

Safety Noncompliance Report

Date:
12/10/08

NCR NUMBER: AMS-02-NCR-001

FLIGHT EFFECTIVITY: non-flight specific

EXPIRATION DATE: n/a

ORIGINATOR: (*Organization/Company*) JSC-EA3/AMS-02 Project Manager/Trent Martin

TITLE: AMS-02 Payload EVA Touch Temperature

END ITEM IDENTIFICATION: (*Include reference to applicable end item, subsystem, and/or component*)

Alpha Magnetic Spectrometer-02 (AMS-02) Payload

APPLICABLE REQUIREMENT:

NSTS 1700.7B ISS Addendum

217 Extravehicular Activity (EVA)

200.3 Environmental Compatibility. (See Note Below)

NOTE: Reference below for specific EVA contact temperature values consistent with NSTS 07700 Volume XIV, Appendix 7 and SSP 57003

SSP 57003, 3.11.5.14.1 INCIDENTAL CONTACT

For incidental contact, temperature shall be maintained within -180 to +235 degrees Fahrenheit or limited heat transfer rates as listed in Table 3.11.5.14.1-1 [per SSP 41162, paragraph 3.3.6.12.2.1]

SSP 57003, 3.11.5.14.2 UNLIMITED CONTACT

For unlimited contact, temperatures shall be maintained within -45 to +145 degrees F, or for designated EVA crew interfaces listed in Table 3.11.5.14.2-1, limit heat transfer rates as listed in table 3.11.5.14.1-1. [per SSP 41162, paragraph 3.3.6.12.2.2]

DESCRIPTION OF NONCOMPLIANCE: (*Specify how the design or operation does not meet the safety requirements.*)

A worst case thermal analysis of AMS payload shows a Debris Shield reaching -183 degrees F (violating Incidental contact temperatures and heat rates), a Flight Releasable Grapple Fixture (FRGF) reaching 258 degrees F (violating Unlimited contact temperature and heat rates) and an EVA Connector Panel reaching 174 degrees F (violating Unlimited contact temperature and heat rates). See attached memo.

REASON REQUIREMENT CANNOT BE FULFILLED:

Because of the induced thermal environment and hardware material, the hardware cannot remain within temperature limits or allowable heat rates for all ISS attitudes.

RATIONALE FOR ACCEPTANCE: (*Define the design feature or procedure used to conclude that the noncompliance condition is safe. Attach applicable support data, i.e. drawings, test reports, analyses, etc.*)

The hardware does meet the requirements of JSC 28918, "EVA Design Requirements and Consideration" for incidental contact and poses no risks to EVA suit or crewmember. Analysis of the EVA connector panel shows a high pressure grasp time of 4 minutes

and a 1-psi grasp time of 9.55 minutes. This should be ample time to perform the contingency EVA of swapping connectors. The connector panel does not need to be touched or held continuously during this operation. Similarly, the FRGF shows high pressure grasp time of 2 minutes and 1-psi grasp time of 3.25 minutes. This should also be sufficient for the FRGF contingency EVA. All temperatures are enveloped by NCR-EVA-XA002.

SIGNATURES			
SUBMITTED BY:			
AUTHOR			DATE
	TRENT MARTIN		12/10/08
PROGRAM MANAGER OF SUBMITTING ORGANIZATION OR GFE PROJECT MANAGER			DATE
CONCURRENCE			
AFFECTED AIT/SPRT/FIT	DATE	FLIGHT EQUIPMENT SAFETY AND RELIABILITY REVIEW PANEL (FESRRP)	DATE
			1/6/2009
AFFECTED AIT/SPRT/FIT	DATE	SAFETY REVIEW PANEL (SRP/PSRP)	DATE
ISS S&MA PANEL	DATE	SHUTTLE S&MA PANEL	DATE
APPROVAL			
ISS CHIEF S&MA OFFICER	DATE	SHUTTLE CHIEF S&MA OFFICER	DATE
ISS INDEPENDENT TECHNICAL AUTHORITY	DATE	SHUTTLE INDEPENDENT TECHNICAL AUTHORITY	DATE
ISS PROGRAM MANAGER	DATE	SHUTTLE PROGRAM MANAGER	DATE

* Approved as Equivalent Safety.



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July 28, 2008

To: J. C. Tutt ESCG
Via: J. L. Cox *JLC* ESCG
Reviewed by: A. H. Milliken *A.H.M.* ESCG
From: E. L. Yagoda ESCG
Revised by: C. S. Clark ESCG

Subject: **Alpha Magnetic Spectrometer (AMS-02) EVA Touch Temperature Evaluation**

Note: This document was revised to correct typos in a referenced document and transposed results in the Conclusions section.

1.0 Summary

This report presents an Extra Vehicular Activity (EVA) touch temperature evaluation of the Alpha Magnetic Spectrometer (AMS-02). EVA interfaces that were designed to be touched by the EVA Mobility Unit (EMU) include the handrails, the Flight Releasable Grapple Fixture (FRGF), the Power and Video Grapple Fixture (PVGf), the EVA connector panel, and the Remotely Operated Electrical Umbilical (ROEU). In addition to the EVA interfaces, an addition investigation was done in order to determine if any of the external portions of the payload that can be touched or bumped during EVA operations exceeds the incidental contact limits.

Craig S. Clark
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2.0 Introduction

The AMS-02 is a large external attached payload that will be mounted to the International Space Station (ISS) S3 truss payload attach site. There are no planned EVAs associated with the AMS-02 but there are several contingency EVAs while attached to the ISS that must be considered. Requirements for the AMS-02 are defined in SSP 57003 [1].

3.0 Environmental Survey

Extensive analysis has been performed to determine extreme temperatures for the AMS-02 while it is mounted to the ISS. Results were calculated considering the entire range of solar beta angles (-75 to +75°) as well as the range of possible ISS attitudes. These cases were further analyzed assuming extreme hot or cold natural environments.

This data was used to find temperature extremes for all EVA interfaces. For cold temperatures it was also assumed that the payload would be powered off with heaters disabled for 20 hours. The results of this survey are shown in Table 1. Note that only the hottest and coldest handrails are included.

Table 1: Environmental Survey Results

Component Description	Attitude	Beta Angle	Submodel	Node Number	Max/Min Temp °F	Results
Handrails	-15+25-15	b-75c	HANDRL	1033	-78.4	Cold
	+00-20-15	b+75h	HANDRL	1013	182.6	Hot
Grapple Fixture	+00+00+15	b+00c	FRGF3	8	-75.4	Cold
	+15+00+00	b-75h	FRGF3	3	258.3	Hot
Grapple Fixture	-15+00-15	b-75c	PVGF	7	-72.5	Cold
	+00-20-15	b+75h	PVGF	8	221.5	Hot
Connector Panel	-15-20-15	b+00c	USS02	53100	-6.7	Cold
	-15+00-15	b-75h	USS02	53100	173.6	Hot
ROEU Clevis	-15-20+15	b+75c	ROEU	10	-61.0	Cold
	-15+25+15	b-75h	ROEU	10	154.2	Hot
ROEU Mount Brkt	-15-20+15	b+75c	ROEU	20	-68.3	Cold
	-15+25+15	b-75h	ROEU	20	134.0	Hot
ROEU PDA	-15-20+15	b+75c	ROEU	50	-59.1	Cold
	-15+25+15	b-75h	ROEU	50	111.8	Hot
ROEU Pin	-15-20+15	b+75c	ROEU	102	-62.5	Cold
	-15+25+15	b-75h	ROEU	102	120.7	Hot

4.0 EVA Touch Temperature Evaluation

An EVA touch temperature evaluation was performed using the methods outlined in SSP 57003 [1]. This document dictates that for unlimited contact with designated crew interfaces, temperatures shall be maintained within -45 to +145°F or heat transfer rates be limited as specified in Table 2. For incidental contact, temperatures shall be maintained within -180 to +235°F or heat transfer rates be limited as specified in Table 2.

Table 2: Heat Transfer Rates [1]

Object Temperatures	Contact Duration (minutes)	Boundary Node Temperatures (°F)	Linear Conductor (BTU/hr.°F)	Maximum Avg Heat Rate (BTU/hr)
Hot Object	Unlimited	113	1.149	45.52 (2)
	Incidental (0.5 max)	113	1.444	176.2 (3)
Cold Object	Unlimited	-40	1.062	±132.7 (2)
	Incidental (0.5 max)	-40	1.478	±325.2 (3)

Notes:

- (1) Positive denotes heat out of object, negative denotes heat into object.
- (2) Averaged over 30 minutes of simulated contact.
- (3) Averaged over 2 minutes of simulated contact.

If the touch temperature analysis fails to satisfy the above requirements, it is recommended that the EMU grasp limits outlined in JSC 28918 [2] be used to justify a waiver. This document dictates that for unlimited contact, EVA hardware temperatures shall be maintained between -80 to +150°F. If a particular component falls outside of these grasp limits, a heat rate analysis must be performed to ensure that the heat rate of any object does not exceed the maximum allowable average heat rates in Table 3. If any component fails to meet this criteria, grasp time limits are determined by the phase VI EMU glove palm limits which allow for a short duration grasp time for both "high pressure" and 1 PSI grasps [3]. Hardware that could be inadvertently touched by brushing or bumping during EVA shall be maintained within -244 to +320°F [2].

Table 3: 30 Minute Touch Temperature Heat Transfer Compliance [2]

Object Temperature (°F) Before Contact	Contact Duration (minutes)	Boundary Node Temperatures (°F)	Linear Conductance (BTU/hr.in ² .°F)	Maximum Avg Heat Rate (BTU/hr.in ²)
Greater Than 150	30	101	0.0033	0.205
Less Than -80	30	75	0.0033	-0.583

5.0 EVA Touch Temperature Results

Table 4 shows the results of the heat rate analysis for the method described in SSP 57003 [1]. All items passed this analysis with the exception of the FRGF and the EVA connector panel in the hot case. Table 5 shows that these two objects also fail the heat rate analysis of JSC 28918 [2]. The two right hand columns in Table 5 show the grasp times for these two items, per the phase VI EMU glove palm limits [3].

Table 4: Touch Temperature Results - Reference 1 Method

Component Description	Submodel	Node Number	Max/Min Temp °F	Unlimited Contact Analysis Required	Avg Heat Rate (BTU/hr)	Pass/Fail	Incidental Contact Analysis Required	Avg Heat Rate (BTU/hr)	Pass/Fail
Handrails	HANDRL	1033	-78.4	Yes	-53.5	P	No	NA	NA
	HANDRL	1013	182.6	Yes	41.6	P	No	NA	NA
Grapple Fixture	FRGF3	8	-75.4	Yes	-40.5	P	No	NA	NA
	FRGF3	3	258.3	Yes	46.9	F	Yes	163.6	P
Grapple Fixture	PVGF	7	-72.5	Yes	-40.5	P	No	NA	NA
	PVGF	8	221.5	Yes	34.3	P	No	NA	NA
Connector Panel	USS02	53100	-6.7	No	NA	NA	No	NA	NA
	USS02	53100	173.6	Yes	63.7	F	No	NA	NA
ROEU Clevis	ROEU	10	-61.0	Yes	-91.3	P	No	NA	NA
	ROEU	10	154.2	Yes	42.0	P	No	NA	NA
ROEU Mount Brkt	ROEU	20	-68.3	Yes	-101.2	P	No	NA	NA
	ROEU	20	134.0	No	NA	NA	No	NA	NA
ROEU PDA	ROEU	50	-59.1	Yes	-88.0	P	No	NA	NA
	ROEU	50	111.8	No	NA	NA	No	NA	NA
ROEU Pin	ROEU	102	-62.5	Yes	31.0	P	No	NA	NA
	ROEU	102	120.7	No	NA	NA	No	NA	NA

Table 5: Touch Temperature Results - Reference 2 & 3 Method

Component Description	Submodel	Node Number	Max/Min Temp °F	Contact Analysis Required	Avg Heat Rate (BTU/hr.in ²)	Pass/Fail	High PSI Grasp Time Limit (minutes)	1 PSI Grasp Time Limit (minutes)
Grapple Fixture	FRGF3	3	258.3	Yes	0.41	F	2.00	3.25
Connector Panel	USS02	53100	173.6	Yes	0.24	F	4.00	9.50

6.0 Incidental Touch Temperature Survey

A survey was done of all external surfaces (excluding soft goods) that can be inadvertently touched by brushing or bumping during an EVA operation. This survey was conducted for all surfaces at all attitudes and beta angles. The results of this survey indicated that a debris shield, node 60211, in the USS02 submodel reached a minimum temperature of -183°F. This temperature is outside the minimum incidental contact temperature stated in SSP 57003 [1] but is within the acceptable limits of those stated in JSC 28918 [2].

7.0 Conclusions

A touch temperature thermal evaluation of the AMS-02 was performed. EVA interfaces that were evaluated include the handrails, grapple fixtures, the EVA connector panel, and the ROEU. The results of this analysis showed that all the components passed touch temperature requirements as stated in SSP 57003 [1] with the exception of the EVA connector panel and the FRGF. Further analysis as described in References [2] and [3] result in an allowable high pressure and 1 PSI grasp times of 4.00 and 9.50 minutes respectively for the EVA connector panel. Similarly, the allowable high pressure and 1 PSI grasp times are 2.00 and 3.25 minutes respectively for the FRGF. The investigation to determine if any of the external portions of the hardware that can be touched or bumped during EVA operations exceeds the incidental contact limits revealed that the debris shield, reached a minimum temperature of -183°F. This temperature is outside the minimum incidental contact temperature stated in SSP 57003 [1] but is within the acceptable limits of those stated in JSC 28918 [2]. It is recommended that based on these results, a waiver be processed for these items.

References

- 1) "Attached Payload Interface Requirements Document", SSP 57003, Rev.C, NASA- Johnson Space Center, July 2006.
- 2) "EVA Design Requirements and Considerations", JSC 28918, NASA – Johnson Space Center, February 2005.
- 3) Bue, G., "EMU ISS EVA Thermal Environment Requirements for Certification", JSC 39117, NASA-JSC, May 2004.

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