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

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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
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