PAYLOAD FLIGHT HAZARD REPORT				a. NO:	AMS-02-F03
b. PAYLOAD	Alpha Magnetic Spectrometer-02 (AMS-02)			c. PHASE:	II
d. SUBSYSTEM:	Cryogenics, Pressure Systems, Structures	e. HAZARD GROUP:	Explosion, Injury, Loss of Orbiter Entry Capability	f. DATE:	May 22, 2006
g. HAZARD TITLE:	Rupture of Superfluid Helium Tank, Vacuum Case and/or Cryosystem Pressurized System Element			i. HAZARD CATEGORY:	CATASTROPHIC **X** CRITICAL
h. APPLICABLE SAFETY REQUIREMENTS:	NSTS 1700.7B and ISS Addendum, 200.1, 200.1b, 200.2, 200.3, 200.4a, 201.3, 205, 206, 208.1, 208.2, 208.3, 208.4, 208.4a, 208.4b, 208.4c & 208.4e				
j. DESCRIPTION OF HAZARD:	Rupture/Explosion of the vacuum case and/or SFHe pressure system results in significant damage to/loss of the STS, ISS, crew and/or other payloads. NOTE: Other Pressurized Systems, including composite overwrapped tanks, are addressed in AMS-02-F05				
k. CAUSES *(list)*	1. Inadequate design strength for pressure and other loading environments. 2. Improper material selection and processing. 3. Improper workmanship and/or assembly. 4. Propagation of crack-like defects. 5. Liquid freezing/thawing. 6. Improper filling/over filling of vessel/system. 7. Incorrect commanding of valves. 8. Meteoroid and Orbital Debris (M/OD) impact.				

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

PAYLOAD FLIGHT HAZARD REPORT	a. NO: AMS-02-F03
b. PAYLOAD Alpha Magnetic Spectrometer-02 (AMS-02)	c. PHASE: II

l. HAZARD CONTROL (CONTROL), m. SAFETY VERIFICATION METHODS (SVM), n. STATUS OF VERIFICATIONS (STATUS)	OPS CONTROL
1. CAUSE: Inadequate design strength for pressure and other loading environments.	
1.1 CONTROL: The AMS-02 hardware has been designed to provide positive margins of safety to the appropriate factors of safety for the hardware as defined in NSTS 1700.7B and NSTS 1700.7B ISS Addendum. The MDP for the hardware components have been established under the worst case environmental conditions and where applicable, two failure case. Where pressure systems elements also experience mechanical loads, the combined loads have been used in establishing the positive margin of safety for the pressurized hardware. 1.1.1 SVM: AMS-02 Structural Analysis and Tests as defined in AMS-02 SVP (JSC 28792C). 1.1.1 STATUS: Open. MDP for each piece of hardware has been established. Structural analysis is ongoing.	
1.2 CONTROL: The Cryomagnet system utilizes burst disks to establish the pressure within discrete volumes within the Cryomagnet system helium and vacuum vessel volumes, these burst disks are used to establish the MDP of the systems of the AMS-02 Cryogenic system. The MDP of the system elements are documented in the attached table. The Vacuum Case is constructed of aluminum forgings that are of welded construction except for the interfaces between the support rings, conical flanges and outer cylinder and the feed through port interfaces all which use double o-ring interfaces. The VC is designed to have an MDP of -14.7 psia and 0.8 bar (11.6 psi). The positive pressure MDP is protected by multiple burst disks (see below). The Superfluid Helium Tank is a 2500 liter toroidal vessel which contains the bulk of the cryogen used by AMS-02. the tank consists of a central support ring attached to two rib-stiffened cylinders made up of Al 5083 forgings and all interfaces are welded. Sixteen through tubes are welded in place to allow for support straps to pass through. The tank itself has been designed to a maximum positive pressure of 3 bar and a maximum negative pressure of 1 bar. The tank over pressure is protected by multiple burst disks (see below). The Cryogenic plumbing system is constructed principally of stainless steel and the MDPs of the various system elements are described in the attached table. These system segments are ultimately protected by burst disks installed in the systems that the lines route to or attached to the lines directly (see below). All burst disks will meet the requirements for a single failure tolerant specially certified burst disk per NASA/JSC TA-88-074. The burst disks implemented are “Reverse Acting Circumferentially Scored with Cutting Teeth” Burst Disk manufactured by Fike. The burst disks are designed to open along the scored line upon pressure exceedence. In addition to	

PAYLOAD FLIGHT HAZARD REPORT	a. NO: AMS-02-F03
b. PAYLOAD Alpha Magnetic Spectrometer-02 (AMS-02)	c. PHASE: II

the nominal manner of rupture, teeth will tear into the scoring as the pressure distorts the disk. All burst disks are sized to individually allow for sufficient flow to preclude pressure build up based on the worst-case thermal input into the cryogenic system. The interspace between the burst disks is evacuated to allow for a constant stress condition while in space. These volumes are evacuated and the stubs used for this are double crimped and welded.

1.2.1 SVM: Review of design

1.2.2 SVM: Inspection of as built hardware.

1.2.3 SVM: Qualification of Burst Disks (as described in attached memos)

1.2.4 SVM: Qualification of the evacuation port crimping and welding.

1.2.5 SVM: Vacuum Case Testing/Analysis

1.2.6 SVM: Qualification/Acceptance testing/analysis of Helium Tank

1.2.7 SVM: Qualification/Acceptance testing/analysis of Cryogenic Plumbing System.

1.2.1 STATUS: Open

1.2.2 STATUS: Open

1.2.3 STATUS: Open. Burst disk qualification plan described in Space Cryomagnetics Limited (SCL) Memo #2484, under review by EP4.

1.2.4 STATUS: Open. Memo from Scientific Magnetics outlines qualification procedure (Memo Ref 2837, "Proposed Qualification Procedure for Burst Disc Crimping", dated January 12, 2006.)

1.2.5 STATUS: Open

1.2.6 STATUS: Open

1.2.7 STATUS: Open

NOTE: Valve DV02 within the Superfluid Cooling Loop (SCL) is utilized only on the ground and is not operated during launch. DV02 seals the Superfluid Cooling Loop (SCL) from the filling line. For ground processing the filling line is ~~generally~~ connected to a clean, ambient temperature helium supply. For the entire cool down process (from ambient temperature to 2.3 K) valve DV02 is open, so that the SCL is connected to the warm supply. Clean helium is drawn into the SCL throughout the cool down process: when the temperature of the main helium tank and coils is below 4.2 K it will condense. Once the temperature is below 2.3 K, DV02 is closed to seal the SCL. The filling line (between DV02 and the ambient helium supply) is evacuated. DV02 will never be opened again, unless there is a need to warm up the magnet on

PAYLOAD FLIGHT HAZARD REPORT		a. NO: AMS-02-F03
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the ground. If the magnet is warmed up, the filling line will again be connected to the ambient helium supply, and DV02 will be opened for the duration of the warm up.

2. CAUSE: Improper material selection and processing.

2.1 CONTROL: All AMS-02 pressure system materials are selected to meet the requirements of MSFC-STD-3029 for Stress Corrosion Cracking. Materials with high resistance to stress corrosion cracking will be used where possible. If materials with moderate or low resistance to stress corrosion cracking have to be used, MUAs will be generated and submitted for approval.

2.1.1 SVM: Stress Corrosion Evaluation of materials list and drawings.

2.1.2 SVM: ES4/Material and Processes Branch Certification for materials usage.

2.1.1 STATUS: Open

2.1.2 STATUS: Open

2.2 CONTROL: The wetted parts of the SFHe pressure system are made of stainless steel, aluminum or copper, these materials will not react with He (Inert gas/liquid).

2.2.1 SVM: Material Compatibility Assessment/ JSC ES4/Materials and Processes Branch Material Certification Letter.

2.2.1 STATUS: Open

2.3 CONTROLS: Cleaning materials will be compatible with working fluid and materials of construction.

2.3.1 SVM: Materials Compatibility Assessment/Review

2.3.1 STATUS: Open

2.4 CONTROLS: Joints and junctions of dissimilar metals will be avoided and where they cannot be avoided the materials will be selected to reduce the potential for galvanic corrosion.

2.4.1 SVM: Material Compatibility Assessment

2.4.2 SVM: Approval of material use and MUAs by JSC ES4/Materials and Processes Branch

2.4.1 STATUS: Open

2.4.2 STATUS: Open

PAYLOAD FLIGHT HAZARD REPORT	a. NO: AMS-02-F03
b. PAYLOAD Alpha Magnetic Spectrometer-02 (AMS-02)	c. PHASE: II

3. CAUSE: Improper workmanship and/or assembly.	
3.1 CONTROL: Approved drawings and procedures will be used for manufacturing and assembly. 3.1.1 SVM: Each supplier of hardware will provide a certificate of compliance (C of C) to AMS-02 Project. Project will Review and Accept each of the C of Cs. 3.1.1 STATUS: Open	
3.2 CONTROL: Welding Processes are controlled by implementation of the AMS-02 Weld Control Plans. 3.2.1 SVM: Review and approval of AMS-02 Weld Control Plans by ES4/Materials and Processes Branch. 3.2.2 SVM: Welds will be inspected: Dye Penetrant, Ultrasound or~~z~~ X-ray 3.2.1 STATUS: ~~Open~~Closed. Confirmation of ES4 acceptance of Weld Plan Review by ESCG/D. Rybiki and ES4/G. Ecord transmitted by email from ES4/B. S. Files on November 20, 2006 to AMS-02 Chief Engineer Chris Tutt. 3.2.2 STATUS: Open	
3.3 CONTROL: All welds have a positive margin of safety for all mission phases, environmental factors and credible load combinations as documented in the AMS-02 Structural Verification Plan (SVP), JSC 28792C. 3.3.1 SVM: AMS-02 Structural Analysis and Tests as defined in AMS-02 SVP (JSC 28792C). 3.3.1 STATUS: Open	
4. CAUSE: Propagation of crack-like defects.	
4.1 CONTROL: The AMS-02 has implemented fracture control by using JSC 25863A and implemented in accordance with fracture control requirements of NASA-STD-5003 and SSP 30558C. All pressurized components of the Superfluid Helium Tank, Vacuum Case and associated pressurized system have been shown to be Leak Before Burst. 4.1.1 SVM: Compliance with the fracture control requirements of NASA-STD-5003 and SSP-30558C will be verified by approval of fracture control summary by JSC ES4/Materials and Processes Branch. 4.1.1 STATUS: Open	
5. CAUSE: Liquid freezing/thawing.	

PAYLOAD FLIGHT HAZARD REPORT	a. NO: AMS-02-F03
b. PAYLOAD Alpha Magnetic Spectrometer-02 (AMS-02)	c. PHASE: II

5.1 CONTROL: The freezing of helium is precluded by the physical property that liquid helium cannot be frozen unless under the compression of approximately 25 atmospheres. The design of the Cryomagnet precludes pressure and temperature conditions that can result in helium freezing. The highest burst value for bursts disks used on the AMS-02 is 23 bar (22.7 atm).

5.1.1 SVM: Review of design

5.1.2 SVM: Inspection of as built hardware.

5.1.1 STATUS: CLOSED. Review has been conducted independently by AMS-02 Chief Engineer and documented in memorandum ESCG-4390-06-SP-MEMO-002, “Freezing of Helium within AMS-02” prepared by Chris Tutt on December 8, 2005.

5.1.2 STATUS: Open

5.2 CONTROL: During pre-launch operations a vent pump is the only nominally open path for atmosphere entering the plumbing of the Cryosystem that doesn’t involve opening valves or bursting disks. This vent pump is operating during the preflight condition and will be extracting helium, precluding the introduction of the atmosphere. Just prior to launch the valve to the pump is closed and the pump’s operation ceases. Once atmospheric pressure in the payload bay is less than the pressure of the main helium tank based on a baroswitch operation between 5 mbar (0.04 psia) and 15 mbar (0.12 psia), valves DV15A/C are opened. With these valves open a positive flow of helium out of the plumbing resumes. Atmosphere cannot enter the cryosystem.

Note: These valves are opened at this time to avoid a specific condition where all superfluid helium could be lost in a relatively short period of time in comparison with the nominal mission time. This is a mission success concern, not safety. This condition is caused by the unique properties of the superfluid helium. For return all valves will be closed (mission success, not safety critical.)

5.2.1 SVM: Review of design

5.2.2 SVM: Inspection of as built hardware

5.2.3 SVM: Review of ground pre-launch procedures.

5.2.4 SVM: Functional testing of pump and valves.

5.2.1 STATUS: Closed. Memo ESCG-4390-06-SP-MEMO-0004, “Cryosystem External Interfaces” Dated 6 March 2006, from AMS-02 Chief Engineer Chris Tutt.

5.2.2 STATUS: Open

5.2.3 STATUS: Open

5.2.4 STATUS: Open

6. CAUSE: Improper filling/over filling of vessel/system

6.1 CONTROL: Ground servicing procedures and hardware will provide high purity helium in gaseous and liquid form (at 4.2 K liquid helium is quite pure). Ground procedures will purge, evacuate and/or filter all other gases during the cool down and fill procedures.

6.1.1 SVM: Implement procurement of appropriate quality gases, QA certification of received gases.

6.1.2 SVM: Review of ground filling procedures.

6.1.3 SVM: QA Approval of procedure implementation.

6.1.1 STATUS: Open

6.1.2 STATUS: Open

6.1.2 STATUS: Open

7. CAUSE: Incorrect commanding of valves.

7.1 CONTROL: All valve pairs with the exception of valve pairs in gaseous vent paths have a pressure relief device (burst disk) where any volume of cold gas or liquid may become trapped. The small segments between valve pairs in the gaseous vents have been assessed based on worst case thermal conditions and MDPs established accordingly.

7.1.1 SVM: Review of design

7.1.2 SVM: Inspection of as built hardware.

7.1.3 SVM: Analysis/Testing of pressurized components per SVP

7.1.1 STATUS: Open

7.1.2 STATUS: Open

7.1.3 STATUS: Open

8. CAUSE: Meteoroid and Orbital Debris (M/OD) Impact

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8.1 CONTROL: The AMS-02 is designed to meet the probability of non-penetration (PNP) requirements of SSP 52005. While the AMS-02 will have an extended on-orbit life, the pressurized tanks (Helium Dewar specifically) will only represent a hazardous condition for a limited period of time before the pressure reserves are spent. Each tank will be assessed for PNP for the duration of operational life. The tank is surrounded by the vacuum case and 120 layers of MLI, four vapor shields and the vacuum case. 8.1.1 SVM: M/OD Risk Assessment to establish a PNP in accordance with SSP 52005. 8.1.2 SVM: Hypervelocity impact testing on sample materials of construction (Vacuum case, MLI, vapor cooled shields and the SFHe tank) to verify tank not susceptible to M/OD impact per SSP 52005. 8.1.3 SVM: Analysis of AMS-02 pressurized system utilization to establish on-orbit penetration threat life duration (period during which M/OD represents a hazard to the pressure vessel.) 8.1.1 STATUS: Open. Preliminary Report Complete. 8.1.2 STATUS: Open. 8.1.3 STATUS: Open.	
Notes: Helium Boiling Point 4.2 K	

ACRONYMS	
AMS-02 – Alpha Magnetic Spectrometer 02	Ops – Operations
atm – atmospheres	PGSC – Payload General Support Computer
C of C – Certificate of Compliance	psia – pounds per square inch absolute
CDC – Cool Down Circuit	psid – pounds per square inch differential
CHX – Cold Heat Exchanger	QA – Quality Assurance
DLCM -	RTEF -
He – Helium	SCL – Space Cryomagnetics Limited
K – Kelvin	SCL – Superfluid Cooling Loop
ksi – kilo pounds per square inch	SFHe – Superfluid Helium
lbf – pound force	STA – Structural Test Article
M/OD – Meteoroid/Orbital Debris	SVM – Safety Verification Method
mbar – millibar	SVP – Safety Verification Plan
MDP – Maximum Design Pressure	ult – Ultimate
MUA – Material Usage Agreements	

CRYOSYSTEM Pressure Table (Including Warm Helium Gas Supply Hardware Addressed in AMS-02-F05)

Description	Volume	Operating Pressure	Material (See Note 2)	Temp	MDP	MDP Determin-ation	Burst Pressure	Burst Safety Factor		Proof Pressure	Proof SF	Basis (See Note 3)	Reference Document
Units	Liter (in^3)	Bar (psid)		(K)	Bar (psid)		Bar (psid)	Reqd	Actual	Bar (psid)		A:Analysis T:Test	
Super Fluid Helium Vessel	2455 (~150,000)	0.016 (0.24)	5083-H321, H-111	1.8	3 (44)	See Note 1	>4.5 (66)	1.5	1.5	3.3 (48.5)	1.1	T To Be Done (TBD)	MIL-STD-1522A SSP 30559C
Vacuum Case	~2295 (~140,000) effective volume	-1 (-14.7)	2219-T62 7050-T7451 2219-T852	300	0.8 (11.8) See Note 4	See Note 5	1.2 (17.7)	1.5	1.5	0.8 (11.8)	1	T	MIL-STD-1522A SSP 30559C
Cool Down Circuit (CDC)	<10 (<610)	<0.016	AISI 316 L AISI 316 L	1.8 300	11 (162) 11 (162)	See Note 1	1198 (17611) 383 (5630)	4 4	109 35	16.5 (242.6) 16.5 (242.6)	1.5 1.5	A A	MIL-STD-1522A SSP 30559C
Superfluid Cooling Loop (SCL)	<10 (<610)	1 (14.7)	CU 103 AISI 316L CU 103 AISI 316L	1.8 1.8 300 300	25 (368) 25 (368) 20 (294) 20 (294)	See Note 1	422 (6203) 908 (13348) 211 (3102) 291 (4278)	4 4 4 4	16.9 36.3 10.5 14.5	37.5 (551) 37.5 (551) 30.0 (441) 30.0 (441)	1.5 1.5 1.5 1.5	A A A A	MIL-STD-1522A SSP 30559C
Cold Heat Exchanger (CHX)	30 (1830)	1 (14.7)	Alum 1050A-O Alum 1050A-O	1.8 300	25 (368) 20 (294)	See Note 1	>180 (>2646) 57 (838)	2.5 2.5	>7.2 2.85	37.5 (551) 30.0 (441)	1.5 1.5	T T	MIL-STD-1522A SSP 30559C
Radiation Shield Vent Line	<10 (<610)	0.016	AISI 316 L AISI 316 L	1.8 300	11 (162) 11 (162)	See Note 1	909 (13362) 223 (3278)	4 4	83 20	16.5 (242.6) 16.5 (242.6)	1.5 1.5	A A	MIL-STD-1522A SSP 30559C
Helium Fill Line	<10 (<610)	1 (14.7)	AISI 316 L AISI 316 L	1.8 300	11 (162) 11 (162)	See Note 1	1579 (23211) 505 (7424)	4 4	144 46	16.5 (242.6) 16.5 (242.6)	1.5 1.5	A A	MIL-STD-1522A SSP 30559C
Helium Vent Line	<10 (<610)	1 (14.7)	AISI 316 L AISI 316 L	1.8 300	11 (162) 11 (162)	See Note 1	769 (11304) 246 (3616)	4 4	70 22	16.5 (242.6) 16.5 (242.6)	1.5 1.5	A A	MIL-STD-1522A SSP 30559C

Description	Volume	Operating Pressure	Material (See Note 2)	Temp	MDP	MDP Determin-ation	Burst Pressure	Burst Safety Factor		Proof Pressure	Proof SF	Basis (See Note 3)	Reference Document
Units	Liter (in^3)	Bar (psid)		(K)	Bar (psid)		Bar (psid)	Reqd	Actual	Bar (psid)		A:Analysis T:Test	
Helium vessel Emergency Vent Line	<10 (<610)	-1 (-14.7)	AISI 316 L	1.8	3 (44)	See Note 1	195 (2867)	2.5	65.0	4.5 (66.2)	1.5	A	NSTS 1700.7B ISS addendum
			AISI 316 L	300	3 (44)		62 (911)	2.5	20.9	4.5 (66.2)	1.5	A	
			AISI 316 L	1.8	3 (44)		379 (5571)	2.5	127	4.5 (66.2)	1.5	A	
			AISI 316 L	300	3 (44)		122 (1793)	2.5	40	4.5 (66.2)	1.5	A	
			Epoxy-Gl	1.8	3 (44)		586 (8614)	2.5	196	4.5 (66.2)	1.5	A	
			Epoxy-Gl	300	3 (44)		489 (7188)	2.5	163	4.5 (66.2)	1.5	A	
Current Lead Line	<10 (<610)	0.2 (2.94)	AISI 316 L	1.8	11 (162)	See Note 1	1575 (23153)	4	143	16.5 (242.6)	1.5	A	MIL-STD-1522A SSP 30559C
			AISI 316 L	300	11 (162)		504 (7409)	4	46	16.5 (242.6)	1.5	A	
			Al1050A-0	1.8	11 (162)		466 (6850)	4	42	16.5 (242.6)	1.5	A	
			Al1050A-0	300	11 (162)		150 (2205)	4	13.6	16.5 (242.6)	1.5	A	
Bi-metal on SCL (SCD0905 -15)	-	0.016	AISI 316 L	1.8	25(368)	See Note 1	1020 (14994)	2.5	40.8	37.5(551)	1.5	A	MIL-STD-1522A SSP 30559C
			5083-H321 (welded)	1.8	25(368)		703 (10334)	2.5	28.1	37.5(551)	1.5	A	
			AISI 316 L	300	20 (294)		408 (5998)	2.5	16.3	30.0(441)	1.5	A	
			5083-H321 (welded)	300	20 (294)		588 (8644)	2.5	23.5	30.0(441)	1.5	A	
Bi-metal on Inst Feed through (SCD 0905-29	-	0.016	AISI 316 L	1.8	3 (44)	See Note 1	666 (9790)	2.5	222	4.5 (66.2)	1.5	A	MIL-STD-1522A SSP 30559C
			5083-H321 (welded)	1.8	3 (44)		498 (7321)	2.5	166	4.5(66.2)	1.5	A	
			AISI 316 L	300	3 (44)		213 (3131)	2.5	71.1	4.5 (66.2)	1.5	A	
			5083-H321 (welded)	300	3 (44)		333 (4895)	2.5	111	4.5 (66.2)	1.5	A	
Bi-metal on DLCM (SCD 0905 -26)	-	0.016	AISI 316 L	1.8	3 (44)	See Note 1	243 (3572)	2.5	81.1	4.5 (66.2)	1.5	A	MIL-STD-1522A SSP 30559C
			5083-H321 (welded)	1.8	3 (44)		303 (4454)	2.5	101	4.5(66.2)	1.5	A	
			AISI 316 L	300	3 (44)		78 (1147)	2.5	25.9	4.5 (66.2)	1.5	A	
			5083-H321 (welded)	300	3 (44)		203 (2984)	2.5	67.8	4.5(66.2)	1.5	A	

Description	Volume	Operating Pressure	Material (See Note 2)	Temp	MDP	MDP Determin-ation	Burst Pressure	Burst Safety Factor		Proof Pressure	Proof SF	Basis (See Note 3)	Reference Document
Units	**Liter (in^3)**	**Bar (psid)**		**(K)**	**Bar (psid)**		**Bar (psid)**	**Reqd**	**Actual**	**Bar (psid)**		**A:Analysis T:Test**	
Relief Valve RV02	<10 (<610)	0.016	Stainless Steel and Vespel DIN 1.4571 1.4310 Vespel SP-1	1.8-300	3 (44)	See Note 1	> 25 (>368)	2.5	>8.3	4.5 (66.2)	1.5	-	Linde Acceptance data package: Doc No's. A-QA 3501/3502
Burst Disc BD02	<10 (<610)	1 (14.7)	Stainless steel, 316 / 316L	300 1.8	23 (338) See Note 6	-	-	-	-	-	-	T (TBD)	
Burst Disc BD03, BD06A, BD06B	<10 (<610)	0.016	Stainless steel, 316 Nickel 200	300	3 (44) See Note 6	-	-	-	-	-	-	T (TBD)	
Pressure Xducers P04,P05 Supplier: Baumer	<10 (<610)	0.016 (0.24)	Stainless steel DIN 1.4301 and 1.4542	1.8-300	3 (44)	See Note 1	>10 (>147)	2.5	>2.5	6 (88)	2.0	T (TBD)	
or Bourdon Haenni	<10 (<610)	0.016 (0.24)	15.5 PH steel Hastelloy C276	1.8-300	3 (44)	See Note 1	120 (1764)	2.5	16	9 (132)	3.0		

Description	Volume	Operating Pressure	Material (See Note 2)	Temp	MDP	MDP Determin-ation	Burst Pressure	Burst Safety Factor		Proof Pressure	Proof SF	Basis (See Note 3)	Reference Document
Units	**Liter (in^3)**	**Bar (psid)**		**(K)**	**Bar (psid)**		**Bar (psid)**	**Reqd**	**Actual**	**Bar (psid)**		**A:Analysis T:Test**	
Pressure Xducers on V case PO6, PO7 Supplier: Leybold Or	<10 (<610)	-1 (-14.7)	Stainless steel CrNi, NiFe. Al203, Ceramics Mo, Cu, Ni, Titanium	300	0.8 (11.8)	See Note 1	>10 (>147)	2.5	>5	10 (147)	12.5	T (TBD)	
Edwards	<10 (<610)	-1 (-14.7)	・Stainless steel 304, 316, 347 ・Copper ・Ceramic	300	0.8 (11.8)	See Note 1	>10 (>147)	2.5	>2.5	>6(147)	>1.5		
Thermo mechanical pump TMP01	<10 (<610)	0.2 (2.94)	Stainless steel CRES 300	1.8-300	3 (44)	See Note 1	256.2 (3715)	2.5	85.4	4.5 (66.2)	1.5	A	SCL - TMP Burst Pressure Calculation
Thermo mechanical pump TMP02	<10 (<610)	0.2 (2.94)	Stainless steel CRES 300	1.8-300	3 (44)	See Note 1	256.2 (3715)	2.5	85.4	4.5 (66.2)	1.5	A	SCL - TMP Burst Pressure Calculation
Porous Plug (PPS)	<10 (<610)	0.016 (0.24)	Stainless steel	1.8-300	3 (44)	See Note 1	>15 (>221)	**2.5**	>5	4.5 (66.2)	1.5	-	Linde Acceptance data package: Doc No's. A-QA 1501/1502
Mass Gauging (DLCM) HR01 and HR02	<10 (<610)	0.016 (0.24)	Stainless steel	1.8-300	3 (44)	See Note 1	>15 (>221)	**2.5**	>5	4.5 (66.2)	1.5	-	Linde Acceptance data package: Doc No's. A-QA 2501/2502

Description	Volume	Operating Pressure	Material (See Note 2)	Temp	MDP	MDP Determin-ation	Burst Pressure	Burst Safety Factor		Proof Pressure	Proof SF	Basis (See Note 3)	Reference Document
Units	Liter (in^3)	Bar (psid)		(K)	Bar (psid)		Bar (psid)	Reqd	Actual	Bar (psid)		A:Analysis T:Test	
Cryogenic Valves DV03, 05, 10, 12	<10 (<610)	0.016 (0.24)	St st 316L/ EN1.4404, 1.4432. 1.4435	300 1.8	11 (162) 3 (44)	See Note 1 See Note 1	>58.5 (>860)	**2.5**	>2.5	>34.5 (>507)	>1.5	T (TBD)	
Cryogenic Valves DV06a, 06b, 07, 14	<10 (<610)	0.2 (2.94)	St st 316L/ EN1.4404, 1.4432. 1.4435	300 1.8	11 (162) 3 (44)	See Note 1 See Note 1	>58.5 (>860)	**2.5**	>2.5	>34.5 (>507)	>1.5	T (TBD)	
Cryogenic Valve DV02	<10 (<610)	1 (14.7)	St st 316L/ EN1.4404, 1.4432. 1.4435	300 1.8	11 (162) 23 (338)	See Note 1 See Note 1	>58.5 (>860)	**2.5**	>2.5	>34.5 (>507)	>1.5	T (TBD)	
Bellows Actuators in Current leads	<10 (<610)	6 (88)	Stainless steel 316 L	1.8 - 65	11 (162)	See Note 1	>27.5 (>404)	**2.5**	>2.5	>16.5 (>243)	>1.5	T (TBD)	
Burst Disc BD07A BD07B BD07C	<10 (<610)	-1 (-14.7)	Stainless steel 316L Nickel 200	300	1.8 (26.5) See Note 6	-	-	**-**	-	-	-	T (TBD)	
Burst Disc BD05A BD05B BD13A BD13B	<10 (<610)	0.016 (0.24)	Stainless steel 316L Nickel 200	300	11 (162) See Note 6	-	-	**-**	-	-	-	T (TBD)	
Burst Disc BD14	<10 (<610)	6 (88)	Stainless steel 316L Nickel 200	300	11 (162) See Note 6	-	-	**-**	-	-	-	T (TBD)	
Burst Disc BD11A BD11B	<10 (<610)	1 (14.7)	Stainless steel 316L Nickel 200	300	11 (162) See Note 6	-	-	**-**	-	-	-	T (TBD)	

Description	Volume	Operating Pressure	Material (See Note 2)	Temp	MDP	MDP Determin-ation	Burst Pressure	Burst Safety Factor		Proof Pressure	Proof SF	Basis (See Note 3)	Reference Document
Units	**Liter (in^3)**	**Bar (psid)**		**(K)**	**Bar (psid)**		**Bar (psid)**	**Reqd**	**Actual**	**Bar (psid)**		**A:Analysis T:Test**	
Burst Disc BD12A BD12B BD10A BD10B	<10 (<610)	0.2 (2.94)	Stainless steel 316L Nickel 200	300	11 (162) See Note 6	-	-	**-**	-	-	-	T (TBD)	
Burst Disc BD17A BD17B	<10 (<610)	-1 (-14.7)	Stainless steel 316L Nickel 200	300	11 (162) See Note 6	-	-	**-**	-	-	-	T (TBD)	
Burst Disc BD15	<10 (<610)	200 - 273	Stainless steel 316L Nickel 200	300	301 (4433) See Note 6	-	-	**-**	-	-	-	T (TBD)	
Warm valves DV11A-B DV16A-B	<10 (<610)	0.2 (2.94)	Stainless 316	300	11 (162)	See Note 1	>27.5 (>404)	**2.5**	>2.5	18 (265)	1.6	T (TBD)	
MV17A-B MV43 MV44	<10 (<610)	1 (14.7)	Stainless 316	300	11 (162)	See Note 1	>27.5 (>404)	**2.5**	>2.5	18 (265)	1.6	T (TBD)	
DV09A-B DV15A-D MV34A-B MV41	<10 (<610)	0.016 (0.24)	Stainless 316	300	11 (162)	See Note 1	>27.5 (>404)	**2.5**	>2.5	18 (265)	1.6	T (TBD)	
Warm valves MV33A-B	<10 (<610)	-1 (-14.7)	Stainless 316	300	3 (44)	See Note 1	>27.5 (>404)	**2.5**	>2.5	5 (74)	1.7	T (TBD)	
Warm valve MV30	<10 (<610)	-1 (-14.7)	Stainless 316	300	1.8 (26.5)	See Note 1	>4.5 (>66)	**2.5**	>2.5	3 (44)	1.7	T (TBD)	
Warm valves DV20A-D	<10 (<610)	-1 (-14.7)	CRES	300	11 (162)	See Note 1	450 (6525)	**2.5**	40.9	225 (3265)	20.5	-	See Manufacturers Qualification Docs (TBD)

Description	Volume	Operating Pressure	Material (See Note 2)	Temp	MDP	MDP Determin-ation	Burst Pressure	Burst Safety Factor		Proof Pressure	Proof SF	Basis (See Note 3)	Reference Document
Units	Liter (in^3)	Bar (psid)		(K)	Bar (psid)		Bar (psid)	Reqd	Actual	Bar (psid)		A:Analysis T:Test	
Warm valves DV22A-D	<10 (<610)	6 (88)	CRES	300	11 (162)	See Note 1	450 (6525)	**2.5**	40.9	225 (3265)	20.5	-	See Manufacturers Qualification Docs (TBD)
Warm valves DV21A-D DV52 DV53 DV55 DV56A-B DV57 DV60 DV62 DV64	<10 (<610)	6 (88)	PAA GF60, Brass, Spring Steel, Steel, Nitric Rubber, POM, Aluminium	300	11 (162)	See Note 1	>27.5 (>404)	**2.5**	>2.5	>16.5 (>243)	>1.5	T (TBD)	
Warm Valves MV40	<10 (<610)	Outlet: 6 (88) Inlet: 200 (2940)	Al. Aly., CRES 17-4PH, CRES 300 SER, Nylon	300	Outlet: 11 (162) Inlet: 301 (4425)	See Note 1	>27.5 (>404)	**2.5**	>2.5	Outlet: 11.5 (169) See Note 8 Inlet: 450 (6615)	Inlet: 1.05 Outlet: 1.5	T (TBD)	
Warm Helium Fill and Drain Port MV42	<10 (<610)	200 (2940)	6Al4V Titanium	300	301 (4425)	See Note 1	>750 (>11025)	**2.5**	>2.5	450 (6615)	1.5	T (TBD)	
Warm Helium Supply	8.3 (506)	200 (2940)	Al 2219, Carbon Fibre	300	301 (4433)	See Note 1	938 (13789)	**2.5**	3.1	500 (7350)	1.5	T (TBD)	

Description	Volume	Operating Pressure	Material (See Note 2)	Temp	MDP	MDP Determin-ation	Burst Pressure	Burst Safety Factor		Proof Pressure	Proof SF	Basis (See Note 3)	Reference Document
Units	**Liter (in^3)**	**Bar (psid)**		**(K)**	**Bar (psid)**		**Bar (psid)**	**Reqd**	**Actual**	**Bar (psid)**		**A:Analysis T:Test**	
4 mm, 3 mm I.D. line from pilot valves to Weka valves. See Note 11 for fittings	<10 (<610)	6 (88)	316 SS Grade A	300	11 (162)	See Note 1	>728 (>10702)	**2.5**	>66.1	728 (10702)	66.1	A	SCL – Warm Helium Supply Pipe Yield Pressures
6 mm, 4 mm I.D. line from warm helium supply to pilot valves. See Note 11 for fittings	<10 (<610)	200 (2940)	316 SS Grade A	300	301 (4425)	See Note 1	>1000 (>14700)	**2.5**	>3.3	1000 (14700)	3.3	A	SCL – Warm Helium Supply Pipe Yield Pressures
Warm Weka valves actuation for DV09A – B DV11A – B DV15A – D DV16A – B	<10 (<610)	6 (88)	Stainless 316	300	11 (162)	See Note 10	>27.5 (>404)	**2.5**	>2.5	>16.5 (>243)	>1.5	T (TBD)	
Pilot valve vacuum vessel	4.0	-1 (-14.7)	Stainless Steel 304-S12	300	11 (162)	See Note 1	88 (1294)	**2.5**	8	37.7 (554)	3.4	A See Note 9	

Description	Volume	Operating Pressure	Material (See Note 2)	Temp	MDP	MDP Determin-ation	Burst Pressure	Burst Safety Factor		Proof Pressure	Proof SF	Basis (See Note 3)	Reference Document
Units	Liter (in^3)	Bar (psid)		(K)	Bar (psid)		Bar (psid)	Reqd	Actual	Bar (psid)		A:Analysis T:Test	
Warm valve pilot valves DV61AS-BS DV61AO-BO DV66AS-BS DV66AO-BO DV59AS-BS DV59AS-BO DV65AS-DS DV65AO-DO	<10 (<610)	6 (88)	PAA GF60, Brass, Spring Steel, Steel, Nitric Rubber, POM, Aluminium	300	11 (162)	See Note 1	>27.5 (>404)	**2.5**	>2.5	>16.5 (>243)	>1.5	T (TBD)	
Relief valve RV03	<10 (<610)	6 (88)	6061 T6 Al. Aly., 316 SST, VESPEL SP1, 320 SST, TEFLON	300	Fault: 10 (147)	See Note 1	24.8 (365)	**2.5**	2.5	15 (220)	1.5	-	See Manufacturers Qualification Docs (TBD)
Relief valve RV04	<10 (<610)	6 (88)	6061 T6 Al. Aly., 316 SST, VESPEL SP1, 320 SST, TEFLON	300	Fault: 10 (147)	See Note 1	24.8 (365)	**2.5**	2.5	15 (220)	1.5	-	See Manufacturers Qualification Docs (TBD)
Vent Pump	<10 (<610)	-1 (-14.7)	Aluminium shell	300	11 (162)	See Note 1	>27.5 (>404)	**2.5**	>2.5	>16.5 (>243)	>1.5	T (TBD)	
Barometric Switch	<<10 (<610)	0.02 (0.3)	2024 T4 Aluminium, Ni-SPAN-C Alloy	300	1 (14.7)	-	>2.5 (>37)	**2.5**	>2.5	2.04 (30)	2.04	-	See Manufacturers Qualification Docs (TBD)

Note 1: Derivation of MDP values per NSTS 1700.7B and ISS Addendum, section 208.4

The maximum design pressure (MDP) for all systems considered in this report is set by the upper defined limit of the relevant pressure relief device which is a space-qualified bursting disc or relief valve.

The bursting disc systems have been extensively assessed by LM/NASA and SCL and accepted.

a) 3 bar Pressure Relief

The pressure is set by the upper limit on the differential pressure, when cold, necessary to rupture bursting disc BD03, shown on SCL Cryogenic System Schematic Drawing SCD 1000.

In service and in test, the downstream pressure on this disc is kept at zero bar absolute.

In the warm state, the bursting disc will rupture at less than 3 bar.

b) 25 bar Pressure Relief

The pressure is set by the upper limit on the differential pressure, when cold, necessary to rupture bursting disc BD02, shown on SCL Cryogenic System Schematic Drawing SCD 1000.

Although in service the downstream pressure is ~ 10 mbar (fill vacuum), the design allows for the downstream pressure being 3 bar abs. The superfluid cooling loop SCL is thus designed for 25 bar abs (and differential), whereas the bursting disc BD02 is set for a maximum differential of 23 bar, in the cold state.

In the warm state, the bursting disc BD02 will rupture at less than 22 bar differential.

c) 10 bar Pressure Relief

The pressure is set by the upper limit on the burst disc differential pressure and vacuum case vacuum, when cold, necessary to rupture bursting discs BD05A, BD05B, BD10A, BD11A,BD11B, BD12A, BD12B, BD13 shown on SCL Cryogenic System Schematic Drawing SCD 1000.

Although in service the pipework pressure is < 1.0 bar, the design allows for the trapped volume pressures being up to 11 bar abs. (10 bar differential of the bursting disc failing to atmosphere + 1 bar vacuum in the Vacuum Case) The general pipework is thus designed for 11 bar abs (and differential), whereas the bursting discs listed are set for a maximum differential of 10 bar.

d) RV03 / RV04

RV03 and RV04 relief valves operate in parallel and pressure is set by the upper limit of the relief valve cracking pressures.

Note 2: Materials of pressure-containing part.

Note 3: Basis for verification of Burst Safety Factor.

Note 4: This is a vacuum vessel and the MDP only applies in the event of contingency case.

Note 5: Ground Case - Worst case thermal pressure environment caused by rupture of the Super Fluid He Tank into the Vacuum Case.

Note 6: Pressure on upstream side of disc, absolute.

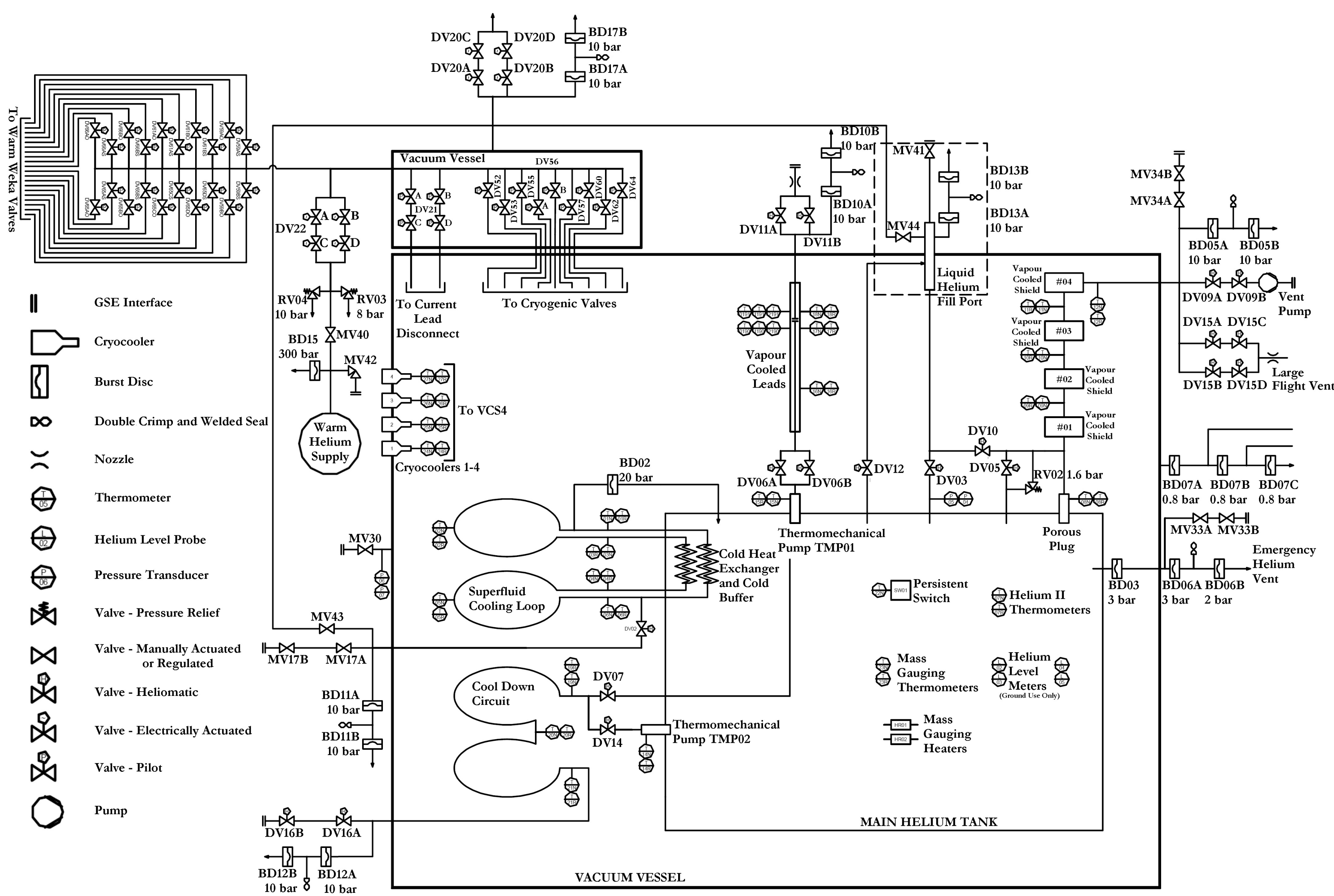
Note 7: For all items in this table, the designed on-orbit life is: 3 years + 2 contingency years. Expected life is TBD as the AMS-02 does not have an independent means of end of life disposal from the ISS.

Note 8: Proof pressure is based upon current specification for valve fittings and will be updated when valves are ordered to meet requirements of 1.5 times MDP.

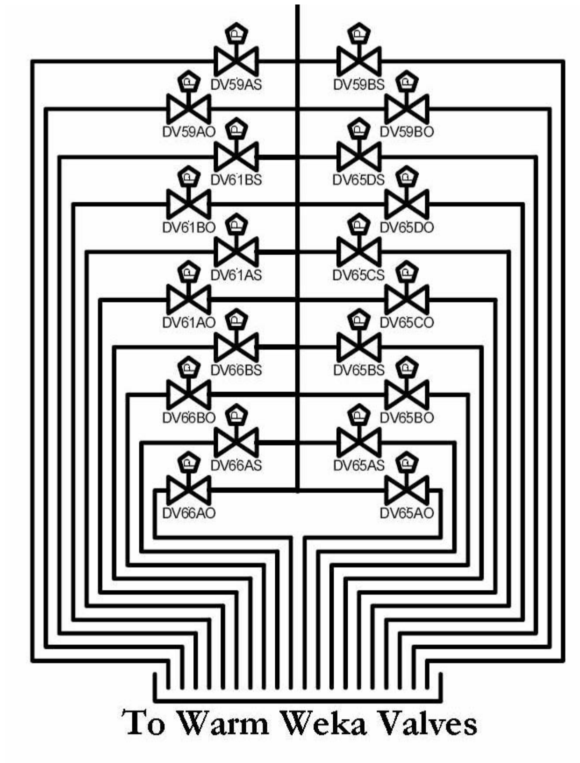
Note 9: Current pilot valve vacuum vessel design based upon calculations in BS 5500. Vessel will be proof tested to 16.5 bar once manufactured.

Note 10: Actuation, hence pressurisation can only occur when DV22A – D are open; therefore MDP determination set by RV04 due to two relief valves being present in the system.

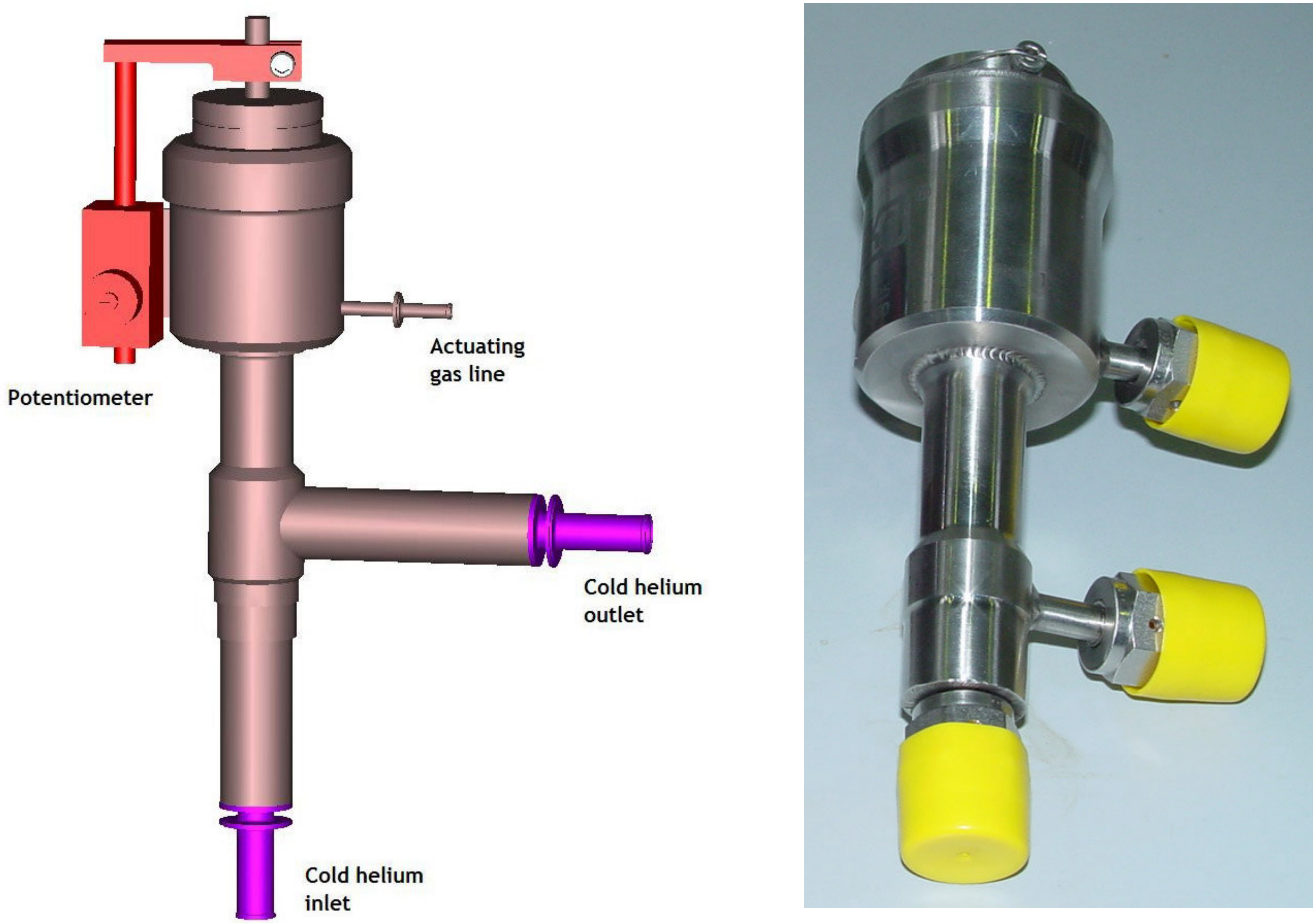
Note 11: Once routing for the warm pressure system is finalised, any fittings required for 6 mm and 4 mm 316 SS lines will be designed to have a yield pressure greater than the lines themselves.



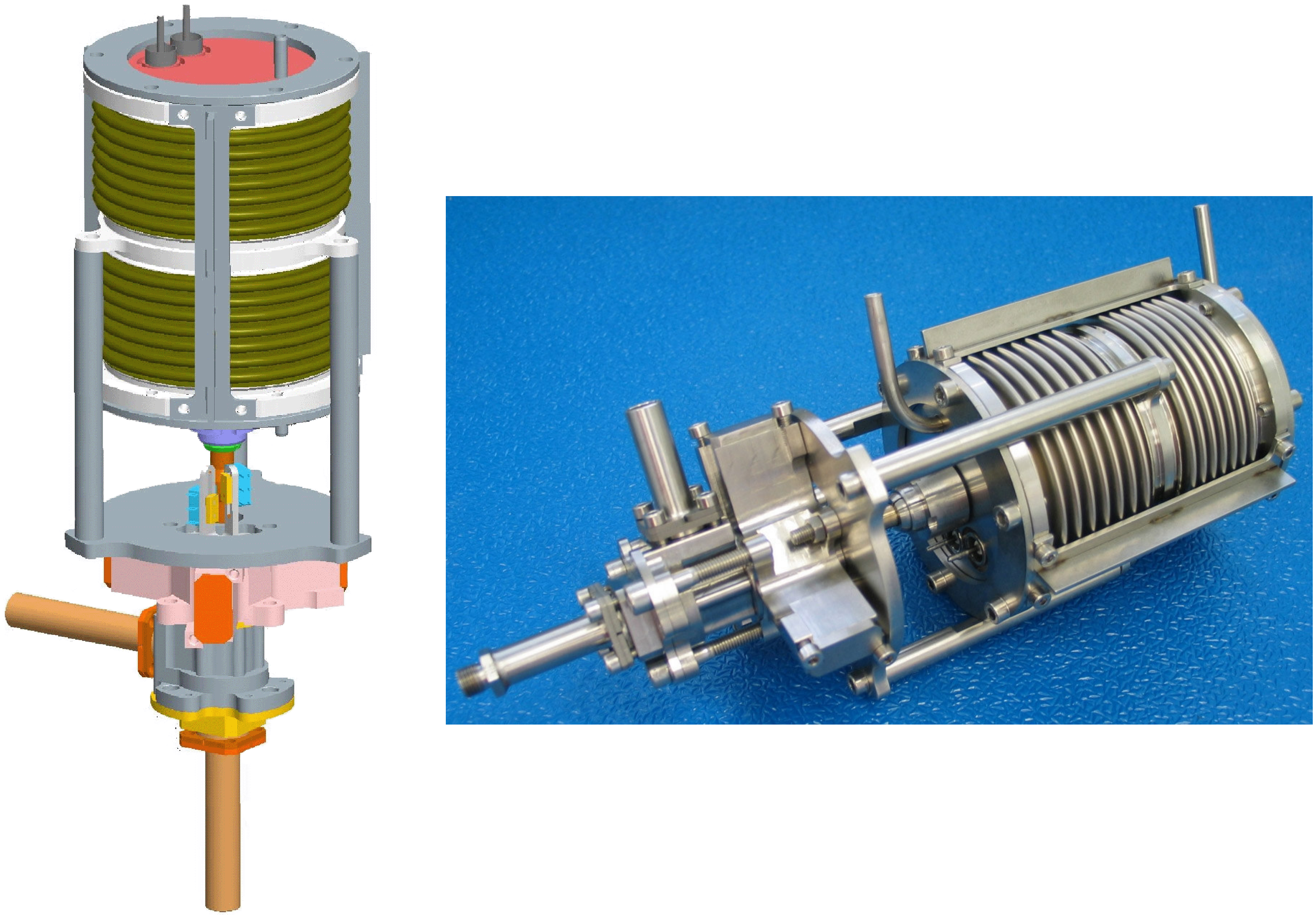
Cryomagnet System



Pilot Valve Details Enlarged



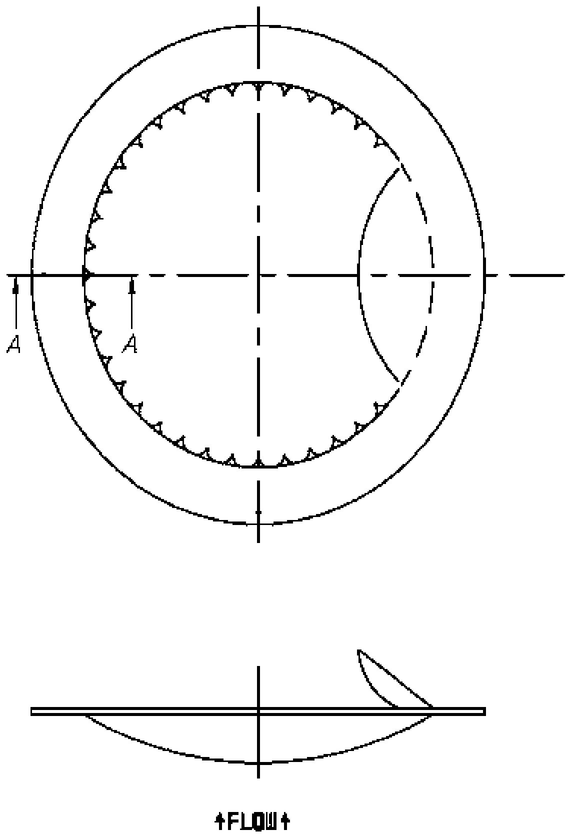
Weka Cryogenic Valve (Cold Valve)



Weka Warm Valves (Addressed in AMS-02-F05)

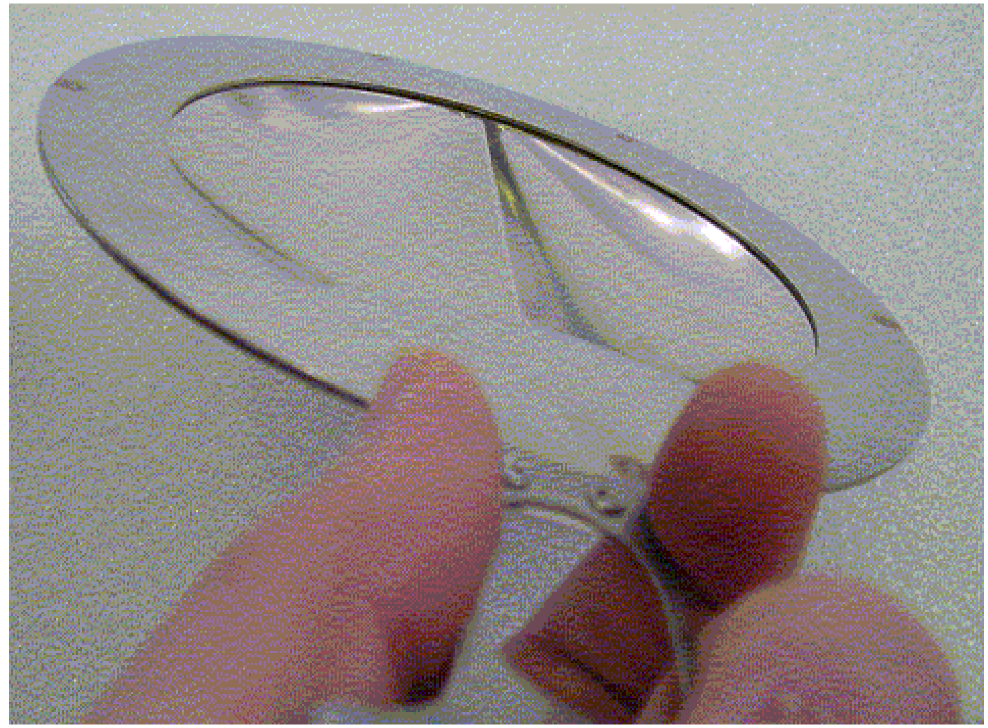
Table 3: Cryosystem Burst Disks

Subsystem	System ID	Number of Disks	Relief Pressure (bar)	Relief Pressure (psi)	"Vent To" Location
Main Helium Tank	BD03, BD06A, BD06B	3 in series	3 (Outer BD set to 2 bar to account for atmospheric pressure and evacuated line)	43.5	Out of AMS-02 Emergency Helium Vent
Vacuum Vessel	BD07A, BD07B, BD07C	3 in series	0.8	11.6	Out of AMS-02
Main Helium Tank – Through Pourous Plug	BD05A, BD05B	2 in series	10	145	Out of AMS-02
Liquid Helium Fill Port	BD13A, BD13B	2 in series	10	145	Out of AMS-02
Vapor Cooled Leads	BD10A, BD10B	2 in series	10	145	Out of AMS-02
Cold Buffer Volume/ Superfluid Cooling Loop	BD11A, BD11B	2 in series	10	145	Out of AMS-02
Cold Buffer Volume/ Superfluid Cooling Loop	BD02	1	20	290	Main Helium Tank
Cool Down Circuit	BD12A, BD12B	2 in series	10	145	Out of AMS-02



Cryogenic System Burst Disk

The burst disk manufacturer is **Fike**. (UK, 35 Earl Street, Maidstone, Kent, ME14 1PF, Tel +44 (0) 1622 677081 | US, Tel +1 816 229 3405.)



The burst disk numbers are as follows: SCL designation (BD..) followed by Fike disk number (SK...).

BD02 - SK2456-2 Rev C
BD03 - SK2456-6 Rev B
BD05, BD10, BD11, BD12, BD13 - SK2456-4 Rev B
BD06 - SK2456-7 Rev A
BD07 - SK2456-5 Rev B

Alpha Magnetic Spectrometer - 02
Burst Disk Certification Approach
January 7, 2003
Trent Martin (Lockheed Martin Space Operations)
Stephen Harrison (Space Cryomagnetics Limited)

The Alpha Magnetic Spectrometer – 02 (AMS-02) includes a large superconducting magnet that is being built by Space Cryomagnetics Limited (SCL) of Culham, England. The cryogenic system on AMS-02 employs three burst disks in a single series for the Superfluid Helium Tank Pressure Relief System and another three burst disks in a single series for the Vacuum Case Pressure Relief System. Additional burst disks are used as appropriate to protect other small volumes from excessive pressures. AMS-02 will certify all burst disks to meet NSTS-JSC, TA-88-074 (October 18, 1988) entitled 'Fault Tolerance of Systems Using Specially Certified Burst Disks.'

The current burst disk design that AMS-02 intends to use is a reverse acting – circumferentially scored design with cutting teeth to provide a redundant burst method. TA-88-074 details 4 criteria that must be met by the proposed burst disk design:

a) The design does not employ sliding parts or surfaces subject to friction and/or galling. In addition, special attention shall be given to the use of stress corrosion resistant materials, particularly in parts under continuous load such as Bellville springs.

The proposed design does not employ sliding parts or Bellville springs.

b) The design used must be qualified for the intended application by test data applicable to the intended use conditions including temperature and flow rate.

AMS-02 will utilize a special test rig that will closely match the peak flow rate and flight temperatures of the flight relief system.

c) Qualification must be for the specific part number used, and it must be verified that no design or material changes exist between flight assemblies and assemblies making up the data base.

The burst disk supplier will have the correct quality assurance procedures in place to certify the integrity of the manufacturing process. Certification letters will accompany each burst disk lot, and testing will be performed for each specific part number.

d) Each flight assembly shall be verified for membrane actuation pressure by use of special tooling or a procedure to prevent cutting edge contact during the test. If this is not feasible, demonstration of good materials and processes control and a rigorous lot screening program approved by the NSTS Payload Safety Review Panel are required.

TA-88-074 states 'The preferred burst disk design for payloads is one which employs a reversing membrane against a cutting edge to assure rupture. Historical use and experience indicate that a burst disk of this type can be certified as a highly reliable pressure relief device. When a burst disk of this type is used as the second and final control of pressure, the two fault tolerant requirement may be assessed as having been met if the burst disk.' The burst disk design that AMS-02 found that exactly meets this statement is known as a Reverse Acting Bladed Burst Disk Design. It was suggested to AMS-02 that the reason that this burst disk design was originally chosen was because the actual flight burst disk could be checked to ensure that it would relieve at the proper pressure. AMS-02 believes there to be some risk involved with testing the actual flight disks if they are Reverse Acting Bladed Burst Disk Design. If the blades are removed and the disk is allowed to pop over at the set pressure, then the blades may not be reattached correctly, or more importantly the material properties of the dome may be altered. AMS-02 also believes this design to be incompatible with disks with genuine redundancy.

AMS-02, instead recommends a design known as Reverse Acting Circumferentially Scored with Cutting Teeth Burst Disk Design. This design is truly redundant because the burst disk is designed to open along the scored line. If the burst disk fails to open along the scoring, then the teeth act to initiate a tear along the scored line. Since the actual flight burst disks cannot be tested in this design, AMS-02 recommends a rigorous lot testing plan. British Standard 2915, that is typically used by British burst disk manufacturers, recommends testing of 2 disks out of a lot of 10. AMS-02 will test 4 out of 6 disks.

In addition to the proposed testing, the burst disk manufacturers maintain databases of information on this type of burst disk design. By applying statistical analysis to demonstrate certainty to an acceptable level that the flight disks will operate within a given range of burst pressures. The MDP associated with that burst disk will use the upper limit of this range. This is the same technique that burst disk manufacturers have used in the past for the aerospace applications.

The burst disk manufacturer will supply Certificates of Compliance to confirm burst disk lot numbers and material certification and compliance for each disk.

Memorandum

Space Cryomagnetics

To: Trent Martin	From: Richard McMahon
Ref No.: 2484	Date: 9/1/04
Re: Burst Disc Qualification	CC: SMH, RCSA

Purpose
This memo describes the qualification procedure for AMS flight and STA burst discs.

Qualification Procedure
To supply two bursting discs for the flight or STA systems, six burst discs must be manufactured. All six discs will be identical and four of the six will be vibrated at operating temperature and then burst.
Data will be recorded to show bursting temperature and pressure for each qualification disc burst.
Assuming the four discs tested have been acceptable the remaining two will then be considered flight qualified.

General points
1. SCD1000 issue 6 is a schematic of the AMS flight cryogenics and includes all burst discs.
2. Each of the burst discs used is of the peripherally scored, reverse buckling type that is considered equivalent to two relief devices.
3. None of the bursting discs used will have sliding parts – cross section drawings of the discs will be forwarded on as they become available.
4. Qualification testing for each of the burst discs will be under representative flight conditions. Temperature and pressure are the two parameters that will be controlled in the test. Table 1 gives the pressure and temperature that each disc will be tested at.
5. Qualification of the burst discs will be for the specific flight part numbers. No design, material or process changes will exist between the qualified discs and the flight discs. The disc holder for qualification testing will be identical to the holder for flight discs.
6. It is not feasible to test burst discs for membrane actuation pressure. This requirement will instead be demonstrated through materials and process control. The burst disc manufacturer has been asked to advise SCL of the controls intended to be used. These will be passed on to LM/NASA for approval.

Table 1 gives a summary of the numbers of discs, bursting pressure and the operating temperature for each disc type.

Tag no's	BD02	BD03	BD05A&B	BD06A	BD06B
Burst Pressure (bar)	20+/-5%	3 +0/-10%	10 +/- 10%	3 +0/-10%	2 +0/-10%
Temp (K)	1.8	1.8	275	275	275
Orifice diameter (mm)	25	50	25	50	50
Number on Flight	1	1	2	1	1
Number on STA	1	1	2	1	1
Vibration & Burst Quantity	4	4	8	4	4

Tag no's	BD07A&B&C	BD10A&B	BD11A&B	BD12A&B	BD13A&B
Burst Pressure (bar)	0.8 +0/-10%	10 +/- 10%	10 +/- 10%	10 +/- 10%	11 +/- 10%
Temp (K)	275	275	275	275	275
Orifice diameter (mm)	100	25	25	25	25
Number on Flight	3	2	2	2	2
Number on STA	3	2	2	2	2
Vibration & Burst Quantity	12	8	8	8	8

Table 1: Summary of pressure, temp and test quantity for each burst disc type.

Richard McMahon

Email Excerpt on Acceptability of Burst Disk Qualification Plan

-----Original Message-----
From: Martin, Trent
Sent: Wednesday, January 14, 2004 6:35 AM
To: 'MANHA, WILLIAM D. (BILL) (JSC-EP4) (LM)'
Cc: FLYNN, HOWARD F. (JSC-EP4) (NASA); 'Steve Harrison (SCL)'; 'Richard McMahon (SCL)'; 'Hans Hofer (ETH)'; 'Juergen Ulbricht of ETH'
Subject: RE: Burst disc qualification for AMS Cryosystem - NASA OK with pl an

Thank you gentlemen, we are pleased to hear that our burst disk qualification plan is acceptable to NASA.

Trent

-----Original Message-----
From: MANHA, WILLIAM D. (BILL) (JSC-EP4) (LM) [mailto:william.d.manha1@jsc.nasa.gov]
Sent: Tuesday, January 13, 2004 2:44 PM
To: Martin, Trent
Cc: FLYNN, HOWARD F. (JSC-EP4) (NASA)
Subject: RE: Burst disc qualification for AMS Cryosystem - NASA OK with pl an

Trent,

I've briefly discussed this with Howard and we feel the questions have been satisfactorily answered to assure the burst disc qualification plan is acceptable to qualify the burst discs to satisfy NASA payload safety requirements.

Bill Manha
Propulsion, Fluid and Pressurized Systems
PSRP Engineering Support
Phone 281 483-6439
FAX 281 483-3704
wmanha@ems.jsc.nasa.gov
Building 15, Room 170, Mail Code EP4
JSC, 2101 NASA Parkway
Houston, TX 77058-3696

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Fracture Classification for AMS-02 Cryo Magnet

Item	Drawing Number	Material and temper	Material allowable stress (ksi)	Max. applied tensile stress (ksi)	Ratio of applied limit stress to allowable stress	Margin of Safety (ult) FS =1.50	Fracture Classification	Rationale	Comments
Race track End frame	SCD0825	6061-T6 (10 in)	53.7	29.4	0.55	0.22	Low risk	Note 2	Page 7, sect.1.1.1 Note 4
Dipole Island	SCD0810	6061-T6 (10 in)	53.7	29.0	0.54	0.23	Low risk	Note 2	Page 8,sect.1.1.2 c Note 4
Race track coils	SCD0841	6061-T6 (10 in)	53.7	19.6	0.37	0.83	Low risk	Note 2	Page 8,sect.1.1.2 b Note 4
Race track edge plate outer	SCD0851-4	2219-T851	60.9	27.6	0.45	0.47	Low risk	Note 2	Page 13,sect 1.1.5 a, max. tens stress preload warm, Note 4
Race track edge plate curved	SCD0851-3	6061-T6 (10 in)	53.7	21.6	0.40	0.14	Low risk	Note 2	Page 13,sect 1.1.5 b, max. tens stress preload warm, Note 4
Dipole edge Plate	SCD0812-01	6061-T6 (10 in)	53.7	22.5	0.42	0.10	Low risk	Note 2	Page 14,sect 1.1.5 c, max. tens stress preload warm, Note 4
Helium vessel Fx support pin	SCD0889-02	316 Hi proof stainless steel	232.1	143.6	0.62	0.08	Low risk	Note 2	Page 47, sect 4.1.d inertia loads, Note 4
Helium vessel Fy support pin	SCD0910-01	316 Hi proof stainless steel	31.9	20.5	0.64	0.42 yield	Low risk	Note 2	Page 49, sect 4.2.A inertia loads, Note 4
Helium vessel Fz support pin	SCD0898-01	316 Hi proof stainless steel	232.1	130.7	0.56	0.18	Low risk	Note 2	Page 54, sect 4.4.C inertia loads, Note 4

Fasteners

Item	Drawing Number	Material and temper	Material allowable Load (lbf)	Applied Load (lbf)	Ratio of applied limit load to allowable load	Margin of Safety FS =1.0	Fracture Classification	Rationale	Comments
RT1 to RT3 bolts	SCD0842-01	A4/70, M8 316 stainless steel	3702	2534	0.68	0.46 yield	Fail-safe	Note 3	Page 2, Appendix 5 Note 4
RT3 to RT5 bolts	SCD0845-04	A4/70, M12 316 stainless steel	8527	5666	0.66	0.50 yield	Fail-safe	Note 3	Page 2, Appendix 5 Note 4
RTEF to RT5 bolts	SCDXXX	M8, 316 Hi proof stainless steel	6129	2468	0.40	1.48 yield	Fail-safe	Note 3	Page 2, Appendix 5 Note 4
Dipole crossbeam to RTEF bolts	SCD0815	UNF 316 Hi proof stainless steel	17417	3758	0.22	3.63 yield	Fail-safe	Note 3	Page 2, Appendix 5 Note 4
Dipole island to RTEF bolts	SCD0824	M5, 316 Hi proof stainless steel	2378	1114	0.47	1.14 yield	Fail- safe	Note 3	Page 2, Appendix 5 Note 4
Dipole edge plate to RTEF bolts	SCD0824	M5, 316 Hi proof stainless steel	2378	1166	0.49	1.04 yield	Fail- safe	Note 3	Page 2, Appendix 5 Note 4

Helium vessel Fz support bolts	SCD0898	M8, 316 Hi proof stainless steel	6129	3313	0.54	0.85 yield	Fail- safe	Note 3	Page 2, Appendix 5 Note 4

Notes:
1) The components will be classified as per JSC 25863A, August 1998 to comply with NASA-STD-5003, October 1996 and SSP 30558 Rev. B, June 1994
2) The component will be classified as low risk as per section 5.1.L.1, 5.1.L.2.A and 5.1.L.2.B.3 of JSC25863A, and will be shown that the component possesses acceptable durability(Possesses acceptable resistance to crack growth)
3) The component will be classified fail-safe as per section 5.1.c of JSC25853A
4) Reference summary of Structural Analysis of AMS-02 Super conducting Magnet, September 2003, issue 02

Fracture Classification of AMS-02 Helium Tank

Item	Drawing number	Material and temper	Material allowable yield stress (ksi)	Max. applied yield stress (ksi)	Ratio of applied stress to allowable stress	Margin of Safety (ult) FS=2.0	Fracture Classification	Rationale	Comments
Central Ring	SCD 0905-01	5083-H111 forging	32.6	28.2	0.86	0.05	Non Fracture critical	Note 2	Page 18 Note 3
Thru tube weld	SCD 0903-02	5083-H111 forging	25.89	23.4	0.90	0.01	Non Fracture critical	Note 2	Page 18 Note 3
Outer ring	SCD 0905-02,-03	5083-H321	25.52	17.7	0.69	0.31	Non Fracture critical	Note 2	Page18 Note 3
Inner ring weld	SCD 0905-04,-05	5083-H321	25.52	20.3	0.79	0.14	Non Fracture critical	Note 2	Page 18 Note 3
Porous plug weld	SCD 0905-22	5083-H321	25.89	20.7	0.80	0.13	Non Fracture critical	Note 2	Page18 Note 3
End dish weld	SCD 0906	5083-H321	25.52	14.0	0.55	0.66	Non fracture critical	Note 2	Page 18 Note 3

Notes:
1) The components will be classified as per JSC25863A, August 1998 to comply with NASA-STD-5003, October 1996 and SSP 30558 Rev. B, June 1994.
2) The component will be classified as non fracture critical(Leak-before burst) as per sect.5.1 d of JSC 25863 A
3) Ref. Helium tank strength assessment, July 24, 2003

Fracture Classification for AMS-02 Cryo Magnet Suspension Straps

Item	Drawing Number	Material and temper	Material allowable stress (ksi)	Max. applied tensile stress (ksi)	Ratio of applied limit stress to allowable stress	Margin of Safety (ult) FS =1.40	Fracture Classification	Rationale	Comments
Race track end frame clevis	SCD0825	6061-T6 (10 in)	13.69	4.43	0.32	0.11	Fracture critical	Note 2,3	Page 7, Note 5 RTEF_C1W1_clevis
Race track end frame clevis pin	SCD 0678-02	316L Hi-Proof stainless steel	127.64	85.77	0.67	0.06	Fracture critical	Note 2,3	Page 13, Note 5 RTEF_C1W1_clevis
Carbon Band	SCD 0678-03	Carbon Fiber epoxy	275.65	117.7	0.43	0.67	Fracture critical	Note 2,3	Note 4
FGR Band	SCD 0678-12	FGR3 epoxy	261.07	59.3	0.22	2.14	Fracture critical	Note 2,3	Note 4
Glass Band	SCD 0678-11	S2 glass epoxy	217.56	61.2	0.28	1.53	Fracture critical	Note 2,3	Note 4
Glass Bod	SCD 0678-18	S2 glass epoxy	217.56	98.3	0.45	0.58	Fracture critical	Note 2,3	Note 4

Notes:
1) The components will be calassified as per JSC25863A, August 1998 to comply with NASA-STD-5003, October 1996 and SSP 30558 Rev. B, June 1994
2) The component is classified as fracture critical as per sect 5.2 and is shown acceptable by sect. 6.0 of JSC 25863A
3) The flight hardware will be tested to a minimum of 1.2 times limit load
4) Ref. Space Cryomagnetics Ltd (SCL) analysis, 6 February 2002
5) Ref. Cryomagnet Suspension Strap Analysis

INSERT OR REFERENCE TO M/OD PRELIMINARY ASSESSMENT