PAYLOAD HAZARD REPORT

a. NO: GHR AMS02--004

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

c. PHASE: II

d. SUBSYSTEM: Pressure Vessels, Pressurized Lines, Vacuum Shroud

e. HAZARD GROUP: Pressure Systems

f. DATE: May 2008

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	[signature] TRENT MARTIN 10/3/08	[signature] 10/3/08
PHASE III		

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

k. HAZARD CAUSES:

1. Structural failure of pressure vessel(s)/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.

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 psid (> 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.

n. STATUS OF VERIFICATION:

1.1.1	Open
1.1.2	Open
1.2.1	Open
1.2.2	Open
1.3.1	Open
1.3.2	Open

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

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.

2.2.2 Review of CGSE operating procedures.

n. STATUS OF VERIFICATION:

2.1.1	Open
2.1.2	Open
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 II

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

3.2.1 Review of AMS-02 procedures and KSC Standard procedures for handling/lifting..

n. STATUS OF VERIFICATION:

3.1.1	Open
3.1.2	Open
3.2.1	Open

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

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.

n. STATUS OF VERIFICATION:

4.1.1 Open

PAYLOAD HAZARD REPORT CONTINUATION SHEET	a. NO: GHR AMS02--004
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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.

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 II

k. HAZARD CAUSES:

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

l. HAZARD CONTROLS:

6.1. Helium 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.

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
6.2.1 Open
6.3.1 Open
6.4.1 Open
6.5.1 Open

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

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
7.1.2.	Open
7.2.1.	Open

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

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	Open
8.1.2	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: II

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.

9.3.1 Review of design schematics.

9.4.1 Review of design schematics.

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
9.1.2	Open
9.1.3	Open
9.2.1	Open
9.3.1.	Open
9.4.1.	Open

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

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.

10.1.2 Review of design.

10.1.3 Inspection of as built hardware.

10.2.1 Review of design and as built hardware.

10.2.2 Review of ground procedures.

10.2.3 Functional testing of pump and valves.

n. STATUS OF VERIFICATION:

10.1.1	Open
10.1.2	Open
10.1.3	Open
10.2.1	Open
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:	II

k. HAZARD CAUSES:

11. Damage to COPV.

l. HAZARD CONTROLS:

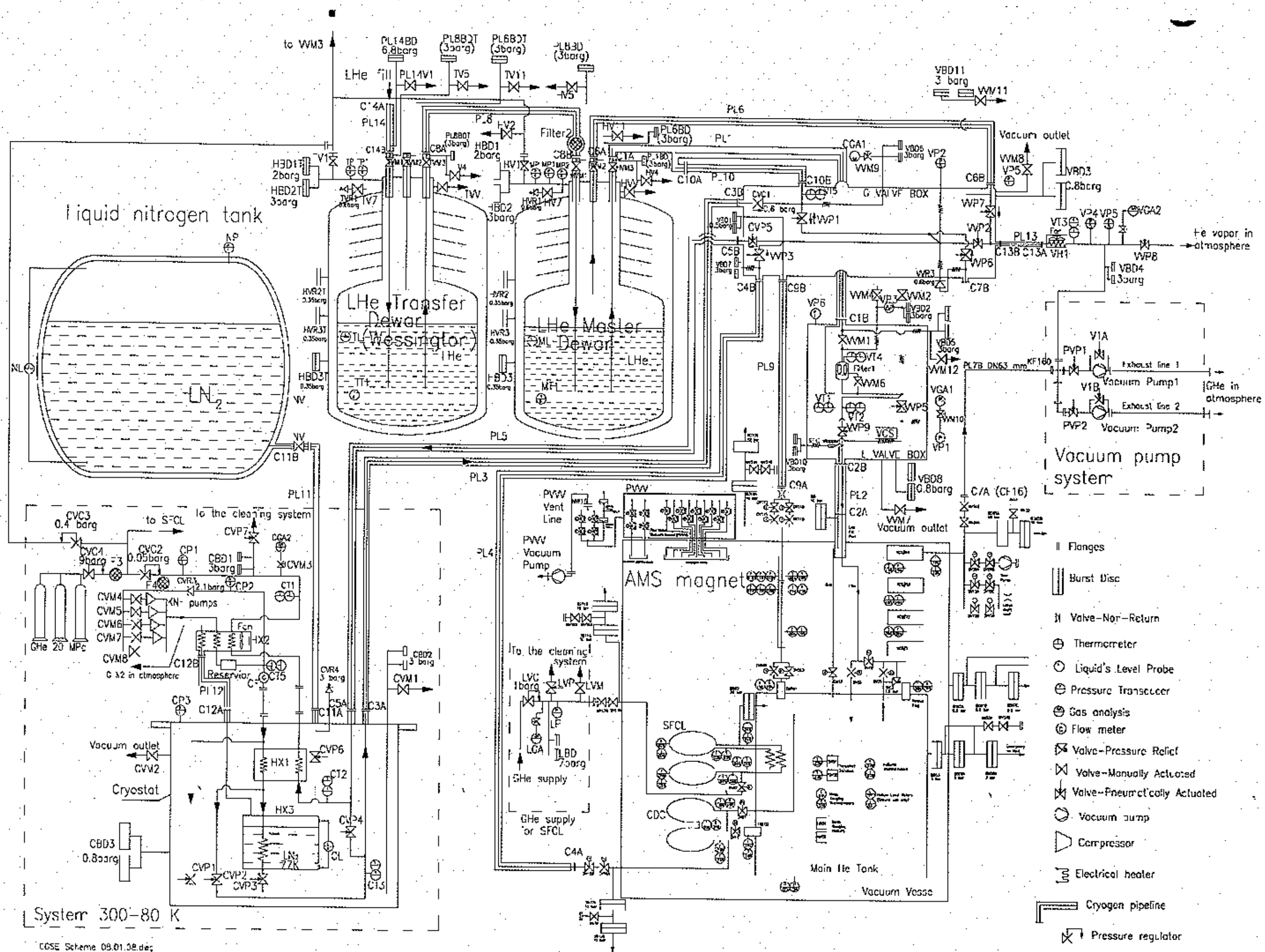
11.1 Damage control features will be implemented per the AMS-02 COPV Mechanical Damage Control Plan

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



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

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	According ASME req.		According ASME req.			Lesker, SLO100MVQF

Valves for HV4, VH5, VH11	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 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											

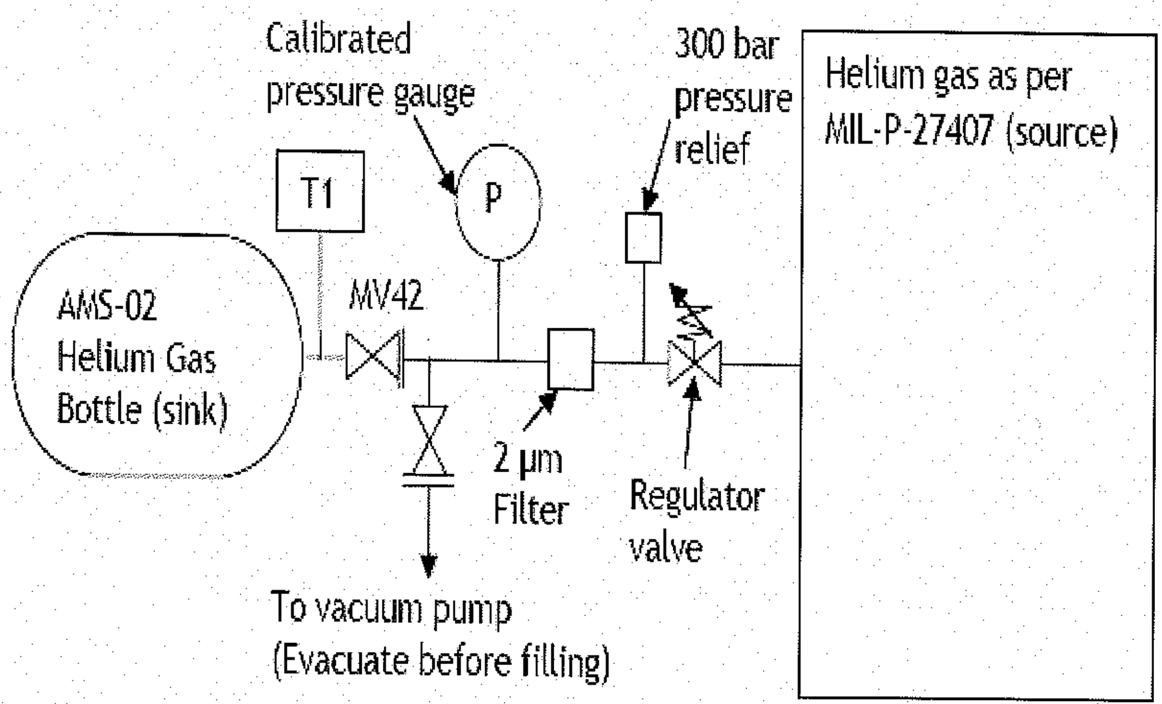
Line PL1+PL10 made by DeMaCo	DeMaCo, Holland	0.69	10.00	4.50	65.27	6.75	97.90	18.0	261. 07	TBD DeMaCo[1]	
Line PL2 made by DeMaCo	DeMaCo, Holland	0.69	10.00	4.50	65.27	6.75	97.90	18.0	261. 07	TBD DeMaCo	
Spare Line PL1+PL10 made by Chengdu	Chengdu, China	0.69	10.00	4.50	65.27	6.75	97.90	18.0	261. 07	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	232.0 6	24.00	348.0 9	min 96.0[3]	139 2.36	29.01.2007	
Line PL4	Chengdu, China	0.60	8.70	16.00	232.0 6	24.00	348.0 9	min 96.0	139 2.36	29.01.2007	
Line PL5	Chengdu, China	0.60	8.70	16.00	232.0 6	24.00	348.0 9	min 96.0	139 2.36	29.01.2007	
Line PL6	Chengdu, China	0.69	10.01	16.00	232.0 6	24.00	348.0 9	min 96.0	139 2.36	29.01.2007	
Line PL7	Chengdu, China	0.60	8.70	16.00	232.0 6	24.00	348.0 9	min 96.0	139 2.36	29.01.2007	
Line PL8	Chengdu, China	0.69	10.01	16.00	232.0 6	24.00	348.0 9	min 96.0	139 2.36	29.01.2007	
Line PL9	Chengdu, China	0.60	8.70	16.00	232.0 6	24.00	348.0 9	min 96.0	139 2.36	29.01.2007	
Line PL11	Chengdu, China	2.00	29.01	16.00	232.0 6	24.00	348.0 9	min 96.0	139 2.36	29.01.2007	
Line PL12	Chengdu, China	1.00	14.50	16.00	232.0 6	24.00	348.0 9	min 96.0	139 2.36	29.01.2007	
Line PL13	Chengdu, China	1.00	14.50	16.00	232.0 6	24.00	348.0 9	min 96.0	139 2.36	29.01.2007	
Line PL14	Chengdu, China	0.69	10.01								
System 300-80 K with cryostat											
KNF membraine pumps	NO150.1.2 ANE, KNF, Germany	2.00	29.0	2.00	29.0	10.00	145.0	N/A	N/A		
Heat exchanger HX1 tube pass	Lanzhou, China	2.00	29.0	16.0	232.1	16.00	232.1	483.53	701 3.0		
Heat exchanger HX1 shell pass	Lanzhou, China	1.00	14.5	16.0	232.1	16.00	232.1	17.42	252. 7		
Heat exchanger HX2	Lanzhou, China	2.00	29.0	16.0	232.1	16.00	232.1	483.53	701 3.0		
Heat exchanger HX3 tube pass	Lanzhou, China	2.50	36.3	16.0	232.1	16.00	232.1	238.26	345 5.7		
Heat exchanger HX3 shell	Lanzhou, China	1.00	14.5	16.0	232.1	16.00	232.1	17.42	252. 7		

Cryostat 300-80 K vacuum case (nominal with vacuum)	Lanzhou, China	-1.00	-14.7	-1.0	-14.7	-1.00	-14.7	-1.00	- 14.7		
Cryostat 300-80 K vacuum case (Contingency with Burst Disk Release)	Lanzhou, China	0.8	11.6	0.8	11.6	2.1	30.5				
Flow meter	Brooks Instruments 5863 S	2.00	29.01	20.00	290.0 8						
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	232.0 6	24.00	348.0 9	min 96.0	139 2.36		
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	145.0 4	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	232.0 6	24.00	348.0 9	96.0	139 2.36	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:	

WEKA valves for AMS simulator CVR3, VS1, VVM6, VS3, VS4, VS5, VS6	Weka, Switzerland	2.00	29.01	6.0	87.0	9.0	130.5	36.0	522.14	29.06.05; CVP6: 2005-06-24; CVP2: 30.06.05; CVP7:01.07.05; CVR3: 31.10.05; VS1, VVM6, VS3, VS4:23.11.05; VS5: 01.12.05;	
Vacuum valve VVM7 for L valve box		-1.00	-14.50	-1.00		Tested -1.0 and +32					-1.00 nominal +0.8 if problem
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				
The rest valves for Cryostat 300-80K											
Valve CVM1 in Cryostat		1.30	18.85	16.00	232.06						
Valve CVM2 in Cryostat		1.30	18.85	16.00	232.06						
Pressure reducers CVC2, CVC3	Parker instrumentation IR4002	6.00	87.02	276.0	4000.00	414.0	6004.56	828.0	12009.12	October 28, 2005	
Pressure reducer CVC4	Parker instrumentation IR4002	200.00	2900.75	276.0	4000.00	414.0	6004.56	828.0	12009.12	October 28, 2005	
Valve HV2		0.40	5.80								
Valves CVM4,5,6,7	WJ21W-25P	1.00	14.50	16.0	232.06	18.0	261,07	24.0	348.09		
Filter F3	Shanghai Yiling Filter Company, China	6.00	87.02	10.0	145.04	10.0	145.04			April 15, 2007	
Filter F4	Shanghai Yiling Filter Company, China	1.00	14.50	10.0	145.04	10.0	145.04			April 15, 2007	

Valves for SFCL										
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	

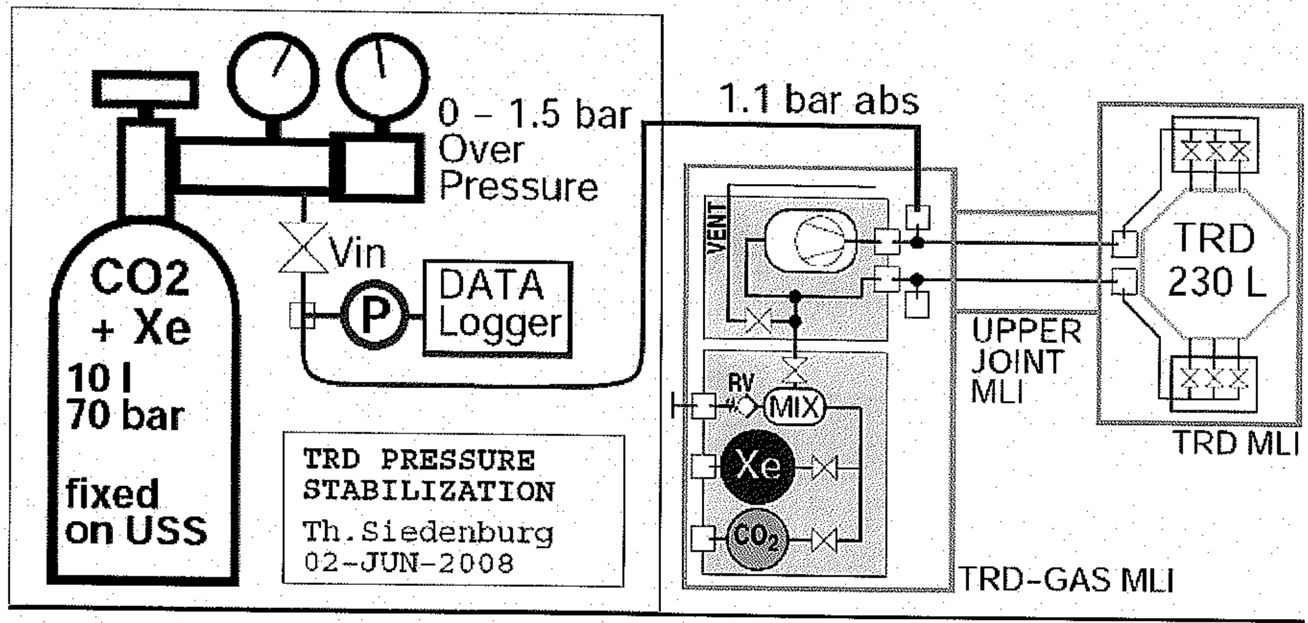
Burst Disk CBD3, VBD3, VBD8		0.80	11.60	0.80	11.60	N/A	N/A	0.80	11.60		
Burst Disk VBD2, VBD4, VBD5, VBD6, VBD7, VBD9, VBD10, LBD, PL8BD2, PL14BD1, HBD3		3.00	43.51	3.00	43.51	N/A	N/A	3.00	43.51		
Air compressor	Hitachi, 2.2P-9.5V5C	7.00	101.53	9.30	134.89	10.5	152.29				
Air dryer	HCA-1.1HC, Han Ye 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

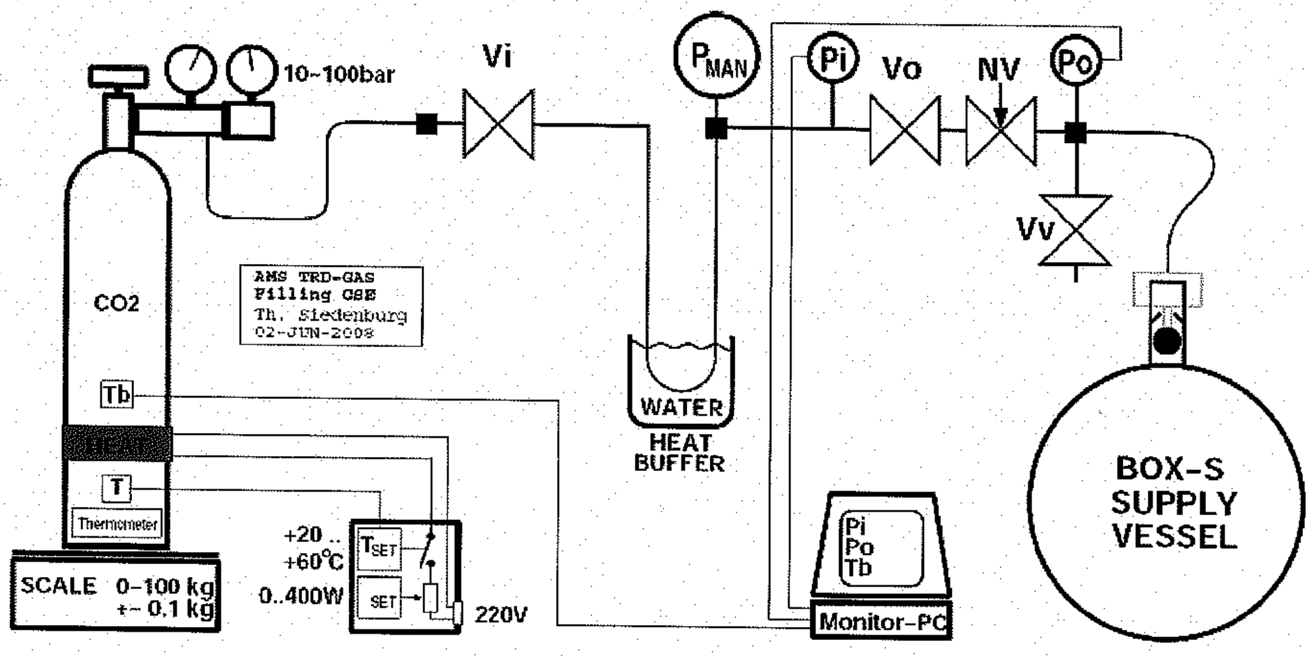
COMPONENT	MAXIMUM OPERATING PRESSURE (MOP)	DESIGN MAXIMUM ALLOWABLE WORKING PRESSURE (MAWP)	PROOF PRESSURE	DESIGN BURST PRESSURE	PROOF TEST DATE	**COMMENTS** (GAUGE OR REGULATOR RANGE, RELIEF SETTINGS, ETC.)
Warm Helium System-TBD						



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)	?	Available when bought	Regulator 0-1.5 bar (0-22 psid)
1/8" stainless steel tubing	0.2 bar (3 psid)					Relief valve in Box-c opens at 1.7 bar (25 psid)



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 bottle	60 bar (882 psia)	200 bar (2940 psia)	300 bar (4410 psia)	?	Available when bought	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 psia)	?	

GROUP
Engineering and Science Contract Group
2224 Bay Area Boulevard
Houston, Texas 77058

COPV PLAN

ESCG Memo Number
Date

TO: Leland Hill, Eric Harvey

FROM: Chris Tutt

SUBJECT: AMS-02 COPV Damage Control Plan

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Introduction

The second Alpha Magnetic Spectrometer (AMS-02) payload has three Composite Overwrap Pressure Vessels (COPVs) used to hold pressurized gas for use by the detector: one containing xenon, one containing carbon dioxide, and one containing helium. Accidental impact loads on the outer surface of the tank have the potential to damage the composite fibers. This type of damage can reduce the tank's overall structural strength and pressure rating but is often difficult to identify without very close specialized inspection. For this reason, both ANSI/AIAA S-081 and KNPR 8715.3 require a damage control plan to be developed to mitigate this hazard. This memo therefore summarizes the damage control procedures developed by the AMS-02 project for these three tanks.

All three tanks were manufactured by Arde' Incorporated of New Jersey. None of the tanks used on AMS-02 were uniquely designs for this payload but were duplicates of previously designed tanks for other space applications. The xenon tank is a duplicate of the tank used in the Plasma Contactor Unit (PCU) and was previously certified and flown to ISS on board the Shuttle. The other two tanks have previously been certified for flight on expendable launch vehicles. Each of the tanks has a certificate of conformance from Arde' documenting that it was built, tested, and inspected per their standard procedures which are compliant with ANSI/AIAA S-081.

The xenon and carbon dioxide tanks are mounted adjacent to each other on the Shuttle aft starboard side of the experiment, as shown in Figure 1. Each tank is surrounded by a thin MLI blanket, while a second blanket containing a layer of betacloth surrounds the entire mounting assembly. In addition, the outside surfaces of both tanks is protected by a rigid MMOD shield. The helium tank is mounted on the lower ring of the AMS-02 Vacuum Case (VC), as shown in Figure 2. It is entirely surrounded by an MMOD shield.

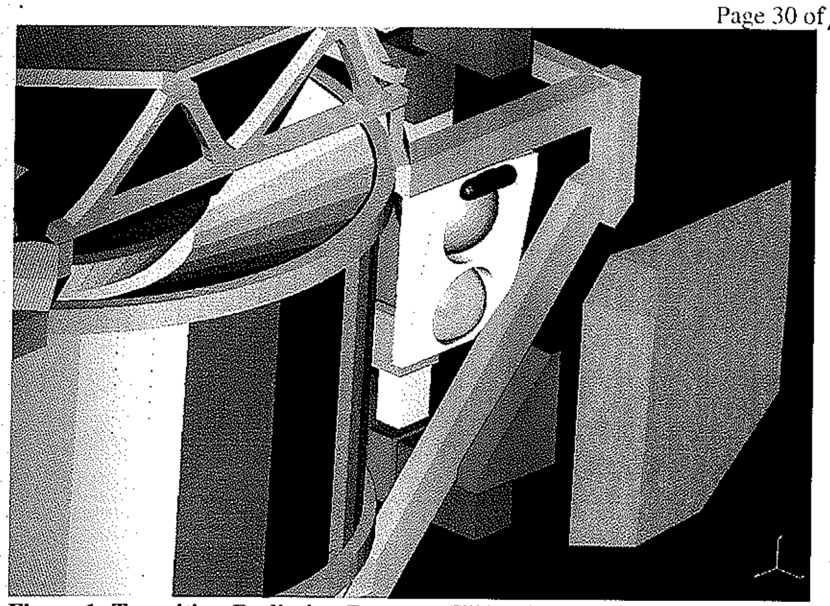

Figure 1: Transition Radiation Detector (TRD) Gas Supply Tanks

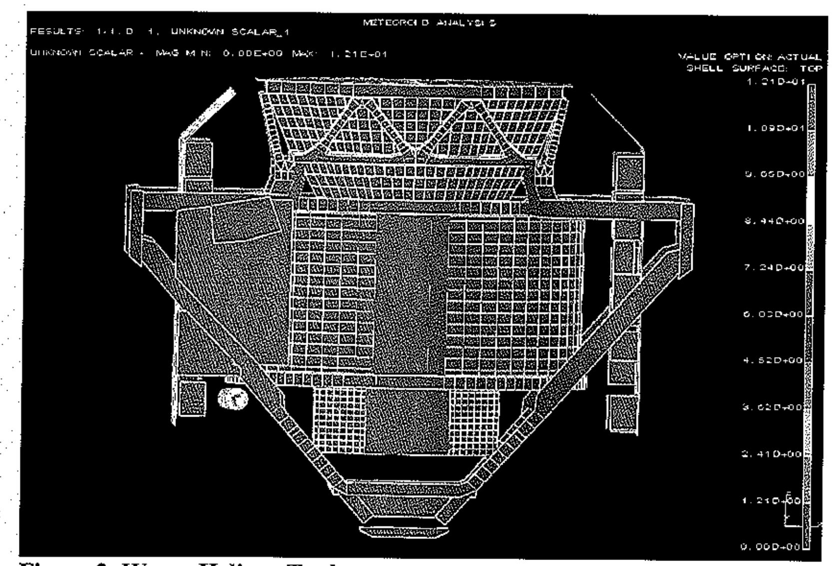

Figure 2: Warm Helium Tank

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Critical parameters for all three tanks are summarized in Table 1. Note that the MDPs described in the table are for flight operations. These are based on thermal profiles which are more extreme than what will be reached on the ground, so their use here is conservative.

Table 1: Summary of AMS-02 Tank Pressure Characteristics

Tank	Arde' Part No.	MOP	MDP	Proof Pressure	Burst Pressure
Xenon	D4815	2500 psid	3000 psid	4500 psid (1.5xMDP) (1.8xMOP)	9300 psid (3.1xMDP) (3.7xMOP)
CO_2	D4816	1440 psid	3200 psid	4800 psid (1.5xMDP) (3.3xMOP)	6400 psid (2.0xMDP) (4.4xMOP)
Helium	D4697	2900 psid	3538 psid	7250 psid (2.0xMDP) (2.5xMOP)	8845 psid (2.5xMDP) (3.0xMOP)

As can be seen in the table, each tank meets the relevant AIAA and NASA pressure requirements, usually with a large margin:

- All tanks have a burst factor of at least 2.0, exceeding the requirement of 1.5 in ANSI/AIAA S-081 para 4.2.2.
- All tanks have been proof tested to a minimum of 1.5xMDP, meeting the requirement in ANSI/AIAA S-081 para 5.1.2 and exceeding the requirement of 1.1xMDP in KNPR 8715.3 para 13.18.1d.
- All tanks have a burst pressure at least three times higher than the maximum operating pressure, which does not trigger the special tank handling requirements defined in KNPR 8715.3 paras 13.18.1e, f, and g.

Based on this, the AMS-02 COPVs clearly do not present any abnormal safety hazard so long as the composite overwrap does not sustain damage and proper handling procedures are followed.

Mitigation Plan

There are four credible avenues for mechanical damage to the AMS-02 COPVs:

1) Damage during tank construction and assembly.
2) Incidental contact during shipping and/or storage.
3) Incidental contact by personnel or tools during nearby assembly operations.
4) Falling objects dropped from above.

The first cause can be eliminated from further consideration given that the tanks were fully inspected and certified by Arde'. Each tank has an associated Acceptance Data Package which documents the tank inspections and the proof pressure testing for each unit. In all cases, the tank met the requirements of both ANSI/AIAA paragraph 5.1 and KNPR 8715.3 paragraph 13.18.1.

Control of the remaining hazards implies the presence of protective covers of some type both above the tanks and between the tanks and surrounding work areas. Shielding must not only encompass the final payload configuration, but also during the assembly process where special care and operations are in place to eliminate

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damage risk to the tanks. Addressing this requires a review of the planned life history of each tank after it left Arde'.

Helium Tank (D4697)

The helium tank was sent from Arde' to Scientific Magnetics (SM), the AMS-02 magnet contractor, in a foam-lined crate. The tank will remain in its crate in a storage location physically separated from the magnet assembly area until it is ready for installation. At that point, it will be installed concurrently with its surrounding rigid MMOD shielding. Once installed, this shielding will also serve as incidental damage protection. Therefore the only period when the composite surface is exposed to contact will be during the installation itself which will occur with special handling procedures in place. The composite will be clearly identified as a no-contact area, and no other work will be allowed to take place on the VC while this operation is underway. For similar reasons, scaffolding above the assembly area will be closed to personnel, cleared of loose items and no crane operations will be allowed in proximity. All of these requirements will be clearly documented in the assembly procedures and will be enforced by project and quality support.

Xenon Tank (D4815) and Carbon Dioxide Tank (D4816)

The xenon and carbon dioxide tanks were delivered to the Massachusetts Institute of Technology (MIT), the contractor for the specific detector which uses the gas supplies. For mission success reasons, MIT, then applied heaters and thermostatic control devices to the outside surface of the COPV. This procedure was developed by MIT and reviewed by Arde'. The installation itself was done by MIT technicians with Arde' QA present. After installation, the entire tank surface (with the obvious exception of the areas now underneath the heaters) was reinspected and the proof pressure test was redone. This process went smoothly and no anomalies were noted.

Once the heaters were installed, protective covers were installed over the composite surface of each tank. These covers will remain in place through all tank assembly and installation operations, except on the rare occasions when direct access to the tanks themselves is required. There are two occasions on which this will be required:

1) The covers were removed to allow installation of the interior tank MLI blankets. This installation was done by trained NASA personnel who were made aware of the delicate nature of the tank surfaces. The tank assembly itself was in its shipping fixture during this operation, physically separated from the rest of the hardware, and access was restricted to the two technicians doing the work and the quality engineer providing oversight. No scaffolding was nearby, and no crane operations were allowed until the covers were replaced on top of the new blankets.
2) The covers and the MLI will be removed later to allow potting of the thermostats previously installed on the COPV surface. This operation will be done by the same technicians as in the previous step, the tank assembly will be in the same fixture as before, and identical access and crane restrictions will be included in the procedure.

Even after the tank assembly is installed, the protective covers will remain in place until the outermost layer of MLI is ready to be installed. At that point, the covers will be removed. A temporary shield will be installed above the tanks to prevent damage from items falling above. In addition, the MMOD shield should be installed on the outboard side of the tanks shortly afterwards. Just as with the helium tank, this MMOD shield will also serve as a protective cover for work taking place on that side of the tanks. At this point, only minimal work will remain in the area adjacent to the inboard side of the tanks, so the betacloth layer in the MLI combined with clear instructions on assembly procedures will be sufficient to protect the tanks from damage from inadvertent contact.

The temporary shield protecting the inboard side of the xenon and carbon dioxide tanks will remain in place during all remaining assembly and testing operations until AMS-02 reaches the launch pad with the exception of the thermal-vacuum test and the electromagnetic interference test. In both of these cases, the payload will be in the controlled environment of the test chambers and no personnel will be present. The risk of falling debris will be controlled by standard procedures at the test site. Once the tests are complete, the temporary shield will be reinstalled prior to any activity taking place near the tanks. These requirements will be clearly documented in the test procedures.

Final removal of the temporary shield will take place at the launch pad just prior to final installation in the bay. As with the test operations, this is a controlled environment and the risk of falling debris and inadvertent contact will be controlled by standard KSC procedures. Additionally, since both tanks are on the aft side of AMS-02, the payload itself will provide some layer of protection precluding falling debris from having an unobstructed path to the composite surfaces.

In summary, the risk of damage to each of the three COPVs used in AMS-02 has been mitigated through a combination of shielding and procedural controls. All inspection data, analysis, and procedures will be fully documented in the ground safety package. Based on this, the risk of COPV rupture due to impact damage to the overwrap is considered fully controlled.