONLINE	L-20	L-3

Ascent/ Descent	Location	KSC Commit	Commit Source	KSC Commit Info	Use	Facility	Room	Comments
Ascent	KSC	TBD			H/W			N/A

Requirement Number	Requirement	Specifications	Qty	Units	Processing Activity	Launch From	Launch To
AMS-??-????-018	Exhaust Lines	Provide exhaust line for each AMS CGSE pump, connected with AMS provided flex line: Exhaust flange: DN100 mm ISO-K	2	Each	OFFLINE	L-120	L-60

Ascent/ Descent	Location	KSC Commit	Commit Source	KSC Commit Info	Use	Facility	Room	Comments
Ascent	KSC	TBD			H/W			SSPF

Requirement Number	Requirement	Specifications	Qty	Units	Processing Activity	Launch From	Launch To
AMS-??-????-019	Exhaust Lines	Provide exhaust line for each AMS CGSE pump, connected with AMS provided flex line: Exhaust flange: DN100 mm ISO-K	2	Each	ONLINE	L-60	L-20

Ascent/ Descent	Location	KSC Commit	Commit Source	KSC Commit Info	Use	Facility	Room	Comments
Ascent	KSC	TBD			H/W			SSPF

Processing Requirements

Payload: Alpha Magnetic Spectrometer
Flight: ULF6

Equipment

Requirement Number	Requirement	Specifications	Qty	Units	Processing Activity	Launch From	Launch To
AMS-??-????-020	Exhaust Lines	Provide exhaust line for each AMS CGSE pump, connected with AMS provided flex line: Exhaust flange: DN100 mm ISO-K	2	Each	ONLINE	L-20	L-3

Ascent/ Descent	Location	KSC Commit	Commit Source	KSC Commit Info	Use	Facility	Room	Comments
Ascent	KSC	TBD			H/W			PCR

Requirement Number	Requirement	Specifications	Qty	Units	Processing Activity	Launch From	Launch To
AMS-??-????-021	Power Quality Test Equipment	Tektronix TDS 784A or 784C or 754C Oscilloscope	1	Each	OFFLINE	L-80	L-75

Ascent/ Descent	Location	KSC Commit	Commit Source	KSC Commit Info	Use	Facility	Room	Comments
Ascent	KSC	TBD			H/W			PQT in CEWS in SSPF footprint 7

Requirement Number	Requirement	Specifications	Qty	Units	Processing Activity	Launch From	Launch To
AMS-??-????-022	Power Quality Test Equipment	Tektronix 6302 or 6303 Current Probe	1	Each	OFFLINE	L-80	L-75

Ascent/ Descent	Location	KSC Commit	Commit Source	KSC Commit Info	Use	Facility	Room	Comments
Ascent	KSC	TBD			H/W			PQT in CEWS in SSPF footprint 7

Processing Requirements

Payload: Alpha Magnetic Spectrometer
Flight: ULF6

Equipment

Requirement Number	Requirement	Specifications	Qty	Units	Processing Activity	Launch From	Launch To
AMS-??-????-023	Power Quality Test Equipment	Tektronix AM503 Current Amplifier	2	Each	OFFLINE	L-80	L-75

Ascent/ Descent	Location	KSC Commit	Commit Source	KSC Commit Info	Use	Facility	Room	Comments
Ascent	KSC	TBD			H/W			PQT in CEWS in SSPF footprint 7

Requirement Number	Requirement	Specifications	Qty	Units	Processing Activity	Launch From	Launch To
AMS-??-????-024	Power Quality Test Equipment	Venable Frequency Analyzer 5060A	1	Each	OFFLINE	L-80	L-75

Ascent/ Descent	Location	KSC Commit	Commit Source	KSC Commit Info	Use	Facility	Room	Comments
Ascent	KSC	TBD			H/W			PQT in CEWS in SSPF footprint 7

Requirement Number	Requirement	Specifications	Qty	Units	Processing Activity	Launch From	Launch To
AMS-??-????-025	Power Quality Test Equipment	Resistance Decade Box	1	Each	OFFLINE	L-80	L-75

Ascent/ Descent	Location	KSC Commit	Commit Source	KSC Commit Info	Use	Facility	Room	Comments
Ascent	KSC	TBD			H/W			PQT in CEWS in SSPF footprint 7

Processing Requirements

Payload: Alpha Magnetic Spectrometer
Flight: ULF6

Equipment

Requirement Number	Requirement	Specifications	Qty	Units	Processing Activity	Launch From	Launch To
AMS-??-????-026	Power Quality Test Equipment	HP33120A Waveform Generator	1	Each	OFFLINE	L-80	L-75

Ascent/ Descent	Location	KSC Commit	Commit Source	KSC Commit Info	Use	Facility	Room	Comments
Ascent	KSC	TBD			H/W			PQT in CEWS in SSPF footprint 7

Requirement Number	Requirement	Specifications	Qty	Units	Processing Activity	Launch From	Launch To
AMS-??-????-027	Power Quality Test Equipment	Tri-electron Power Suuply & DDCU/RPCM Simulator	1	Each	OFFLINE	L-80	L-75

Ascent/ Descent	Location	KSC Commit	Commit Source	KSC Commit Info	Use	Facility	Room	Comments
Ascent	KSC	TBD			H/W			PQT in CEWS in SSPF footprint 7

Requirement Number	Requirement	Specifications	Qty	Units	Processing Activity	Launch From	Launch To
AMS-??-????-028	Voice Loop headsets	Payload dedicated voice loop	24	Each	OFFLINE	L-120	L-60

Ascent/ Descent	Location	KSC Commit	Commit Source	KSC Commit Info	Use	Facility	Room	Comments
Ascent	KSC	TBD			H/W			N/A

Processing Requirements

Payload: Alpha Magnetic Spectrometer
Flight: ULF6

Equipment

Requirement Number	Requirement	Specifications	Qty	Units	Processing Activity	Launch From	Launch To
AMS-??-????-029	Voice Loop headsets	Payload dedicated voice loop	24	Each	ONLINE	L-60	L+3

Ascent/ Descent	Location	KSC Commit	Commit Source	KSC Commit Info	Use	Facility	Room	Comments
Ascent	KSC	TBD			H/W			N/A

Requirement Number	Requirement	Specifications	Qty	Units	Processing Activity	Launch From	Launch To
AMS-??-????-030	Fans	Size and air flow rate TBD	6	Each	ONLINE	L-20	L-3

Ascent/ Descent	Location	KSC Commit	Commit Source	KSC Commit Info	Use	Facility	Room	Comments
Ascent	KSC	TBD			H/W			PCR - Payload installed in STS payload bay

Requirement Number	Requirement	Specifications	Qty	Units	Processing Activity	Launch From	Launch To
AMS-??-????-031	MICRO-OHM METER	Measure < 0.2mohm for bond verifications of sill trunnion joint bond wipers.	1	Each	ONLINE	L-20	L-3

Ascent/ Descent	Location	KSC Commit	Commit Source	KSC Commit Info	Use	Facility	Room	Comments
Ascent	KSC	TBD			H/W			PCR

Processing Requirements

Payload: Alpha Magnetic Spectrometer
Flight: ULF6

Equipment

Requirement Number	Requirement	Specifications	Qty	Units	Processing Activity	Launch From	Launch To
AMS-??-????-032	Portable AC Units	Cooling capacity of 2200 W / 8000 BTU	3	Each	OFFLINE	L-88	L-22

Ascent/ Descent	Location	KSC Commit	Commit Source	KSC Commit Info	Use	Facility	Room	Comments
Ascent	KSC	TBD			H/W			SSPF

Processing Requirements

Payload: Alpha Magnetic Spectrometer
Flight: ULF6

Commodities

Requirement Number	Requirement	Specifications	Qty	Units	Processing Activity	Launch From	Launch To
AMS-??-????-001	Helium gas	Payload requires 99.9999% pure gaseous Helium for processing. Quantity TBC.	25	K-bottle	OFFLINE	L-120	L-60

Ascent/ Descent	Location	KSC Commit	Commit Source	KSC Commit Info	Use	Facility	Room	Comments
Ascent	KSC	TBD			H/W			SSPF

Requirement Number	Requirement	Specifications	Qty	Units	Processing Activity	Launch From	Launch To
AMS-??-????-002	Liquid Helium	1000 liter fill dewar - to be refilled multiple times.	1	Dewar	OFFLINE	L-120	L-60

Ascent/ Descent	Location	KSC Commit	Commit Source	KSC Commit Info	Use	Facility	Room	Comments
Ascent	KSC	TBD			H/W			SSPF

Requirement Number	Requirement	Specifications	Qty	Units	Processing Activity	Launch From	Launch To
AMS-??-????-003	Cleaning supplies - IPA	Isopropyl Alcohol	10	Gallon	OFFLINE	L-120	L-3

Ascent/ Descent	Location	KSC Commit	Commit Source	KSC Commit Info	Use	Facility	Room	Comments
Ascent	KSC	TBD			H/W			SSPF & PCR

Processing Requirements

Payload: Alpha Magnetic Spectrometer
Flight: ULF6

Commodities

Requirement Number	Requirement	Specifications	Qty	Units	Processing Activity	Launch From	Launch To
AMS-??-????-004	Cleaning supplies - Acetone	Acetone	2	Gallon	OFFLINE	L-120	L-3

Ascent/ Descent	Location	KSC Commit	Commit Source	KSC Commit Info	Use	Facility	Room	Comments
Ascent	KSC	TBD			H/W			SSPF & PCR.

Requirement Number	Requirement	Specifications	Qty	Units	Processing Activity	Launch From	Launch To
AMS-??-????-005	Cleaning supplies - Tech wipes.	Lint-free wipes.	3	Case	OFFLINE	L-120	L-3

Ascent/ Descent	Location	KSC Commit	Commit Source	KSC Commit Info	Use	Facility	Room	Comments
Ascent	KSC	TBD			H/W			SSPF & PCR.

Requirement Number	Requirement	Specifications	Qty	Units	Processing Activity	Launch From	Launch To
AMS-??-????-006	Gloves - Nitrile	Small, Medium, Large and Extra Large - 1 case each	4	Case	OFFLINE	L-120	L-1

Ascent/ Descent	Location	KSC Commit	Commit Source	KSC Commit Info	Use	Facility	Room	Comments
Ascent	KSC	TBD			H/W			SSPF & PCR.

Processing Requirements

Payload: Alpha Magnetic Spectrometer
Flight: ULF6

Commodities

Requirement Number	Requirement	Specifications	Qty	Units	Processing Activity	Launch From	Launch To
AMS-??-????-007	Cleanroom garments & footwear	Small, Medium, Large and Extra Large - 1 case each	4	Case	OFFLINE	L-120	L-1

Ascent/ Descent	Location	KSC Commit	Commit Source	KSC Commit Info	Use	Facility	Room	Comments
Ascent	KSC	TBD			H/W			SSPF & PCR

Requirement Number	Requirement	Specifications	Qty	Units	Processing Activity	Launch From	Launch To
AMS-??-????-008	Tape - kapton	1" and 2" - 12 rolls each	24	Each	OFFLINE	L-120	L-1

Ascent/ Descent	Location	KSC Commit	Commit Source	KSC Commit Info	Use	Facility	Room	Comments
Ascent	KSC	TBD			H/W			SSPF & PCR

Requirement Number	Requirement	Specifications	Qty	Units	Processing Activity	Launch From	Launch To
AMS-??-????-009	Tape - glass cloth	1" and 2" - 12 rolls each	24	Each	OFFLINE	L-120	L-3

Ascent/ Descent	Location	KSC Commit	Commit Source	KSC Commit Info	Use	Facility	Room	Comments
Ascent	KSC	TBD			H/W			SSPF & PCR

Processing Requirements

Payload: Alpha Magnetic Spectrometer
Flight: ULF6

Commodities

Requirement Number	Requirement	Specifications	Qty	Units	Processing Activity	Launch From	Launch To
AMS-??-????-010	dry gaseous nitrogen	Supply dry gaseous nitrogen at the SSPF and Pad. This will be for purging temporary jackets to avoid ice buildup around the exhausts for the Cool Down Circuit, Current Leads, and Vapour Cooled Shields. The supply pressure only needs to be a few PSIG and the flow will be on the order of 6 SCFM for all three jackets combined. The jackets will be open so no relief devices are needed. Payload interface will most likely be flexible plastic tubing. Tapping into the existing gas manifold supply rack in footprint 7 of the SSPF. Purity TBD.	3	Bottle	OFFLINE	L-120	L-3

Ascent/ Descent	Location	KSC Commit	Commit Source	KSC Commit Info	Use	Facility	Room	Comments
Ascent	KSC	TBD			H/W			SSPF & PCR

Requirement Number	Requirement	Specifications	Qty	Units	Processing Activity	Launch From	Launch To
AMS-??-????-011	Chilled water	Provide chilled water cooling loops for CGSE pumps in the SSPF. Flow & Temp TBD.	2	Each	OFFLINE	L-120	L-60

Ascent/ Descent	Location	KSC Commit	Commit Source	KSC Commit Info	Use	Facility	Room	Comments
Ascent	KSC	TBD			H/W			SSPF

Processing Requirements

Payload: Alpha Magnetic Spectrometer
Flight: ULF6

Commodities

Requirement Number	Requirement	Specifications	Qty	Units	Processing Activity	Launch From	Launch To
AMS-??-????-012	Chilled water	in the PCR. 15-25 degree C, 700L/h Water connections are 1" (TBC) flex hose with hose clamps.	2	Each	ONLINE	L-60	L-20

Ascent/ Descent	Location	KSC Commit	Commit Source	KSC Commit Info	Use	Facility	Room	Comments
Ascent	KSC	TBD			H/W	SSPF		

Requirement Number	Requirement	Specifications	Qty	Units	Processing Activity	Launch From	Launch To
AMS-??-????-013	Chilled water	Provide chilled water cooling loops for CGSE pumps in the PCR. 15-25 degree C, 700L/h Water connections are 1" (TBC) flex hose with hose clamps.	2	Each	ONLINE	L-20	L-3

Ascent/ Descent	Location	KSC Commit	Commit Source	KSC Commit Info	Use	Facility	Room	Comments
Ascent	KSC	TBD			H/W	PCR		

Requirement Number	Requirement	Specifications	Qty	Units	Processing Activity	Launch From	Launch To
AMS-??-????-014	Shop air	Provide oil-free shop air, TBD # circuits / outlets, max press. 120PSIG - regulated.	1	Each	OFFLINE	L-120	L-60

Ascent/ Descent	Location	KSC Commit	Commit Source	KSC Commit Info	Use	Facility	Room	Comments
Ascent	KSC	TBD			H/W	SSPF		

Processing Requirements

Payload: Alpha Magnetic Spectrometer
Flight: ULF6

Commodities

Requirement Number	Requirement	Specifications	Qty	Units	Processing Activity	Launch From	Launch To
AMS-??-????-015	Shop air	Provide oil-free shop air, TBD # circuits / outlets, max press. 120PSIG - regulated.	1	Each	ONLINE	L-60	L-20

Ascent/ Descent	Location	KSC Commit	Commit Source	KSC Commit Info	Use	Facility	Room	Comments
Ascent	KSC	TBD			H/W		SSPF	

Requirement Number	Requirement	Specifications	Qty	Units	Processing Activity	Launch From	Launch To
AMS-??-????-016	Shop air	Provide oil-free shop air, TBD # circuits / outlets, max press. 120PSIG - regulated.	1	Each	ONLINE	L-20	L-0

Ascent/ Descent	Location	KSC Commit	Commit Source	KSC Commit Info	Use	Facility	Room	Comments
Ascent	KSC	TBD			H/W		PCR	

Requirement Number	Requirement	Specifications	Qty	Units	Processing Activity	Launch From	Launch To
AMS-??-????-017	Shop air back-up	Provide oil-free compressed air (k-bottle) back-up to shop air, TBD # circuits / outlets, max press. 120PSIG - regulated.	4	K-bottle	OFFLINE	L-120	L-60

Ascent/ Descent	Location	KSC Commit	Commit Source	KSC Commit Info	Use	Facility	Room	Comments
Ascent	KSC	TBD			H/W		SSPF	

Processing Requirements

Payload: Alpha Magnetic Spectrometer
Flight: ULF6

Commodities

Requirement Number	Requirement	Specifications	Qty	Units	Processing Activity	Launch From	Launch To
AMS-??-????-018	Helium gas	Payload requires 99.9999% pure gaseous Helium for processing. Quantity TBC.	25	K-bottle	ONLINE	L-60	L-20

Ascent/ Descent	Location	KSC Commit	Commit Source	KSC Commit Info	Use	Facility	Room	Comments
Ascent	KSC	TBD			H/W			SSPF

Requirement Number	Requirement	Specifications	Qty	Units	Processing Activity	Launch From	Launch To
AMS-??-????-019	Helium gas	Payload requires 99.9999% pure gaseous Helium for processing. Quantity TBC.	12	K-bottle	ONLINE	L-20	L-0

Ascent/ Descent	Location	KSC Commit	Commit Source	KSC Commit Info	Use	Facility	Room	Comments
Ascent	KSC	TBD			H/W			PCR

Requirement Number	Requirement	Specifications	Qty	Units	Processing Activity	Launch From	Launch To
AMS-??-????-020	Liquid Helium	1000 liter fill dewar - to be refilled multiple times.	1	Dewar	ONLINE	L-60	L-3

Ascent/ Descent	Location	KSC Commit	Commit Source	KSC Commit Info	Use	Facility	Room	Comments
Ascent	KSC	TBD			H/W			SSPF & PCR

Processing Requirements

Payload: Alpha Magnetic Spectrometer
Flight: ULF6

Commodities

Requirement Number	Requirement	Specifications	Qty	Units	Processing Activity	Launch From	Launch To
AMS-??-????-021	Shop air back-up	Provide oil-free compressed air (k-bottle) back-up to shop air, TBD # circuits / outlets, max press. 120PSIG - regulated.	4	K-bottle	ONLINE	L-60	L-0

Ascent/ Descent	Location	KSC Commit	Commit Source	KSC Commit Info	Use	Facility	Room	Comments
Ascent	KSC	TBD			H/W			SSPF & PCR

Processing Requirements

Payload: Alpha Magnetic Spectrometer
Flight: ULF6

Services

Requirement Number	Requirement	Specifications	Qty	Units	Processing Activity	Launch From	Launch To
AMS-??-????-001	Transportation, Special	critical rigger and lift support for payload and its support stand	1	N/A	OFFLINE	L-120	L-60

Ascent/ Descent	Location	KSC Commit	Commit Source	KSC Commit Info	Use	Facility	Room	Comments
Ascent	KSC	TBD			H/W			SSPF

Requirement Number	Requirement	Specifications	Qty	Units	Processing Activity	Launch From	Launch To
AMS-??-????-002	Transportation, Special	critical rigger and lift support for payload and its support stand	1	N/A	ONLINE	L-60	L-50

Ascent/ Descent	Location	KSC Commit	Commit Source	KSC Commit Info	Use	Facility	Room	Comments
Ascent	KSC	TBD			H/W			SSPF

Requirement Number	Requirement	Specifications	Qty	Units	Processing Activity	Launch From	Launch To
AMS-??-????-003	Transportation, Special	critical rigger and lift support for payload and its support stand	1	N/A	OFFLINE	L-50	L-24

Ascent/ Descent	Location	KSC Commit	Commit Source	KSC Commit Info	Use	Facility	Room	Comments
Ascent	KSC	TBD			H/W			SSPF

Processing Requirements

Payload: Alpha Magnetic Spectrometer
Flight: ULF6

Services

Requirement Number	Requirement	Specifications	Qty	Units	Processing Activity	Launch From	Launch To
AMS-??-????-004	Transportation, Special	critical rigger and lift support for payload	1	N/A	ONLINE	L-20	L-15

Ascent/ Descent	Location	KSC Commit	Commit Source	KSC Commit Info	Use	Facility	Room	Comments
Ascent	KSC	TBD			H/W			Canister and PCR

Requirement Number	Requirement	Specifications	Qty	Units	Processing Activity	Launch From	Launch To
AMS-??-????-009	Technical Support	Boeing DPA support - payload integration	1	N/A	OFFLINE	L-120	L-60

Ascent/ Descent	Location	KSC Commit	Commit Source	KSC Commit Info	Use	Facility	Room	Comments
Ascent	KSC	TBD			H/W			SSPF

Requirement Number	Requirement	Specifications	Qty	Units	Processing Activity	Launch From	Launch To
AMS-??-????-010	Technical Support	Boeing DPA support - EBCS Alignment	1	N/A	ONLINE	L-60	L-50

Ascent/ Descent	Location	KSC Commit	Commit Source	KSC Commit Info	Use	Facility	Room	Comments
Ascent	KSC	TBD			H/W			SSPF ELC Rotation Stand

Processing Requirements

Payload: Alpha Magnetic Spectrometer
Flight: ULF6

Services

Requirement Number	Requirement	Specifications	Qty	Units	Processing Activity	Launch From	Launch To
AMS-??-????-011	Data Circuit	Guest wireless services to support 5-10 users in SSPF high bay.	1	Circuits	OFFLINE	L-120	L-60

Ascent/ Descent	Location	KSC Commit	Commit Source	KSC Commit Info	Use	Facility	Room	Comments
Ascent	KSC	TBD			H/W			SSPF

Requirement Number	Requirement	Specifications	Qty	Units	Processing Activity	Launch From	Launch To
AMS-??-????-012	Data Circuit	Guest wireless services to support 5-10 users in SSPF high bay.	1	Circuits	ONLINE	L-60	L-20

Ascent/ Descent	Location	KSC Commit	Commit Source	KSC Commit Info	Use	Facility	Room	Comments
Ascent	KSC	TBD			H/W			N/A

Requirement Number	Requirement	Specifications	Qty	Units	Processing Activity	Launch From	Launch To
AMS-??-????-013	Data Circuit	Guest wireless services to support 5-10 in user room (POCC) areas.	1	Circuits	OFFLINE	L-120	L-60

Ascent/ Descent	Location	KSC Commit	Commit Source	KSC Commit Info	Use	Facility	Room	Comments
Ascent	KSC	TBD			H/W			SSPF

Processing Requirements

Payload: Alpha Magnetic Spectrometer
Flight: ULF6

Services

Requirement Number	Requirement	Specifications	Qty	Units	Processing Activity	Launch From	Launch To
AMS-??-????-014	Data Circuit	Guest wireless services to support 5-10 in user room (POCC) areas.	1	Circuits	ONLINE	L-60	L+3

Ascent/ Descent	Location	KSC Commit	Commit Source	KSC Commit Info	Use	Facility	Room	Comments
Ascent	KSC	TBD			H/W			SSPF

Requirement Number	Requirement	Specifications	Qty	Units	Processing Activity	Launch From	Launch To
AMS-??-????-015	Data Circuit	Guest wireless services to support 10-20 users in office areas.	1	Circuits	OFFLINE	L-120	L-60

Ascent/ Descent	Location	KSC Commit	Commit Source	KSC Commit Info	Use	Facility	Room	Comments
Ascent	KSC	TBD			H/W			SSPF

Requirement Number	Requirement	Specifications	Qty	Units	Processing Activity	Launch From	Launch To
AMS-??-????-016	Data Circuit	Guest wireless services to support 10-20 users in office areas.	1	Circuits	ONLINE	L-60	L+3

Ascent/ Descent	Location	KSC Commit	Commit Source	KSC Commit Info	Use	Facility	Room	Comments
Ascent	KSC	TBD			H/W			SSPF

Processing Requirements

Payload: Alpha Magnetic Spectrometer
Flight: ULF6

Services

Requirement Number	Requirement	Specifications	Qty	Units	Processing Activity	Launch From	Launch To
AMS-??-????-017	Data Circuit	Hardwire drops to support guest services for 3 connections in the user room (POCC).	3	Circuits	OFFLINE	L-120	L-60

Ascent/ Descent	Location	KSC Commit	Commit Source	KSC Commit Info	Use	Facility	Room	Comments
Ascent	KSC	TBD			H/W			SSPF

Requirement Number	Requirement	Specifications	Qty	Units	Processing Activity	Launch From	Launch To
AMS-??-????-018	Data Circuit	Hardwire drops to support guest services for 3 connections in the user room (POCC).	3	Circuits	ONLINE	L-60	L+3

Ascent/ Descent	Location	KSC Commit	Commit Source	KSC Commit Info	Use	Facility	Room	Comments
Ascent	KSC	TBD			H/W			N/A

Requirement Number	Requirement	Specifications	Qty	Units	Processing Activity	Launch From	Launch To
AMS-??-????-019	Data Circuit	Hardwire drops to support guest services for 5 connections in the SSPF AMS office area.	5	Circuits	OFFLINE	L-120	L-60

Ascent/ Descent	Location	KSC Commit	Commit Source	KSC Commit Info	Use	Facility	Room	Comments
Ascent	KSC	TBD			H/W			SSPF

Processing Requirements

Payload: Alpha Magnetic Spectrometer
Flight: ULF6

Services

Requirement Number	Requirement	Specifications	Qty	Units	Processing Activity	Launch From	Launch To
AMS-??-????-020	Data Circuit	Hardwire drops to support guest services for 5 connections in the SSPF AMS office area.	5	Circuits	ONLINE	L-60	L+3

Ascent/ Descent	Location	KSC Commit	Commit Source	KSC Commit Info	Use	Facility	Room	Comments
Ascent	KSC	TBD			H/W			SSPF

Requirement Number	Requirement	Specifications	Qty	Units	Processing Activity	Launch From	Launch To
AMS-??-????-021	Data Circuit	External gateway interface (to MSFC, JSC, and CERN) at 10mbytes/sec peak rates TBC	1	Circuits	OFFLINE	L-120	L-60

Ascent/ Descent	Location	KSC Commit	Commit Source	KSC Commit Info	Use	Facility	Room	Comments
Ascent	KSC	TBD			H/W			SSPF

Requirement Number	Requirement	Specifications	Qty	Units	Processing Activity	Launch From	Launch To
AMS-??-????-022	Data Circuit	External gateway interface (to MSFC, JSC, and CERN) at 10mbytes/sec peak rates TBC	1	Circuits	ONLINE	L-60	L+3

Ascent/ Descent	Location	KSC Commit	Commit Source	KSC Commit Info	Use	Facility	Room	Comments
Ascent	KSC	TBD			H/W			SSPF

Processing Requirements

Payload: Alpha Magnetic Spectrometer
Flight: ULF6

Services

Requirement Number	Requirement	Specifications	Qty	Units	Processing Activity	Launch From	Launch To
AMS-??-????-023	Data Circuit	KSC-Cloud-LAN service from MLP 10a at pad to LCC Firing room.	1	Circuits	OFFLINE	L-120	L-60

Ascent/ Descent	Location	KSC Commit	Commit Source	KSC Commit Info	Use	Facility	Room	Comments
Ascent	KSC	TBD			H/W			N/A

Requirement Number	Requirement	Specifications	Qty	Units	Processing Activity	Launch From	Launch To
AMS-??-????-024	Data Circuit	KSC-Cloud-LAN service from MLP 10a at pad to LCC Firing room.	1	Circuits	ONLINE	L-60	L+3

Ascent/ Descent	Location	KSC Commit	Commit Source	KSC Commit Info	Use	Facility	Room	Comments
Ascent	KSC	TBD			H/W			N/A

Requirement Number	Requirement	Specifications	Qty	Units	Processing Activity	Launch From	Launch To
AMS-??-????-025	Data Circuit	Intra-center VPN connections as required to support testing (SSPF High bay to POCC, OPF to POCC, VAB-MLP to POCC, LCC to POCC, PCR to POCC, MLP Rm 10A to POCC) these are 10 mbyes/sec peak TBC. These may have to be split...	1	Circuits	OFFLINE	L-120	L-60

Ascent/ Descent	Location	KSC Commit	Commit Source	KSC Commit Info	Use	Facility	Room	Comments
Ascent	KSC	TBD			H/W			N/A

Processing Requirements

Payload: Alpha Magnetic Spectrometer
Flight: ULF6

Services

Requirement Number	Requirement	Specifications	Qty	Units	Processing Activity	Launch From	Launch To
AMS-??-????-026	Data Circuit	ntra-center VPN connections as required to support testing (SSPF High bay to POCC, OPF to POCC, VAB-MLP to POCC, LCC to POCC, PCR to POCC, MLP Rm 10A to POCC) these are 10 mbyes/sec peak TBC. These may have to be split...	1	Circuits	ONLINE	L-60	L+3

Ascent/ Descent	Location	KSC Commit	Commit Source	KSC Commit Info	Use	Facility	Room	Comments
Ascent	KSC	TBD			H/W			N/A

Requirement Number	Requirement	Specifications	Qty	Units	Processing Activity	Launch From	Launch To
AMS-??-????-027	Data Circuit	Wireless access point (WAP) in SSPF high bay attached to customer LAN. Customer to work with KSC IT to assure no interference with the existing KSC wireless services.	1	Circuits	OFFLINE	L-120	L-60

Ascent/ Descent	Location	KSC Commit	Commit Source	KSC Commit Info	Use	Facility	Room	Comments
Ascent	KSC	TBD			H/W			SSPF

Processing Requirements

Payload: Alpha Magnetic Spectrometer
Flight: ULF6

Services

Requirement Number	Requirement	Specifications	Qty	Units	Processing Activity	Launch From	Launch To
AMS-??-????-028	Data Circuit	Wireless access point (WAP) in SSPF user room POCC attached to customer LAN. Customer to work with KSC IT to assure no interference with the existing KSC wireless services.	1	Circuits	OFFLINE	L-120	L-60

Ascent/ Descent	Location	KSC Commit	Commit Source	KSC Commit Info	Use	Facility	Room	Comments
Ascent	KSC	TBD			H/W			SSPF

Requirement Number	Requirement	Specifications	Qty	Units	Processing Activity	Launch From	Launch To
AMS-??-????-029	Data Circuit	Wireless access point (WAP) in SSPF high bay attached to customer LAN. Customer to work with KSC IT to assure no interference with the existing KSC wireless services.	1	Circuits	ONLINE	L-60	L+3

Ascent/ Descent	Location	KSC Commit	Commit Source	KSC Commit Info	Use	Facility	Room	Comments
Ascent	KSC	TBD			H/W			SSPF

Processing Requirements

Payload: Alpha Magnetic Spectrometer
Flight: ULF6

Services

Requirement Number	Requirement	Specifications	Qty	Units	Processing Activity	Launch From	Launch To
AMS-??-????-030	Data Circuit	Wireless access point (WAP) in SSPF user room POCC attached to customer LAN. Customer to work with KSC IT to assure no interference with the existing KSC wireless services.	1	Circuits	ONLINE	L-60	L+3

Ascent/ Descent	Location	KSC Commit	Commit Source	KSC Commit Info	Use	Facility	Room	Comments
Ascent	KSC	TBD			H/W			SSPF

Requirement Number	Requirement	Specifications	Qty	Units	Processing Activity	Launch From	Launch To
AMS-??-????-031	Hazardous materials - disposal/storage	Used cleaning materials - i.e. wipes soaked in IPA and acetone, in AMS processing area.	2	Containers	OFFLINE	L-120	L-60

Ascent/ Descent	Location	KSC Commit	Commit Source	KSC Commit Info	Use	Facility	Room	Comments
Ascent	KSC	TBD			H/W			SSPF Footprint 7

Requirement Number	Requirement	Specifications	Qty	Units	Processing Activity	Launch From	Launch To
AMS-??-????-032	Hazardous materials - disposal/storage	Used cleaning materials - i.e. wipes soaked in IPA and acetone, in AMS processing area.	2	Containers	ONLINE	L-120	L-20

Ascent/ Descent	Location	KSC Commit	Commit Source	KSC Commit Info	Use	Facility	Room	Comments
Ascent	KSC	TBD			H/W			N/A

Processing Requirements

Payload: Alpha Magnetic Spectrometer
Flight: ULF6

Services

Requirement Number	Requirement	Specifications	Qty	Units	Processing Activity	Launch From	Launch To
AMS-??-????-033	Technical Support	Route payload provided power, data and gaseous systems GSE extension lines through and out the canister to payload provided GSE located on the canister transporter back-porch.	1	N/A	ONLINE	L-28	L-20

Ascent/ Descent	Location	KSC Commit	Commit Source	KSC Commit Info	Use	Facility	Room	Comments
Ascent	KSC	TBD			H/W			N/A

Requirement Number	Requirement	Specifications	Qty	Units	Processing Activity	Launch From	Launch To
AMS-??-????-034	Technical Support	Provide sampling capability to verify 99.9999% research grade helium in KSC provided k-bottles.	1	N/A	OFFLINE	L-120	L-60

Ascent/ Descent	Location	KSC Commit	Commit Source	KSC Commit Info	Use	Facility	Room	Comments
Ascent	KSC	TBD			H/W			SSPF

Requirement Number	Requirement	Specifications	Qty	Units	Processing Activity	Launch From	Launch To
AMS-??-????-035	Technical Support	Provide sampling capability to verify 99.9999% research grade helium in KSC provided k-bottles.	1	N/A	ONLINE	L-60	L-20

Ascent/ Descent	Location	KSC Commit	Commit Source	KSC Commit Info	Use	Facility	Room	Comments
Ascent	KSC	TBD			H/W			SSPF

Processing Requirements

Payload: Alpha Magnetic Spectrometer
Flight: ULF6

Services

Requirement Number	Requirement	Specifications	Qty	Units	Processing Activity	Launch From	Launch To
AMS-??-????-036	Technical Support	Provide sampling capability to verify 99.9999% research grade helium in KSC provided k-bottles.	1	N/A	ONLINE	L-20	L-3

Ascent/ Descent	Location	KSC Commit	Commit Source	KSC Commit Info	Use	Facility	Room	Comments
Ascent	KSC	TBD			H/W			PCR

Requirement Number	Requirement	Specifications	Qty	Units	Processing Activity	Launch From	Launch To
AMS-??-????-037	Technical Support	Provide capability to connect 120VDC and 110VAC GSE power supplies, and 1553 and RS-422 data lines, to payload via T0 while STS/Crawler located in VAB during hurricane ride-out.	1	N/A	ONLINE	L-20	L-0

Ascent/ Descent	Location	KSC Commit	Commit Source	KSC Commit Info	Use	Facility	Room	Comments
Ascent	KSC	TBD			H/W			N/A

Requirement Number	Requirement	Specifications	Qty	Units	Processing Activity	Launch From	Launch To
AMS-??-????-038	Technical Support	Provide engineering / technician support for the off-line power quality testing (Tri-electron power supply & DDCU/RPCM Simulator)	1	N/A	OFFLINE	L-80	L-75

Ascent/ Descent	Location	KSC Commit	Commit Source	KSC Commit Info	Use	Facility	Room	Comments
Ascent	KSC	TBD			H/W			PQT in CEWS in SSPF footprint 7

Processing Requirements

Payload: Alpha Magnetic Spectrometer
Flight: ULF6

Services

Requirement Number	Requirement	Specifications	Qty	Units	Processing Activity	Launch From	Launch To
AMS-??-????-039	Technical Support	Provide access to payload Interface Panel A while on PCR PGHM to remove GSE cables and connect flight ROEU PDA cables prior to installation into PLB and execution of STS IVT.	1	N/A	OFFLINE	L-20	L-20

Ascent/ Descent	Location	KSC Commit	Commit Source	KSC Commit Info	Use	Facility	Room	Comments
Ascent	KSC	TBD			H/W			PCR

Requirement Number	Requirement	Specifications	Qty	Units	Processing Activity	Launch From	Launch To
AMS-??-????-040	Voice Channel (dedicated P/L)	AMS will require a payload voice channel to provide communications between the PCR, the POCC, and the LCC AMS console. Quantity 24 headsets will be required.	1	Channels	OFFLINE	L-120	L-60

Ascent/ Descent	Location	KSC Commit	Commit Source	KSC Commit Info	Use	Facility	Room	Comments
Ascent	KSC	TBD			H/W			N/A

Processing Requirements

Payload: Alpha Magnetic Spectrometer
Flight: ULF6

Services

Requirement Number	Requirement	Specifications	Qty	Units	Processing Activity	Launch From	Launch To
AMS-??-????-041	Voice Channel (dedicated P/L)	AMS will require a payload voice channel to provide communications between the PCR, the POCC, and the LCC AMS console. Quantity 24 headsets will be required.	1	Channels	ONLINE	L-60	L+3

Ascent/ Descent	Location	KSC Commit	Commit Source	KSC Commit Info	Use	Facility	Room	Comments
Ascent	KSC	TBD			H/W			N/A

Requirement Number	Requirement	Specifications	Qty	Units	Processing Activity	Launch From	Launch To
AMS-??-????-042	Transportation, Special	AMS will require the use of a KSC transport vvan (specifications TBD) to carry GSE for contingency operations during canister transport and MLP relocation in the event of a hurricane while at the pad.	1	N/A	ONLINE	L-20	L+1

Ascent/ Descent	Location	KSC Commit	Commit Source	KSC Commit Info	Use	Facility	Room	Comments
Ascent	KSC	TBD			H/W			N/A

APPENDIX G: SAFETY VERIFICATION TRACKING LOG

NSTS/ISS PAYLOAD SAFETY VERIFICATION TRACKING LOG a. FLIGHT ☐ GROUND ☒

c. PAYLOAD/ELEMENT AND MISSION: AMS-02/STS-134 (ULF-6) **d. DATE:** January 2010

e. Log No.	f. Hazard Report Number	g. Safety Verification Number	h. Safety Verif. Method (Identify Procedures By Number and Title)	i. Ground Operation(s) Constrained	j. Independent Verification Required	k. Scheduled Completion Date	l. Completion Date	m. Method of Closure (Comments)
1	GHR-AMS02-001	1.2.1	Review of AMS-02 flight and GSE materials lists against KSC-approved lists.	Unable to use plastic films, adhesive tapes, and foams				
2	GHR-AMS02-001	1.2.2	Review of AMS-02 materials usage agreements.	Unable to use plastic films, adhesive tapes, and foams				
3	GHR-AMS02-001	1.4.1	Review of design of sealed containers with flammable liquids to verify positive margins against rupture or leakage.	Unable to use flammable liquids				
4	GHR-AMS02-001	1.5.1	Approval of the Process Waste Questionnaire.	Unable to dispose of flammable by-products				
5	GHR-AMS02-001	2.1.1	Inspect flight hardware and GSE for proper identification of potential ignition sources and correct warning labels.	Unable to access flight hardware or GSE				
6	GHR-AMS02-001	2.3.1	Review of flight hardware and GSE design drawings for proper controls/shielding.	Unable to access flight hardware or GSE				
7	GHR-AMS02-001	3.1.1	Review of AMS-02 electrical GSE to verify it meets the requirements of KHB 1700.7C, Section 4.3.2 (Electrical) and the National Electric Code (NEC), National Fire Protection Association 70 (NFPA 70, or equivalent.	Unable to use GSE electrical circuits.				
8	GHR-AMS02-001	4.1.1	Review of AMS-02 mating/demating procedures.	Unable to perform mate/demate operations with unreviewed proc.'s				
9	GHR-AMS02-001	5.1.1	Review of AMS-02 drawings.	Unable to perform mate/demate operations w/uninspected connectors.				

NSTS/ISS PAYLOAD SAFETY VERIFICATION TRACKING LOG a. FLIGHT ☐ GROUND ☐

c. PAYLOAD/ELEMENT: AMS-02/STS-134 (ULF-6) **d. DAT**

e. Log No.	f. Hazard Report Number	g. Safety Verification	h. Safety Verif. Method (Identify Procedures By Number and Title)	i. Ground Operations Constrained	j. Independent Verification Required Yes/No	k. Scheduled Completion Date	l. Completion Date	m. Method of Closure (Comments)
10	GHR-AMS02-001	5.1.2	QA inspections of as-built hardware to approved drawings.	Unable to use any uninspected connectors.				
11	GHR-AMS02-001	5.2.1	Review of procedures.	Unable to review unreviewed procedures.				
12	GHR-AMS02-001	5.3.1	Review of affected connectors to ensure label placement.	Unable to use those connectors that need labels.				
13	GHR-AMS02-001	6.1.1	Review of AMS-02 procedures to verify monitoring of heater circuit temperatures.	Unable to AMS-02 heaters.				
14	GHR-AMS02-001	6.3.1	Review of AMS-02 heater parameters.	Unable to AMS-02 heaters.				
15	GHR-AMS02-001	7.1.1	Review of component specifications to ensure design lifetime exceeds operational lifetime.	Unable to use unreviewed components.				
16	GHR-AMS02-001	7.2.1	Review of component specifications to ensure they can withstand thermal cycling.	Unable to use unreviewed components.				
17	GHR-AMS02-001	8.3.3	Review of ground procedures to ensure cooling water temperature is monitored.	Unable to use rotating equipment.				
18	GHR-AMS02-001	9.1.1	Review of GSE electrical schematics for proper	Unable to use rotating equipment.				
19	GHR-AMS02-002	1.1.1	Review of list of certified personnel.	Unable to use toxic materials.				
20	GHR-AMS02-002	2.1.1	Inspection of cleaning solvent/adhesive material containers.	Unable to use cleaning solvent/adhesive material.				
21	GHR-AMS02-003	1.2.1	Review of insulation design drawings.	Unable to operate at cryogenic temperatures.				

NSTS/ISS PAYLOAD SAFETY VERIFICATION TRACKING LOG a. FLIGHT ☐ GROUND ☐

c. PAYLOAD/ELEMENT: AMS-02/STS-134 (ULF-6)

d. DATE:

e. Log No.	f. Hazard Report Number	g. Safety Verification Number	h. Safety Verif. Method (Identify Procedures By Number and Title)	i. Ground Operations Constrained	j. Independent Verification Required Yes/No	k. Scheduled Completion Date	l. Completion Date	m. Method of Closure (Comments)
22	GHR-AMS02-003	1.3.1	Inspection to ensure insulation is installed per design drawings.	Unable to operate at cryogenic temperatures.				
23	GHR-AMS02-003	2.1.1	Review of AMS-02 flight and GSE layout to ensure adequate containment is provided..	Unable to operate flt. hardware or GSE.				
24	GHR-AMS02-003	2.1.2	Inspection of containment to ensure proper functioning.	Unable to operate flt. hardware or GSE.				
25	GHR-AMS02-003	2.2.1	Review of AMS-02 safety procedures.	Unable to operate at cryo. temps.				
26	GHR-AMS02-003	2.3.1	Review of AMS-02 safety procedures.	Unable to operate at cryo. temps.				
27	GHR-AMS02-003	3.1.1	Review of flight hardware/GSE layout for proper material usage.	Unable to operate at cryo. temps.				
28	GHR-AMS02-003	3.2.1	Review of flight hardware/GSE design and layout to ensure proper protection.	Unable to operate at cryo. temps.				
29	GHR-AMS02-004	1.3.1	Demonstration of positive margins of safety (by means of test, analysis, etc.).	Unable to operate TRD GSE.				
30	GHR-AMS02-004	1.3.2	Review of TRD design.	Unable to operate TRD				
31	GHR-AMS02-004	1.4.1	Demonstration of positive margins of safety .	Unable to operate Warm He Supply GSE				

32	GHR-AMS02-004	1.4.2	Review of Warm Helium Supply design	Unable to use Warm Helium Supply				
33	GHR-AMS02-004	1.5.1	Demonstration of positive margins of safety.	Unable to use RICH GSE				
34	GHR-AMS02-004	1.5.2	Review of RICH GSE design.	Unable to use RICH GSE				
35	GHR-AMS02-004	2.1.2	Review of AMS-02 drawings showing burst disks and QA inspections of as-built hardware to approved drawings.	Unable to operate flt. pressure system.				

NSTS/ISS PAYLOAD SAFETY VERIFICATION TRACKING LOG a. FLIGHT ☐ GROUND ☐

c. PAYLOAD/ELEMENT: AMS-02/STS-134 (ULF-6) **d. DAT**

e. Log No.	f. Hazard Report Number	g. Safety Verification Number	h. Safety Verif. Method (Identify Procedures By Number and Title)	i. Ground Operations Constrained	j. Independent Verification Required Yes/No	k. Scheduled Completion Date	l. Completion Date	m. Method of Closure (Comments)
36	GHR-AMS02-004	2.2.1	Review of CGSE design.	Unable to mate CGSE to flt. hardware				
37	GHR-AMS02-004	2.2.2	Review of CGSE operating procedures.	Unable to mate CGSE to flt. hardware.				
38	GHR-AMS02-004	3.2.1	Review of procedures.	Unable to use tools in the PLB.				
39	GHR-AMS02-004	3.3.1	Review of AMS-02 procedures and KSC standard procedures for handling/lifting.	Unable to use tools in the PLB.				
40	GHR-AMS02-004	5.1.1	Review and approval of procedures.	Unable to use AMS pressure vessels.				
41	GHR-AMS02-004	5.2.1	Review and approval of training and certification process of personnel.	Personnel will not be able to handle AMS-02 pressure vessels.				
42	GHR-AMS02-004	5.3.1	Review and approval of procedures to restrict access.	Unable to use tools in vicinity of payload.				
43	GHR-AMS02-004	6.3.1	Review of procedures which include the use of LHe filters to fill GSE supply dewars and on the line to fill the flight dewar from the GSE dewars.	Unable to use GSE supply dewars.				
44	GHR-AMS02-004	6.4.1	Review of as-built hardware to ensure pressure relief devices are built as per design drawings.	Unable to GSE supply dewars.				

NSTS/ISS PAYLOAD SAFETY VERIFICATION TRACKING LOG a. FLIGHT ☐ GROUND ☐

c. PAYLOAD/ELEMENT: AMS-02/STS-134 (ULF-6) **d. DATE:**

e. Log No.	f. Hazard Report Number	g. Safety Verification Number	h. Safety Verif. Method (Identify Procedures By Number and Title)	i. Ground Operations Constrained	j. Independent Verification Required Yes/No	k. Scheduled Completion Date	l. Completion Date	m. Method of Closure (Comments)
45	GHR-AMS02-004	6.4.1	Review of as-built hardware to ensure pressure relief devices are built as per design drawings.	Unable to use GSE dewars.				
46	GHR-AMS02-004	7.1.2	Review of design and procedures to ensure appropriate materials usage with hardware.	Unable to use flt. or GSE press. vessels.				
47	GHR-AMS02-004	8.2.1	Review of test/operational data from CERN and ESTEC.	Unable to use flt. or GSE press. vessels.				
48	GHR-AMS02-004	9.1.2	Review of design to confirm no blockages/obstructions for pressure relief valves during filling operations.	Unable to use flt. or GSE press. vessels.				
49	GHR-AMS02-004	9.2.1	Review of filling procedures.	Unable to use flt. or GSE press. vessels.				
50	GHR-AMS02-004	9.4.1	Review of design schematics	Unable to use GSE pressure system components				
51	GHR-AMS02-004	10.1.1	Thermal and pressure analysis	Unable to use flt. or GSE press. vessels.				
52	GHR-AMS02-004	10.2.1	Review of design and as built hardware.	Unable to operate GSE press. vessels.				
53	GHR-AMS02-004	10.2.2	Review of ground procedures.	Unable to operate GSE press. vessels.				

NSTS/ISS PAYLOAD SAFETY VERIFICATION TRACKING LOG a. FLIGHT ☐ GROUND ☐

c. PAYLOAD/ELEMENT: AMS-02/STS-134 (ULF-6) **d. DATE**

e. Log No.	f. Hazard Report Number	g. Safety Verification Number	h. Safety Verif. Method (Identify Procedures By Number and Title)	i. Ground Operations Constrained	j. Independent Verification Required Yes/No	k. Scheduled Completion Date	l. Completion Date	m. Method of Closure (Comments)
54	GHR-AMS02-004	10.2.3	Functional testing of pump and valves	Unable to operate GSE press. vessels.				
55	GHR-AMS02-005	1.2.1	QA inspection of warning labels to verify they are located at each vent and pressure relief device.	Unable to use flt. or GSE hardware.				
56	GHR-AMS02-005	1.3.1	KSC review and approval of the AMS-02 venting analysis and labeling plan.	Unable to use flt. or GSE hardware.				
57	GHR-AMS02-005	1.4.1	Review of manual operations to ensure personnel are not in high volume vent areas.	Unable to conduct operations near flt. or GSE hardware.				
58	GHR-AMS02-005	1.5.1	Review of AMS-02 procedures to ensure use of PPE.	Personnel unable to conduct ops. on cryo. systems while operating.				
59	GHR-AMS02-005	2.1.1	Review of procedures to ensure appropriate PPE is included.	Personnel unable to conduct ops. on cryo. systems while operating.				
60	GHR-AMS02-005	2.2.1	Review of procedures to ensure listing of limited access areas. Procedures stating obvious markings (cones, ropes, warning tape, etc.) to identify filling operations	Personnel unable to conduct ops. on cryo. systems while operating.				

NSTS/ISS PAYLOAD SAFETY VERIFICATION TRACKING LOG a. FLIGHT ☐ GROUND ☐

c. PAYLOAD/ELEMENT: AMS-02/STS-134 (ULF-6)

d. DATE

e. Log No.	f. Hazard Report Number	g. Safety Verification Number	h. Safety Verif. Method (Identify Procedures By Number and Title)	i. Ground Operations Constrained	j. Independent Verification Required Yes/No	k. Scheduled Completion Date	l. Completion Date	m. Method of Closure (Comments)
61	GHR-AMS02-005	2.3.1	QA inspection of warning labels to verify they are located at each vent and on all cold surfaces.	Personnel unable to conduct ops. on cryo. systems while operating.				
62	GHR-AMS02-005	2.4.1	Certification of personnel cryogen handling training. (AMS-02 retains a master list of personnel and certifications.)	Personnel unable to conduct ops. on cryo. systems while operating..				
63	GHR-AMS02-005	2.5.1	Review of CGSE operational hardware/procedures to indicate when active filling operations are occurring.	Personnel unable to conduct ops. on cryo. systems while operating.				
64	GHR-AMS02-005	3.1.1	Review and approval of AMS-02 procedures.	Unable to assemble hardware.				
65	GHR-AMS02-005	3.2.1	Review and approval of AMS-02 procedures.	Personnel unable to conduct ops. on cryo. systems while operating.				
66	GHR-AMS02-005	3.3.1	QA review and approval of successful AMS-02 and CGSE functional test.	Personnel unable to conduct ops. on cryo. systems while operating.				
67	GHR-AMS02-005	3.4.1	Review of AMS procedures to ensure only trained personnel are allowed in the area during operations.	Personnel unable to conduct ops. on cryo. systems while operating.				
68	GHR-AMS02-006	1.1.2	Inspection of as built hardware.	Personnel unable to conduct ops. on cryo. systems while operating.				

NSTS/ISS PAYLOAD SAFETY VERIFICATION TRACKING LOG a. FLIGHT ☐ GROUND ☐

c. PAYLOAD/ELEMENT: AMS-02/STS-134 (ULF-6) **d. DAT**

e. Log No.	f. Hazard Report Number	g. Safety Verification Number	h. Safety Verif. Method (Identify Procedures By Number and Title)	i. Ground Operations Constrained	j. Independent Verification Required Yes/No	k. Scheduled Completion Date	l. Completion Date	m. Method of Closure (Comments)
69	GHR-AMS02-006	1.1.3	Thermal analysis/operational data of touch temperatures at external surfaces of dewars and plumbing.	Personnel unable to conduct ops. on cryo. systems while operating.				
70	GHR-AMS02-006	1.2.1	Inspection of AMS-02 and GSE for proper labeling of keep-out zones.	Personnel unable to conduct ops. on cryo. systems while operating.				
71	GHR-AMS02-006	1.3.1	Review of procedures to ensure personnel are issued PPE.	Personnel unable to conduct ops. on cryo. systems while operating.				
72	GHR-AMS02-006	2.1.5	Review of procedure for diverter installation, taking into consideration where AMS-02 is located.	Unable to use cyro. systems.				
73	GHR-AMS02-006	2.1.6	CGSE will include clear and obvious indications of which portions of the flight hardware and GSE contain cryogenic fluids.	Unable to use cyro. systems.				
74	GHR-AMS02-006	2.2.1	Verification of training of those personnel handling cryogenic systems.	Unable to use cyro. systems.				
75	GHR-AMS02-006	3.2.1	Operational measurements.	Unable to use cyro. systems.				
76	GHR-AMS02-006	3.2.2	Review of design.	Unable to work around cryo. sytems.				
77	GHR-AMS02-006	3.2.3	Inspection of installed “diapers” and “catch pans”.	Unable to work around cryo. sytems				

NSTS/ISS PAYLOAD SAFETY VERIFICATION TRACKING LOG a. FLIGHT ☐ GROUND ☐

c. PAYLOAD/ELEMENT: AMS-02/STS-134 (ULF-6) **d. D**

e. Log No.	f. Hazard Report	g. Safety Verification Number	h. Safety Verif. Method (Identify Procedures By Number and Title)	i. Ground Operations Constrained	j. Independent Verification Required Yes/No	k.Scheduled Completion Date	l. Completion Date	m. Method of Closure (Comments)
78	GHR-AMS02-006	3.3.1	Review of AMS procedures to ensure placement of heaters.	Must use warning signs.				
79	GHR-AMS02-006	3.4.1	Review of AMS procedures to ensure placement of warning signs.	Unable to work around areas of ice/liquefied air.				
80	GHR-AMS02-007	1.2.1	Verification of O2 level monitoring and warning system(s) in all handling and operational procedures involving the flight hardware and GSE gas supplies.	Personnel will not be able to work near payload or GSE.				
81	GHR-AMS02-007	1.2.2	Monitor and warning systems wil be adjusted/calibrated to account for the sensor bias when in a helium environment.	Personnel will not be able to work near payload or GSE.				
82	GHR-AMS02-007	1.3.1	Certification of personnel training on evacuation procedures.	Personnel will not be able to work near payload or GSE.				
83	GHR-AMS02-007	1.4.1	CGSE monitor and warning system will be tested prior to use at KSC.	Personnel will not be able to work near payload or GSE.				
84	GHR-AMS02-	1.4.2	CGSE warning levels will be verified by procedure.	Personnel will not be able to work near payload or GSE.				
85	GHR-AMS02-007	2.1.1	Operational procedures analysis will ensure that work locations avoid potential oxygen depletion zones or streams.	Personnel will not be able to work near payload or GSE.				

NSTS/ISS PAYLOAD SAFETY VERIFICATION TRACKING LOG a. FLIGHT ☐ GROUND ☐

c. PAYLOAD/ELEMENT: AMS-02/STS-134 (ULF-6)

d. DAT

e. Log No.	f. Hazard Report Number	g. Safety Verification Number	h. Safety Verif. Method (Identify Procedures By Number and Title)	i. Ground Operations Constrained	j. Independent Verification Required Yes/No	k. Scheduled Completion Date	l. Completion Date	m. Method of Closure (Comments)
86	GHR-AMS02-007	2.2.1	QA inspection of warning labels to verify that they are appropriately sized and located.	Personnel will not be able to work near payload or GSE.				
87	GHR-AMS02-007	3.1.1	Inspection of layout of payload and GSE in canister.	Personnel will not be able to work near payload or GSE.				
88	GHR-AMS02-007	3.2.1	Review of procedures for entering canister to ensure adequate atmospheric testing is included.	Personnel will not be allowed in canister.				
89	GHR-AMS02-	3.3.1	Review of procedures for entering canister.	Personnel will not be allowed in canister.				
90	GHR-AMS02-009	1.1.1	Stress analysis will be performed to verify the proper safety factors defined in KHB 1700.7C were used.	Will not be able to use lifting equipment.				
91	GHR-AMS02-009	1.1.2	Load testing and tagging of all AMS-02 lifting hardware.	Will not be able to use lifting equipment.				
92	GHR-AMS02-	2.1.1	Review of AMS-02 records to ensure NDI was performed.	Will not be able to use lifting equipment.				
93	GHR-AMS02-009	2.2.1	Review of AMS-02 lifting procedures to ensure inspections are included.	Will not be able to use lifting equipment.				
94	GHR-AMS02-009	3.1.1	Review of AMS-02 drawings to ensure requirements are called out on drawings.	Will not be able to use lifting equipment.				

NSTS/ISS PAYLOAD SAFETY VERIFICATION TRACKING LOG a. FLIGHT ☐ GROUND ☐

c. PAYLOAD/ELEMENT: AMS-02/STS-134 (ULF-6) **d. DATE:**

e. Log No.	f. Hazard Report Number	g. Safety Verification Number	h. Safety Verif. Method (Identify Procedures By Number and Title)	i. Ground Operations Constrained	j. Independent Verification Required Yes/No	k. Scheduled Completion Date	l. Completion Date	m. Method of Closure (Comments)
95	GHR-AMS02-009	3.1.2	QA reports documenting that installed hardware meet requirements.	Will not be able to use lifting equipment.				
96	GHR-AMS02-009	4.1.1	QA inspections/verifications that the AMS-02 lifting equipment in properly posted/tagged.	Will not be able to use lifting equipment.				
97	GHR-AMS02-009	5.1.1	Review of AMS-02 drawings and procedures for the AMS-02 lifting equipment.	Will not be able to use lifting equipment.				
98	GHR-AMS02-009	5.2.1	Review of AMS-02 procedures for reassembly instructions and QA inspections/verifications of proper assembly.	Will not be able to use lifting equipment.				
99	GHR-AMS02-009	5.3.1	Inspection of eyebolt insertion.	Will not be able to use lifting equipment.				
100	GHR-AMS02-009	6.1.1	AMS-02 will participate in lift procedure development per AMS-02 Launch Site Safety Plan.	Will not be able to use lifting equipment.				
101	GHR-AMS02-010	1.1.1	Stress analysis demonstrating positive margins of safety.	Will not be able to use stands.				
102	GHR-AMS02-010	1.2.1	Review of procedures to verify compliance with assumptions in stress analysis.	Will not be able to use stands.				
103	GHR-AMS02-010	2.1.1	Review of the PSS assembly/adjustment procedure.	Will not be able to use stands.				

NSTS/ISS PAYLOAD SAFETY VERIFICATION TRACKING LOG a. FLIGHT ☐ GROUND ☐

c. PAYLOAD/ELEMENT: AMS-02/STS-134 (ULF-6) **d**

e. Log No.	f. Hazard Report Number	g. Safety Verification Number	h. Safety Verif. Method (Identify Procedures By Number and Title)	i. Ground Operations Constrained	j. Independent Verification Required Yes/No	k. Scheduled Completion Date	l. Completion Date	m. Method of Closure (Comments)
104	GHR-AMS02-010	2.3.1	Review of procedures.	Will not be able to use stands.				
105	GHR-AMS02-010	3.1.1	Inspection of support stand assembly to ensure proper installation of fixation device.	Will not be able to use stands.				
106	GHR-AMS02-010	3.2.1	Review of support stand procedures.	Will not be able to use stands.				
107	GHR-AMS02-011	1.1.1	Electrical systems schematics review and approval by AMS to ensure proper fusing for expected loads and appropriate current levels..	Will not be able to use electrical systems.				
108	GHR-AMS02-011	1.1.2	Review and approval of facility GFCI.	Will not be able to use electrical systems.				
109	GHR-AMS02-011	1.1.3	Review and approval of AMS and AMS CGSE electrical systems/schematics to ensure proper GFCI/over voltage protection.	Will not be able to use electrical systems.				
110	GHR-AMS02-011	1.2.1	Review and approval of AMS and AMS CGSE electrical schematics.	Will not be able to use electrical systems.				
111	GHR-AMS02-011	1.2.2	Review of COTS hardware for UL or equivalent electrical safety qualification.	Will not be able to use COTS hardware.				
112	GHR-AMS02-011	2.1.1	Inspection of GSE socket connectors/schematics.	Will not be able to use GSE electrical systems.				

NSTS/ISS PAYLOAD SAFETY VERIFICATION TRACKING LOG a. FLIGHT ☐ GROUND ☐

c. PAYLOAD/ELEMENT: AMS-02/STS-134 (ULF-6) **d. DATE:**

e. Log No.	f. Hazard Report Number	g. Safety Verification Number	h. Safety Verif. Method (Identify Procedures By Number and Title)	i. Ground Operations Constrained	j. Independent Verification Required Yes/No	k. Scheduled Completion Date	l. Completion Date	m. Method of Closure (Comments)
113	GHR-AMS02-011	2.2.1	QA inspection of warning labels to verify that they are appropriately sized and located.	Will not be able to use flt/.GSE electrical systems.				
114	GHR-AMS02-011	2.3.1	QA inspection of hardware ensuring high voltage locations are inaccessible.	Will not be able to use flt/.GSE electrical systems.				
115	GHR-AMS02-011	2.4.1	Review of operational procedures showing lockout-tagout of power supplies for AMS GSE to ensure no power to AMS GSE prior to maintenance and/or mate/demate operations.	Will not be able to conduct maintenance on flt./GSE hardware.				
116	GHR-AMS02-	3.1.1	Review and approval of electrical schematics and cable drawings.	Unable to use connectors.				
117	GHR-AMS02-011	3.1.2	QA inspection of as-built hardware (particularly the electrical connectors).	Unable to use connectors.				
118	GHR-AMS02-	4.1.1	Review AMS-02 vacuum pump assembly procedures.	Unable to use vacuum pumps.				
119	GHR-AMS02-011	4.1.2	QA inspections of as-built hardware to approved drawings.	Unable to use connectors.				
120	GHR-AMS02-011	5.1.1	Grounding and bonding verification tests will be performed on the AMS-02 payload, electrical GSE, and the interfacing between AMS-02 equipment and KSC facilities.	Unable to use flt./GSE electrical systems.				

NSTS/ISS PAYLOAD SAFETY VERIFICATION TRACKING LOG a. FLIGHT ☐ GROUND ☐

c. PAYLOAD/ELEMENT: AMS-02/STS-134 (ULF-6) **d. DAT**

e. Log No.	f. Hazard Report Number	g. Safety Verification Number	h. Safety Verif. Method (Identify Procedures By Number and Title)	i. Ground Operations Constrained	j. Independent Verification Required Yes/No	k. Scheduled Completion Date	l. Completion Date	m. Method of Closure (Comments)
121	GHR-AMS02-011	5.2.1	QA inspections/verification tests of the AMS-02 hardware.	Unable to use GSE power cords.				
122	GHR-AMS02-011	6.1.1	Review of AMS-02 procedures to ensure there is a warning to not perform blind mating.	Will not be able to perform electrical mates.				
123	GHR-AMS02-011	6.2.1	Review of design for non-COTS connectors.	Will not be able to use non-COTS plugs.				
124	GHR-AMS02-011	6.3.1	Review of procedures to ensure personnel will inspect power connectors for debris	Will not be able to perform mating of power connectos.				
125	GHR-AMS02-011	7.1.1	Review of procedures.	Unable to perform electrical mates.				
126	GHR-AMS02-012	1.1.1	Review of procedures to ensure appropriate PPE is required and available at KSC.	Unable to use equipment that has a noise level above 88 dB.				
127	GHR-AMS02-012	1.2.1	Review of AMS-02 GSE layout at SSPF and launch pad.	Unable to use equipment that has a noise level above 88 dB.				
128	GHR-AMS02-012	1.2.2	Acoustics survey of noise-generating devices (vacuum pumps) and containment systems to determine whether frequency and intensity of noise are acceptable to preclude health risks and not block out audible caution and warning.	Unable to use vacuum pumps.				
129	GHR-AMS02-012	2.1.1	Review of procedures to ensure AMS-02 and CGSE pressures and temperatures are monitored at appropriate levels.	Unable to operate flt./GSE pressure systems.				

NSTS/ISS PAYLOAD SAFETY VERIFICATION TRACKING LOG a. FLIGHT ☐ GROUND ☐

c. PAYLOAD/ELEMENT: AMS-02/STS-134 (ULF-6) **d. DATE:**

e. Log No.	f. Hazard Report Number	g. Safety Verification Number	h. Safety Verif. Method (Identify Procedures By Number and Title)	i. Ground Operations Constrained	j. Independent Verification Required Yes/No	k. Scheduled Completion Date	l. Completion Date	m. Method of Closure (Comments)
130	GHR-AMS02-012	2.1.2	Review of Cryosystem performance characteristics to establish time to burst.	Unable to operate flt./GSE pressure systems.				
131	GHR-AMS02-012	2.1.3	Review of procedures/cautions for warnings to personnel in the event a warming/high pressure trend is	Unable to operate flt./GSE pressure systems.				
132	GHR-AMS02-013	1.1.2	Measurement of magnetic field.	Unable to charge the magnet.				
133	GHR-AMS02-013	1.2.1	Functional testing of Cryomagnet (at CERN), including avionics.	Unable to charge the magnet.				
134	GHR-AMS02-013	2.1.1	Review of procedures to ensure placement of warning signs.	Unable to charge the magnet.				
135	GHR-AMS02-013	2.2.1	Review list of tools to ensure inclusion of non-magnetic tools.	Unable to charge the magnet.				
136	GHR-AMS02-013	3.1.1	Review of procedures to ensure placement of warning signs.	Unable to charge the magnet.				
137	GHR-AMS02-014	1.1.1	Inspection of GSE.	Personnel will need to wear PPE to protect against sharp edges.				
138	GHR-AMS02-014	1.3.1	Review of procedures to ensure warnings are in place.	Personnel will need to wear PPE to protect against sharp edges.				
139	GHR-AMS02-015	1.2.1	Review of various pump systems.	Keep out zones will need to be implemented.				
140	GHR-AMS02-015	1.3.1	Review of AMS-02 procedures.	Keep out zones will need to be implemented.				
141	GHR-AMS02-015	2.3.1	Review of AMS-02 procedures.	Dump diodes will not be able to be used.				
142	GHR-AMS02-015	2.4.1	Review of AMS-02 procedures.	Dump diodes will not be able to be used.				

NSTS/ISS PAYLOAD SAFETY VERIFICATION TRACKING LOG a. FLIGHT ☐ GROUND ☐

c. PAYLOAD/ELEMENT: AMS-02/STS-134 (ULF-6) **d. DATE:**

e. Log No.	f. Hazard Report Number	g. Safety Verification Number	h. Safety Verif. Method (Identify Procedures By Number and Title)	i. Ground Operations Constrained	j. Independent Verification Required Yes/No	k. Scheduled Completion Date	l. Completion Date	m. Method of Closure (Comments)
143	GHR-AMS02-015	3.2.1	Review of thermostat specifications.	Unable to use thermostat.				
144	GHR-AMS02-015	3.2.2	Operational testing conducted at CERN.	Unable to use thermostat.				
145	GHR-AMS02-	3.3.1	Review of hardware layout.	Unable to heat K-bottle.				
146	GHR-AMS02-015	4.1.1	Review of AMS-02 procedures.	Will not be able to charge magnet.				
147	GHR-AMS02-017	4.1.1	Review of rack loading procedures.	Will not be able to load or move racks.				
148	GHR-AMS02-017	4.1.2	Tipover analysis of all movable items, including items to be moved in the PCR (7 degree incline and expanded metal flooring).	Will not be able to load or move racks.				
149	GHR-AMS02-017	4.2.1	Personnel training in loading racks.	Personnel will not be able to load racks.				

APPENDIX H: PROCEDURE CONTROL MATRIX

APPENDIX I: CERTIFICATE OF NSTS/ISS PAYLOAD SAFETY COMPLIANCE (JF1114A)

CERTIFICATE OF NSTS/ISS PAYLOAD SAFETY COMPLIANCE FOR

1) Hardware addressed on this Certificate:

a) Payload Name (Acronym): AMS-02

i) If multiple components identify here or add attachment: N/A

b) Launch vehicle(s)/launch Carrier(s)*: STS-134/Payload Bay (Flight Hardware)

c) Return vehicle/hardware disposal*: N/A

d) Hardware On-Orbit Operations (vehicle/ISS Segment): ISS (Flight Hardware)

Note: This 1114A certification is for operations on the **Shuttle and ISS (excluding the Russian Segment). It also addresses **Shuttle** launch/return. Launch/**return**/disposal on other vehicles requires adherence to the unique certification process as dictated by the applicable vehicle/IP process requirements.*

2) Certification Applicability: applicable to

_______ Payload Design and Flight Operations

X Ground Support Equipment Design and Ground Operations

3) The Payload Organization Hereby Certifies that:

_______ For STS, the Payload Hardware Identified on this Form Complies with all Applicable Requirements of the NSTS 1700.7 (current issue), "Safety Policy and Requirements for Payloads Using the National Space Transportation System," and/or KHB 1700.7, "Space Shuttle Payload Ground Safety Handbook."

X For ISS, the Payload Hardware Identified on this Form Complies with all Applicable Requirements of the NSTS 1700.7 (current issue), "Safety Policy and Requirements for Payloads Using the National Space Transportation System," NSTS 1700.7 ISS Addendum (current issue), "Safety Policy and Requirements for Payloads Using the International Space Station," and/or KHB 1700.7, "Space Shuttle Payload Ground Safety Handbook."

1) The Safe Design Life is N/A from N/A (date). This is the time period the payload can be retained at or restored to a specified safe condition using prescribed resources and procedures. The limiting component(s) the determined this safe design life Is (are) N/A, which requires (recalibration, repair, replacement, etc).

2) The Safe Operational Life is N/A from N/A (date). The limiting component(s) that determined this safe operational life is (are) N/A, which requires (recalibration, repair, replacement, etc).

4) Approved Waivers/Deviations: N/A

5) Approved (Payload Organization Manager) and Date:

[signature] 1/14/10

JSC Form 1114A (Rev November 10, 2008) (MS Word September 1997)