CHANGE NOTICE

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Space Station Electrical Bonding Requirements	All Units

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.

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015	Revision and History page	X		7/11/2001
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	Order of Incorporation DCN 009, 010, 011, 013, 012, 015			

16. Technical Concurrence (Contracting Agency)	Date

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

REVISION AND HISTORY PAGE

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	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
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	DCN 009 incorporates SSCD 003213 Eff. 06–28–00	04–13–01
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	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

ERU: /s/ M. Hehn 10–23–01

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, and EMEP TIA–0342) to this paragraph. **DCN 011, 015**

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.

3.2.1.3 CLASS S BONDING (STATIC CHARGE)

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 exception (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, and EMEP TIA–0359) to this paragraph. **DCN 015**

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.

3.2.1.3.3 CONDUCTIVE MECHANICAL SUBASSEMBLIES/PARTS

All moving parts having a surface area greater than 100 square centimeters and which are subject to frictional charging (charging mechanism required), e.g., gears, cams, rotary joints, etc., shall be equipped with a charge bleed off mechanism. This mechanism may take the form of bleed wire, wiper strap, conductive lubricant, etc. The bleed off path shall not exceed 1000 ohms to conductive structure. See appendix C for exception (EMECB TIA–0006, EMECB TIA–0029, EMECB TIA–0047, EMECB TIA–0099, EMEP TIA–0285, and EMECB TIA–0296) to this paragraph. **DCN 012, 015**

3.2.1.3.4 PIPE AND HOSE BONDING

All conductive pipes, tubes, and hoses that carry fluids shall have a mechanically secure conductive connection to conductive structure that shall measure 1 ohm or less. The pipe, tube, or hose installation shall not be the primary path for electrical power under normal or fault conditions. Nonconductive plumbing installations shall be designed so that the static voltage generated by fluid flow will not exceed 350 volts at any point outside the pipes, tubes, or hoses.

3.2.1.3.5 TRADITIONALLY HOMOGENEOUS STRUCTURAL MATERIALS

The traditionally homogeneous class of structural materials includes glass, quartz, surface coatings, polymers, plastics, etc. These materials cover a wide range of conductivities. In each case where Class S applies (in all cases where none of the other classifications applies), the bond methodology shall assure that no conductive surface area greater than 200 square centimeters is without a bond path from conductive layer to conductive structure. The bond resistance from the connection point to conductive structure shall be less than 1 ohm. For example, a metalized thermal blanket may have the dielectric surface exposed to the plasma as long as the metalized layers are grounded to conductive structure. See appendix C for exceptions (EMECB TIA–0136, EMEP TIA–0279, and EMEP TIA–0358) to this paragraph. **DCN 011, 015**

3.2.1.3.6 MULTILAYER INSULATION

Conductive layers shall be bonded together in at least two locations. The bonding resistance from those locations to structure shall be less than 1 ohm. See appendix C for exceptions (EMECB TIA–0120, EMEP TIA–0236, EMEP TIA–0292, and EMEP TIA–0294) to this paragraph. **DCN 010, 013, 012**

3.3 PROCESSES, METHODS, AND PROCEDURES

3.3.1 SELECTION OF MATERIALS

Materials and parts for electrical bonding shall be as specified herein. Materials specified in this document shall also be selected in accordance with SSP 30233.

3.3.2 STANDARD PARTS

Standard parts (Military Standard (MS), Army Navy (AN), or Joint Army Navy (JAN)) that comply with the requirements of this document shall be used for electrical bonding wherever suitable for the purpose intended and shall be identified on drawings by part numbers. Commercial standard parts such as screws, bolts, washers, nuts, and cotter pins that comply with the requirements of this document shall be permitted for electrical bonding in place of standard parts (MS, AN, or JAN).

APPENDIX A ABBREVIATIONS AND ACRONYMS

ac	alternating current	
AN	Army Navy	
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**
EMC	Electromagnetic Compatibility	
EME	Electromagnetic Effects	
ESD	Electrostatic Discharge	**DCN 015**
EVA	Extravehicular Activity	
FDS	Fire Detection System	**DCN 015**
FGB	Functional Cargo Block	**DCN 015**
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	

µF	microfarad	
MHz	megahertz	
MLI	Multi–layered Insulation	
MPLM	Mini–Pressurized Logistics Module	
MS	military standard	
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**
pF	picofarad	
PN	Part Number	
psid	pounds per square inch differential	
PV	Photovoltaic	
RF	radio frequency	
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	
USL	U.S. Laboratory	**DCN 015**

Vdc	Volt direct current

EMEP TIA–0281 **DCN 015**

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

Exceedance: The Fire Detection System (FDS) panels on Node 2 (CI 222180A) are not required to comply with the bonding specifications. Paragraph 3.2.1.3.1 requires that surfaces greater than 100 square cm and subject to frictional charging have a class S bond. **DCN 015**

Rationale: Due to the function of these panels the only time the FDS blankets will be subjected to triboelectric charging, due to airflow inside the cabin, is when the FDS closeout panels have been removed and that will only occur during maintenance. The closeout panel located immediately in front of the FDS blanket is a conductive honeycomb panel that is attached to the secondary structure via quarter turn fasteners. When the FDS closeout panel is in place the FDS blanket will contact the FDS closeout panel and therefore drain any accumulated charge. The FDS panels are made of betacloth and Kapton (a dielectric material) and are attached to the secondary structure via nonconductive hook and loop. Analysis indicates that less than 10 volts of charge will accumulate on the FDS blanket while it is exposed to the cabin airflow, well below the maximum voltage of 330 volts representing the threshold above which possible discharges can occur (per the Paschen law curve). **DCN 015**

EMEP TIA–0285 **DCN 015**

C.3.2.1.3.3 CONDUCTING MECHANICAL SUBASSEMBLIES/PARTS **DCN 015**

Exceedance: The following components are mechanically linked for the STS–250 task: crane support bracket PN SEG33113250–301, ORU translation device PN SEG33106254–303, crane interface adapter PN SEG33113300–301, and pressure dome (Russian hardware, part number unknown). **DCN 015**

The 3.2.1.3.3 bonding is not required between these components or between the support bracket and FGB. **DCN 015**

Rationale: None of the components listed are electrically powered. Each component is launched separately and is individually installed while on orbit, so ascent issues for bonding are not applicable. The Plasma Contactor Unit (PCU) will keep the ISS within 40 volts of the plasma potential. The unbonded components will only reach the plasma potential and will not have an electrical discharge issue due to this low voltage and the low capacitance of the crane. The full complement of components will remain stacked only for the duration of any one EVA (two are planned). Upon completion of the final EVA, the pressure dome is returned to earth via the shuttle. The crane interface adapter is removed from the crane and stowed or returned. Worst case extended duration stack includes the following: Crane attached to crane support bracket attached to Functional Cargo Block (FGB) handrails. A more likely case is to relocate crane to an alternate worksite interface, leaving only the support bracket attached to FGB handrails. **DCN 015**

EMEP TIA–0292 **DCN 012**

C.3.2.1.3.6 MULTILAYER INSULATION **DCN 012**

Exceedance: The multi layer insulation requirement specified in 3.2.1.3.6 shall be relaxed to allow the MLI blanket to have its EVA ground wire disconnected in between flights on–orbit. **DCN 012**

Rationale: The objective of grounding the MLI blanket is to protect the Space to Ground Transmitter Receiver Controller (SGTRC) equipment against the plasmas and electrostatic discharge (ESD) environment and to provide a safety ground for the crews. An exception can be made for a temporarily disconnected ground wire based on the following: **DCN 012**

A. The SGTRC is not operable when the ground wire is disconnected. The build up charges (about 5 to 10 volts) due to plasmas and ESD environment should not be of any concern. **DCN 012**

B. The ORUs, crew suits, and gloves are designed to withstand the ESD requirement of 4000 volts. **DCN 012**

C. The heaters on the SGTRC are activated on Flight 3A so that their sensors are not susceptible to the 5 to 10 volts of ESD and plasmas. The blanket is removed prior to TRC activation on either Flights 5A or 6A. **DCN 012**

When the MLI blanket is disconnected, the PCU will be operational and will prevent any charges that might be built up by the plasma or ESD environment. **DCN 012**

EMEP TIA–0294 **DCN 013**

C.3.2.1.3.6 MULTILAYER INSULATION **DCN 013**

Exceedance: Four MLI patch blankets used under the meteroid debris shield midspan brackets on the U.S. Laboratory (USL) (PN 683–52335–031, no CI number) are allowed not to be bonded to conducting structure in accordance with 3.2.1.3.6. **DCN 013**

Rationale: The additional MLI patch blanket sections are being added in response to recent thermal calculations showing a higher than acceptable heat loss. These patches are standard MLI blanket construction, but lack grounding wires. These patches are approximately 137 square centimeters in area. Items less than 100 square centimeters in area are exempt from class S bonding per 3.2.1.3.1. Homogeneous materials less than 200 square centimeters are exempt from class S bonding per 3.2.1.3.5. These patches will be installed in contact with other MLI blanket sections which are grounded to the USL structure via class S electrical bonds and will be underneath the outer meteroid debris shield. This shield is also grounded to the USL structure via class S electrical bonds. These MLI patch blanket sections will not be exposed to charging mechanisms. **DCN 013**

EMEP TIA–0296 **DCN 012**

C.3.2.1.3.3 CONDUCTIVE MECHANICAL SUBASSEMBLIES/PARTS **DCN 012**

Exceedance: The conductive mechanical subassemblies and part requirement specified in 3.2.1.3.3 shall be relaxed to allow an exception of no bond between the keel and the ITS Z1. **DCN 012**

Rationale: An exception to the 3.2.1.3.3 requirement is to not have an electrical bond between the keel and the ITS Z1 for the following reasons: **DCN 012**

A. The surface area (excluding the holes) of the keel structure is calculated to be about 333 square inches. The surface area of the ITS Z1 is calculated to be about 13,385 square inches. The charge that may build up on the keel due to the plasma and ESD environment is approximately 3 to 7 volts. Comparing it to the potential build up on the ITS Z1 (about 30 volts), the keel build up potential is negligible. There should not be any concern of an ESD during EVA operation. The crew suits and gloves are designed to the ESD requirement of 4000 volts. **DCN 012**

B. There is no ORU installed on the keel. **DCN 012**

C. No safety ground wire is connected to the keel. **DCN 012**

D. The keel is isolated from the ITS Z1, which means that there is no common mode current existing on the keel to cause any conducted or radiated emission. **DCN 012**

E. The keel will be relocated on the ITS Z1 structure only one time. **DCN 012**

During launch, there should not be any ESD voltage or current spike transfer between the shuttle and the ITS Z1 because there is a special longeron latch bond wiper installed on the ITS Z1 trunnion. This provides a class S bonding between the ITS Z1 payload and the shuttle. **DCN 012**

EMEP TIA–0342 **DCN 015**

C.3.2.1.2 CLASS R BONDING (HIGH FREQUENCY POTENTIALS, ANTENNAS)

DCN 015

Exception: The Blanket Restraint System (BRS) system may exceed the 3.2.1.2 class R bonding requirement by a maximum dc resistance of 24.3 milliohms. The test data is as follows: **DCN 015**

Right Blanket Box (milliohms)			Left Blanket Box (milliohms)		
Pin	Primary	Secondary	Pin	Primary	Secondary
1	3.1	2.7	1	2.7	2.9
2	3.3	2.4	2	24.3	6.2
3	2.9	(1)	3	(1)	2.8
4	(1)	(1)	4	(1)	2.6
5	(1)	5.9	5	(1)	(1)
6	3.8	12.6	6	2.8	5.2
7	4.0	3.9	7	3.5	2.5

Notes:
(1) Limit switch is not accessible for measurement. The assumption is that if the limit switches could be tested directly (1 mating surface), the limit switches pass the requirement of class R (less than 2.5 milliohms). **DCN 015**

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–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**