CHANGE NOTICE

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THIS NOTICE INFORMS RECIPIENTS THAT THE DOCUMENT IDENTIFIED BY THE NUMBER (AND REVISION LETTER) SHOWN IN BLOCK 4 HAS BEEN CHANGED. THE PAGES CHANGED BY THIS CDCN BEING THOSE FURNISHED HEREWITH AND CARRYING THE SAME DATE AS THIS CDCN. THE PAGES OF THE PAGE NUMBERS AND DATES LISTED BELOW IN THE SUMMARY OF CHANGED PAGES COMBINED WITH NON–LISTED PAGES OF THE ORIGINAL ISSUE OF THE REVISION SHOWN IN BLOCK 4 CONSTITUTE THE CURRENT VERSION OF THIS DOCUMENT.

13. CDCN No.	14. Pages Changed (Indicate Deletions)	S*	A*	15. Date
016	Revision and History page	X		9/18/2001
	Pages 3–1, 3–2, and 3–3	X		
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016	Page C–22, C–23, C–24, C–25, C–26, and C–27.		X	
	Order of Incorporation DCN 009, 010, 011, 013, 012, 015, 016			

16. Technical Concurrence (Contracting Agency)	Date

* “S” indicates supersedes earlier page. “A” indicates added page.

REVISION AND HISTORY PAGE

REV.	DESCRIPTION	PUB. DATE
	Draft Revision B – SDR Version "Reference SSCBD 000008"	03–22–94
B	Revision B (Reference SSCBD 000008 R1, Eff. 6–3–94) Revised to Transition from Freedom to ISS. Changes include extensive simplification of requirements and scope.	09–30–94
C	Revision C (SSCD 000263, Eff. 09–04–96) Administration Update	01–29–97
	DCN 001 incorporates ECP 263 (Supplemental Release)	06–06–97
	DCN 002 incorporates SSCN 000588	05–13–98
	DCN 003 incorporates SSCN 000777	07–21–98
D	Revision D incorporates SSCN 001102	07–21–98
	DCN 004 incorporates SSCN 001405	01–12–99
	DCN 005 incorporates SSCN 001462	06–09–99
	DCN 006 incorporates SSCN 001662	06–09–99
	DCN 007 incorporates SSCN 001920	08–25–99
	DCN 008 incorporates SSCN 002107	08–27–99
E	Revision E incorporates SSCD 002345 Eff. 08–06–99	11–22–99
	DCN 009 incorporates SSCD 003213 Eff. 06–28–00	04–13–01
	DCN 010 incorporates SSCD 003690 Eff. 11–08–00	04–13–01
	DCN 011 incorporates SSCD 003746 Eff. 11–15–00	04–13–01
	DCN 013 incorporates SSCN 004676 Eff. 12–06–00	04–16–01
	DCN 012 incorporates SSCD 004140	08–31–01
	DCN 015 incorporates SSCN 005263	10–23–01
	DCN 016 incorporates SSCN 005529	10–23–01

ERU: /s/ M. Hehn 10–23–01

3.0 REQUIREMENTS

3.1 DEFINITION OF SPACE STATION ELECTRICAL BONDING REQUIREMENTS

The chassis or structure of all equipment which is operating from a common power source shall be bonded such that maximum electrical fault currents can be conducted without creating a thermal or electrical hazard. Electrical bonds between all equipment shall be made to minimize differences in potential. The criteria for bonding design shall be included in the Electromagnetic Effects (EME) Control Plan as specified in SSP 30243 and the actual design included in the EME Design Analysis Report.

3.2 CHARACTERISTICS

3.2.1 CLASSES OF APPLICATION

Where a single bond is used to serve two or more classes of application, the design shall conform to the more stringent requirement of bonding. Hardware providers shall analyze the application of the bond under evaluation and shall apply the class of bond that meets the functional requirements of the device, equipment, structure or interface in question. See appendix C for the exception (EMEP TIA–0216) to this paragraph. **DCN 009**

3.2.1.1 CLASS H BONDING (SHOCK HAZARD)

Class H bonds shall be applied to electrical and electronic equipment, assembled elements or structure and between mated, docked or berthed spacecraft. Class H bonding applies to nonpermanent interfaces such as mobile interfaces, direct current (dc) power sources or during docking or berthing. See appendix C for exceptions (Electromagnetic Effects Control Board (EMECB) Tailoring/Interpretation Agreement (TIA)–0067, EMECB TIA–0099, EMECB TIA–0179, EMEP TIA–0347, and EMEP TIA–0365) to this paragraph. **DCN 016**

3.2.1.1.1 RESISTANCE

Conductive conduit carrying electrical wiring shall have a low resistance bond of less than 0.1 ohm to conducting structure at each termination and breakpoint. The bonding path may be through the equipment at which the conduit terminates.

3.2.1.1.2 GROUNDING

Exposed conducting frames or parts of electrical or electronic equipment shall have a low resistance bond of less than 0.1 ohm to conducting structure. If the equipment design includes a ground terminal or pin which is internally connected to exposed parts, a ground connection to the terminal or pin shall be provided.

3.2.1.2 CLASS R BONDING (HIGH FREQUENCY POTENTIALS, ANTENNAS)

A Class R bond shall be applied where electronic devices require a low noise, near equipotential environment, a minimum potential drop or where the bond is part of a safety mandated, high frequency (minimum delay time) function such as fault clearing in the presence of an Intervehicular Activity (IVA) or Extravehicular Activity (EVA). See appendix C for exceptions (EMECB TIA–0038, EMECB TIA–0106, EMEP TIA–0251, EMEP TIA–0342, EMEP TIA–0347, and EMEP TIA–0365) to this paragraph. **DCN 011, 015, 016**

3.2.1.2.1 IMPEDANCE

All electrical and electronic units or components which use or produce electromagnetic energy shall be installed to provide a continuous low impedance path from the equipment enclosure to the conductive structure. The supplier shall demonstrate by test or analysis that the proposed bonding method results in a dc resistance of less than 2.5 milliohms across each faying surface in the bond path from enclosure to structure and an impedance of less than 100 milliohms up to a frequency of 1 megahertz. The bond from the equipment enclosure to the mounting plate furnished with the equipment shall also comply with these requirements, except that a suitable ground strap may be used across any necessary vibration isolators or other environment isolators. The impedance of the ground strap (length to width ratio no greater than 5 to 1) is not included in this measurement but the impedance of the faying surface to mating surface of the strap is. See appendix C for exception (EMECB TIA–0166) to this paragraph.

Bonds shall be noted on equipment and structure drawings that show bond surface preparation locations. All Orbital Replaceable Unit (ORU) to mounting surface and structural Class R bonds shall be tested for impedance during acceptance testing, or use processes that have been proven by coupon test to meet this bonding requirement, or have been specifically accepted by the EME Control Board. DC resistance measurements of bonds may be replaced by other in process measurements within a certified process.

The accepted process should address: Materials control, including types of acceptable materials for cleaning, surface prep, sealing, etc.; cleaning methods, including methods for cleaning faying surfaces prior to bonding, coating, etc.; surface preparation, including removal of paints and other nonconductive coatings, machining of surfaces to meet smoothness specifications, etc.; coatings and corrosion control, including definition of acceptable corrosion control coatings, methods for controlling corrosion, acceptable methods for controlling galvanic corrosion, etc,; quality assurance; and process control. The process should have supporting test data to verify repeatability and alternating current (ac) impedance. The list of EME accepted processes shall be maintained in D684–10263–01.

3.2.1.2.2 NEARBY CONDUCTORS

All conducting items having any linear dimension of 30 centimeters (cm) or more installed within one–fourth of the wavelength of the highest operating frequency of wiring carrying signals with frequencies that exceed 10 MHz, such as transmitting or receiving antenna lead–ins, shall have a bond to structure at least every interval that is one–fourth the wavelength of the highest operating frequency. Direct metal–to–metal contact is preferred. If a jumper/strap is used, the jumper/strap shall comply with the requirements of Class R bonds.

3.2.1.2.3 SPACE STATION STRUCTURE

Space Station structure shall be so designed that the conducting members provide a uniform low impedance path through inherent bonding during construction. Structure bond design shall include accommodation of the effects of operational vibration and resultant breakdown of insulating finishes or intermittent electrical contact. See appendix C for exceptions (EMEP TIA–0347) to this paragraph. **DCN 016**

3.2.1.3 CLASS S BONDING (STATIC CHARGE)

See appendix C for exceptions (EMEP TIA–0368) to this paragraph. **DCN 016**

3.2.1.3.1 CONDUCTING STRUCTURAL ITEMS

All isolated structural conducting items having an area greater than 100 square centimeters which carry fluids in motion, or otherwise are subject to frictional charging or plasma–induced current flow or charging, shall have a mechanically secure conducting connection to conductive structure. The resistance of the connection shall be less than 1 ohm. See appendix C for exceptions (EMECB TIA–0012, EMECB TIA–0015, EMECB TIA–0017, EMECB TIA–0018, EMECB TIA–0032, EMECB TIA–0076, EMECB TIA–0078, EMECB TIA–0099, EMEP TIA–0281, EMEP TIA–0345, EMEP TIA–0359, and EMEP TIA–0370) to this paragraph. **DCN 015, 016**

3.2.1.3.2 COMPOSITE MATERIALS

All composite structural materials which are subject to frictional charging or plasma–induced current flow or charging shall have a mechanically secure conductive connection to adjacent conductive structural items. The dc resistance between the composite material connection and the structure shall not exceed 1000 ohms.

APPENDIX A ABBREVIATIONS AND ACRONYMS

ac	alternating current	
AN	Army Navy	
BCB	Blanket Containment Box	**DCN 016**
BCI	bulk current injection	**DCN 016**
BRS	Blanket Restraint System	**DCN 015**
CETA	Crew and Equipment Translation Assembly	**DCN 015**
CI	Configuration Item	
CFRP	Carbon Fiber Reinforced Plastic	
cm	centimeter	
dB	decibel	
dc	direct current	
ECOMM	Early Communication	
ECU	Electronic Control Unit	**DCN 015**
EM	Electromagnetic	**DCN 016**
EMC	Electromagnetic Compatibility	
EME	Electromagnetic Effects	
EMI	Electromagnetic Interference	**DCN 016**
ESD	Electrostatic Discharge	**DCN 015**
EPS	Electrical Power System	**DCN 016**
EVA	Extravehicular Activity	
FCC	Flat Collector Circuit	**DCN 016**
FDS	Fire Detection System	**DCN 015**
FGB	Functional Cargo Block	**DCN 015**
FPC	Foam Pad Cover	**DCN 016**

FRAM	Flight Releasable Attach Mechanism	**DCN 015**
IP	International Partner	
ISS	International Space Station	
IVA	Intravehicular Activity	
JAN	Joint Army Navy	
kV	kilovolt	
m	meter	
mV	millivolt	**DCN 016**
μF	microfarad	
MDR	McDonald Dettwiler	**DCN 016**
MHz	megahertz	
MLI	Multi–layered Insulation	
MPLM	Mini–Pressurized Logistics Module	
MS	military standard	
MSS	Mobile Servicing System	**DCN 016**
MT	Mobile Transporter	**DCN 016**
No.	Number	
NPRV	Negative Pressure Relief Valve	
ORU	Orbital Replaceable Unit	
OTCM	ORU/Tool Change out Mechanism	
OTD	ORU Transfer Device	**DCN 015**
OTP	ORU Tool Platform	**DCN 015**
PCU	Plasma Contactor Unit	**DCN 015**
PFM	Pulse Frequency Modulated	**DCN 016**
pF	picofarad	

PN	Part Number	
psid	pounds per square inch differential	
PV	Photovoltaic	
RF	radio frequency	
SAW	Solar Array Wing	**DCN 016**
SGANT	Space to Ground Antenna	
SGTRC	Space to Ground Transmitter Receiver Controller	**DCN 015**
SPDM	Special Purpose Dexterous Manipulator	
SSP	Space Station Program	
TERA	Temporary Equipment Restraint Aid	**DCN 015**
TIA	Tailoring/Interpretation Agreement	
torr	unit of pressure	
TUS	Trailing Umbilical System	**DCN 016**
UMA	umbilical mechanism assembly	**DCN 016**
USL	U.S. Laboratory	**DCN 015**
Vdc	Volt direct current	

Rationale: The Latch Limit Switch is a passive mechanical device. There is no inrush or decay current when the switch operates. The BRS pin latch switch contact is designed to have an electrical characteristic of maximum 28 volts and 3 amps resistance load. This electrical data indicates that the switch should have less than 9.3 Ohms resistance. Therefore, the electrical bonding measurement of 24.3 milliohms, which is much less than 9.3 Ohms, is sufficient for the BRS to maintain a safe operation. **DCN 015**

The BRS limit switches provide a discrete signal to the Electronic Control Unit (ECU). The signal is nominally 5 Vdc (5.5 maximum) when the switches are open and approximately 1 to 2 milliamps when closed. This voltage and current are controlled by the ECU. **DCN 015**

There are three sections of wiring between the BRS limit switches and the ECU. Section 1 is the hookup wiring at the switches themselves, internal to the blanket box base structure. This wiring is shielded single conductor wire (22 AWG) (TBR) in a loop (seven switches in series). Total loop length is approximately 150 inches. Section 2 is from the hookup wiring to the Blanket Box to Mast Canister interface connectors – 1W4 (Left Blanket Box, reference 5835927) or 1W3 (Right Blanket Box, reference 5835926). This is all shielded twisted pair (22 AWG) and the length is approximately 40 to 50 inches. Section 3 is included in the Mast Canister Wiring harness 1W1 (reference 5835869). This wiring is a shielded twisted pair (22 AWG). Length is approximately 160 inches (to the Right Blanket Box) or 200 inches (to the Left Blanket Box). **DCN 015**

EMEP TIA–0345 **DCN 015**

C.3.2.1.3.1 CONDUCTING STRUCTURAL ITEMS **DCN 015**

Exceedance: When a Zero–G Softrack (CI 136644A) is stowed and attached to an ISPR, RSR, or RSP using kit 9K00626–1, a class S electrical bond path is not required from the ZSR frame to MPLM or ISS structure. **DCN 015**

Rationale:

A. The Zero–G Softrack is not powered and is not in any fault current paths. **DCN 015**

B. The ZSR frame should not be subjected to frictional charging located in a module. **DCN 015**

Enough incidental metal to metal contact between the ZSR frame seat track and ISPR, RSR, or RSP seat track should exist through the Flight Support Equipment to bleed off any charge which may accumulate. **DCN 015**

EMEP TIA–0347 **DCN 016**

C.3.2.1.1 CLASS H BONDING (SHOCK HAZARD),
C.3.2.1.2 CLASS R BONDING (HIGH FREQUENCY POTENTIALS, ANTENNAS),
C.3.2.1.2.3 SPACE STATION STRUCTURE **DCN 016**

Exceedance: The Mobile Transporter (MT) (CI 222201A, PN D60693000–1) shall be designated as mobile and portable equipment per the 3.2.1.1 requirements, whether positioned at a utility port or during translation. This designation will allow the MT to Truss structural ground path to be carried on the UMA cabling and TUS cabling. The alternative interpretation that 3.2.1.2 applies to the MT shall be rejected. Also, the interpretation that the MT is part of the Space Station low impedance structure as in 3.2.1.2.3 shall be rejected. The UMA cable is not required to pass the 3.2.1.2 bonding requirements, and is not required to provide an electrical ground path to structure meeting class “R” standards at its connector interface between the MT and Truss. **DCN 016**

Note: This interpretation has been made due to the advanced state of the MT design and pressure of launch schedules despite serious CSA concern that video interference problems may be experienced in orbit as a consequence. See CSA comments in the rationale section for details. **DCN 016**

Rationale: Boeing, CSA and McDonald Dettwiler (Space & Robotics) (MDR) engineers have worked together to analyze the worst case levels of interference that might be generated within the MT TUS cable forms as a result of the above. (See CSA–SS–RPT–0151 for a summary.) There is reasonable agreement on the levels and agreement that, even though the MT and MSS power and 1553 data bus interfaces are not a concern, the PFM video and synchronization interfaces might be a concern. **DCN 016**

No noise susceptibility threshold data existed for the PFM encoded video, and so characterization was performed on a flight representative PFM video link. CSA–SS–RPT–0159 summarizes and analyzes this test data. **DCN 016**

This test showed that differential mode noise voltages exceeding 5 mVrms and at 40 to 60 MHz would degrade the video and sync interfaces. At slightly higher noise levels, sensitive frequency ranges were 37 to 60, 79 to 109, 117 to 125, and 135 to 182 MHz (adjusted to 50 MHz PFM center frequency). At 60 mV of noise, the picture was lost entirely for any frequency within 1 to 400 MHz. **DCN 016**

The analysis of the predicted noise in the MT TUS PFM video and synchronization cables due to EM environment is presented in MDC99H0818A (Boeing) and MDR–SS–R–5672 (McDonald Dettwiler Robotics). These show that over the frequency range of 1 to 400 MHz, differential mode coupling interference levels of 100 to 230 mVrms are likely to be presented to the PFM demodulator (“worst case”), and suggest that a problem will exist in orbit. **DCN 016**

From these analyses, the performance of the video system and its susceptibility to the EM environment is estimated to be degraded by a factor of 10 to 20 times compared with the RS03 requirement and test level of 5 V/m, as a consequence of the lack of a low impedance ground path and class “R” bonds between the MT and Truss. **DCN 016**

Boeing performed a bulk current injection (BCI) test during integration of the flight equipment at Kennedy Space Center. The BCI test drive levels were 7.5 mA from 1 to 200 MHz and 90 mA from 200 to 400 MHz. This test is based on the CS114 test of MIL–STD–461E, used for military applications, and the RF susceptibility test method of RTCA DO–160D, used for verification of commercial aircraft. The test method has been validated based on actual measurements of aircraft wiring during radiated susceptibility testing. The advantage of the BCI method is that the driven current is monitored during test, insuring the cable is driven to the full specified level, with no consideration of field coupling variations. **DCN 016**

There was no evidence of interference through observed video test patterns, lock and stability of processing indicators, and final analysis of pixel displacement or bias. Extended dwell times were used at all intentional radiator frequencies, and all frequency bands noted as susceptible by analysis. **DCN 016**

Post test analysis has failed to fully resolve why the CSA and MDR test revealed cause for concern, but the integration test failed to confirm that. The integration test was conducted on a flight representative system and depended less heavily on analysis, and the Boeing and MDR analyses were from a worst case perspective and did not allow for the mitigating effect of the shielding afforded by other cables in a multi cable form. However, a satisfactory explanation of why the BCI test injection current of 7.5 mA is so much less than predicted by analysis (50 to 150 times) has not been obtained. The BCI test, as conducted with a test current of 7.5 mA, has not been shown by analysis to be representative of what will actually be experienced in orbit under radiated interference conditions for the system and lacking an adequate low impedance structural ground path. Therefore, CSA continues to have serious concern that interference problems may be experienced on orbit, but has to agree that at this late stage in the design and procurement process, there is no alternative but to approve this TIA. **DCN 016**

It is quite possible that no problems will be experienced in orbit, or that they will manifest infrequently, for very brief periods, or only at specific work stations or sections of orbits. The margin of error in the analysis prevents better clarification. There is no reason to believe that minor disturbances and degradation will affect operations or result in a safety hazard. If problems do prove to be excessive and intolerable, then a potential solution is the introduction of PFM video and synchronization amplifiers at the driven ends of the TUS cable form. **DCN 016**

NB Plasma discharges are not a concern in this context. A low resistance class ”H” bond is supplied to the MT and this is better than needed for static discharge protection. **DCN 016**

EMEP TIA–0358 **DCN 015**

C.3.2.1.3.1 CONDUCTING STRUCTURAL ITEMS **DCN 015**

Exemption: The redesigned 683–52353–12 Multi–Layer Insulation Blanket extension section (around the Airlock nitrogen connector) is allowed to be installed without the 3.2.1.3.1 class S bond to structure. **DCN 015**

Rationale: The 683–52353 is the assembly drawing for putting MLI blankets over the connectors on the Airlock. The MLI blanket (PN 683–52353–3) covers the N2 connector. The 683–52353–3 blanket contains both the top cover subassembly (PN 683–52353–11) blanket and the cylinder subassembly blanket (PN 683–52353–12). Originally the 683–52353–12 subassembly was 82 square centimeters. This amount of area is exempt from the 3.2.1.3.1 class S bonding requirement. The 683–52353–3 blanket itself has grounding provisions to meet the class S requirement. **DCN 015**

Because of thermal concerns that the N2 connector will overheat, the 683–52353–12 subassembly is being redesigned to extend further down the connector channel. The new area is now 122 square centimeters. This additional connector blanket material will be underneath the meteoroid debris shield. This additional blanket subassembly will not be exposed to charging mechanisms when in the shuttle or in its final on–orbit configuration. The debris shields are grounded to comply with the class S requirement. **DCN 015**

SSP 30245 is ambiguous about the permitted limits of unbonded MLI blanket areas. Paragraphs 3.2.1.3.1, 3.2.1.3.2, and 3.2.1.3.3 (for items with moving parts) require bonding to structure for items with greater than 100 square centimeters area. Paragraph 3.2.1.3.5 allows up to 200 square centimeters to go unbonded to structure. Paragraph 3.2.1.3.6 does not specify a specific maximum allowable unbonded area. Boeing Huntsville has been using 100 square centimeters as allowable. **DCN 015**

EMEP TIA–0359 **DCN 015**

C.3.2.1.3.1 CONDUCTING STRUCTURAL ITEMS **DCN 015**

Exception: The Flight Releasable Attach Mechanism (FRAM) (PN 1J00422) is not required to meet the 3.2.1.3.1 requirement while it is being moved from place to place or temporarily parked on EVA tools (CETA, TERA, OTD, SPDM OTP). **DCN 015**

Rationale: An exception to 3.2.1.3.1 is being sought for the following reasons. **DCN 015**

A. Flight rules require that EVA can only occur while the PCUs are operating. Therefore the maximum delta voltage between ISS and the plasma will be less than 40 volts. This voltage is not a shock hazard to the EMU. **DCN 015**

B. If the PCU is not operating during EVA (a violation of flight rules), the maximum delta voltage is 160 volts. The FRAM has relatively low electrical capacitance and will be unbonded for short periods of time, typically less than one week. Therefore the FRAM meets the requirements of an ESD class 2 unit (4000 volts). **DCN 015**

EMEP TIA–0365 **DCN 016**

C.3.2.1.1 CLASS H BONDING (SHOCK HAZARD),
C.3.2.1.2 CLASS R BONDING (HIGH FREQUENCY POTENTIALS, ANTENNAS)
DCN 016

Exceedance: Passive racks (i.e. unpowered racks) installed in the MPLM are not required to comply with the 3.2.1.1 and 3.2.1.2 (Class H and Class R bonding) requirements. **DCN 016**

Rationale: Unpowered racks do not pose a shock hazard to the crew. Any static build up will not pose a hazard to the crew. Equipment is protected through implementation of ESD safe handling procedures. The procedures are found in the flight assembly operations books and the in flight maintenance procedure books. **DCN 016**

EMEP TIA–0368 **DCN 016**

C.3.2.1.3 CLASS S BONDING (STATIC CHARGE) **DCN 016**

Exception: The Solar Array Wing (SAW) Blanket Containment Box (BCB) structure aluminized covers on the foam pads are not required to meet the 3.2.1.3.1 electrical bonding requirements. The pads e–bond test data is shown below: **DCN 016**

TABLE TIA–0368–1 Pads E–bond Test Data

Base Assembly:		
Number	Pads	Resistance (Ohm)
1	FCC pad inboard	Open
2	First pad from inboard after the FCC	3.6
3	All other 5	Open
Cover Assembly:		
Number	Pads	Resistance (Ohm)
1	1st pad from outboard FCC	2.5
2	All other 6	Open
		DCN 016

Rationale: The SAW EMI test results and analysis demonstrates that there will not be any impact to the SAW or Electrical Power System (EPS) performance if the aluminized pads of the SAW BCB assembly are not electrically bonded to the BCB structure. **DCN 016**

EMI Test:

EME ISS Solar Array Assembly Test Report (PN 5825973–503, dated August 12, 1995).
Configuration: 400 series connected solar cells, Flat Collector Circuit (FCC), round wire cable, and wing interface.
RS03 (Radiated susceptibility) “Pass”,
CS01 (Power line conducted susceptibility 30 Hz to 50 kHz) “Pass”,
CS02 (Power line conducted susceptibility 50 kHz to 50 MHz) “Pass”, and
CS06 (Spike susceptibility, power line) “Pass”. **DCN 016**

Analysis: **DCN 016**

TABLE TIA–0368–2 SAW EMI Test Analysis
(PAGE 1 OF 2)

Number	Environmental Interactions	Analytical Data	Location
1	Floating Potential (Unbiased Charging)	–0.89 volts	ISS Structure
2	Floating Potential (Biased Charging)	–140 volts	ISS Structure

TABLE TIA–0368–2 SAW EMI Test Analysis
(PAGE 2 OF 2)

3	Total Induced Potential (Magnetosphere)	Approximately 30 volts	ISS Structure
4	Local Induced Potential (Magnetosphere)	Approximately 6 volts	Foam Pad Cover Area of 2802 square centimeters
5	Local Induced Potential (Magnetosphere)	Approximately 4 volts	Foam Pad Cover Area of 556 square centimeters
6	Plasma arc electron scattering (dE/dt)max–area	80 V/m–sec	Foam Pad Cover Area of 2802 square centimeters
7	Plasma arc electron scattering (dE/dt)min–area	310 V/m–sec	Foam Pad Cover Area of 556 square centimeters
8	Plasma arc transient current	Approximately 1000 Amps	Locally anodized area of Solar Array Wing

DCN 016

The analysis concludes that the radiated scattering from the Foam Pad Cover (FPC) is much less than RS03 test. Considering a worst case plasma arc occurrence to be 1000 amps peak pulse, and the resistance of the FPC is calculated to be approximately 0.007 milliohms, the peak transient voltage during arc would be about 0.007 volts, which is much less than CS06 (+9.1 volts peak) test. **DCN 016**

No safety concerns exist because: **DCN 016**

1. The FPC pads are not used as a ground means to the ISS ORU, EPS, or safety ground. **DCN 016**

2. Astronauts will not have any activity near the FPC pads. **DCN 016**

3. Negligible ESD (microscopic) in orbit because the floating potential (unbiased charging – about 5 to 10 eV) is not sufficient to produce a noticeable or measurable ESD on the surface area of the FPC. The induced potential (magnetosphere is about 3E–5 Tesla) on the station structure will not exceed 30 volts. **DCN 016**

4. The astronaut's gloves are designed to withstand 4000 volts ESD without damage. **DCN 016**

5. No ESD hazard during launch because the FPC pads will be compressed within the SAW containment box assembly to establish an e–bond contact with the BRS. **DCN 016**

6. FW Number 3 and 4 will be relocated on orbit. There will not be any EVA concern. **DCN 016**

EMEP TIA–0370 **DCN 016**

C.3.2.1.3.1 CONDUCTING STRUCTURAL ITEMS **DCN 016**

Exceedance: The "Closeout Assembly, Endcone Softpacks – Prebreathe," (PN 683–42361–21, no CI number), is not required to meet the 3.2.1.3.1 requirements by having a class S electrical bond to structure. **DCN 016**

Rationale: Airlock Problem Report PR001272 has resulted in the creation of Assembly 683–42361–21 on the 683–42361 Revision D, Partition Assembly and Details – Airlock, drawing. This assembly has a 15 inch by 15 inch stainless steel screen sewn into the beta cloth to make a 13 inch by 13 inch vent port. The screen is not grounded. The picture shows the 683–42361–21 Assembly installed in the Airlock. **DCN 016**

The beta cloth into which the screen is sewn is nonconductive and does not attract charge to any degree. This isolates the screen. The screen is 4 by 4 wire mesh, welded joint, 0.032, 300 series corrosion resistant steel. **DCN 016**

Charging Mechanisms: Charge can be transferred to the screen by airborne dust or by swiping an equipment bag across the screen. The voltage, Vs, on the screen is given by Vs = q/C, where q is the charge on the screen and C is the capacitance of the screen. **DCN 016**

An estimate of capacitance can be obtained by computing the capacitance of a sphere of equivalent surface area. The surface area of the screen is as follows: A 15 inch by 15 inch screen has 61 by 61 wires. This gives 1830 inches of wire. The surface area is 1830 X π X 0.032 = 183.97 in^2 = 0.1187 m^2. The capacitance of a sphere is given by C = 8.854 pF/m X $(4\pi \text{ Area})^{0.5}$. An estimate of the capacitance of the screen is Cs = 8.854pF/m X $(4\pi \text{ X } 0.1187)^{0.5}$ = 10.81 pF. Cs = 10.81 pF. **DCN 016**

A limit criteria will be established to use as a measuring rod. A very conservative criteria is an energy of 2 mJ. 2 mJ is the energy it takes to initiate inception in a high dust environment. At an energy of 2 mJ, with 10.81 pF of capacitance, the voltage would be 19,236 volts. The case of bag swiping will be considered first. NOMEX has a surface resistance on the order of 1.5E11 Ohms per square. The charge decay rate is much less than 1 second. As a result NOMEX does not collect charge well at all. The equipment bags will be stacked on top of one another. One will have NOMEX in contact with NOMEX. Picking up a bag (i.e., separating two bags from one another) will not generate a charge. Since there will not be any charge collected on the bag, swiping an equipment bag across the screen will not transfer any charge to the screen. Swiping will not be a problem. **DCN 016**

The Space Station is equivalent to a 100K clean room environment, with 100,000 0.5 micron particles per cubic foot. The air speed in the area of the screen has been measured at the highest fan speed as about 73 feet per minute. The percent fill area of the screen is about 24 percent (i.e., there is 76 percent open area). The air flow will be across the screen and not through it. Assume a 0.16 inch boundary, and that there will be a charge of two electrons per particle and that the fan runs for 24 hours. Assume also that both electrons are transferred to the screen upon particle impact. There will be 4.27E7 particle hits in a 24 hour period. At two electrons transferred per particle hit, the total charge transferred to the screen is (1.6E–19 Coulomb/electron) X 2 electrons X 4.27E7 = 1.3664E–11 Coulombs. The voltage generated on the capacitor is V = q/C. V = (1.3664E–11)/(10.81 pF) = 1.26 volts. 1.26 volts represent an energy level of E = 0.5 X 10.81 pF X $(1.26)^2$ = 8.58E–12 J. Based on the criteria of 2 mJ the safety factor SF is SF = 2 mJ/8.58E–12 J= 233 million. **DCN 016**

Conclusion: There is no problem either from swiping an equipment bag across the screen or from particle impact charging. **DCN 016**