Pressurized Payloads Interface Requirements Document

International Space Station Program

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REVISION AND HISTORY PAGE

REV.	DESCRIPTION	PUB. DATE
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C	Revision C (Reference per SSCD 001822, EFF. 4/28/99). Revision C incorporates the following PIRNs: 57000-NA-0109B, 57000-NA-0111A, 57000-NA-0112A, 57000-NA-0113, 57000-NA-114D, 57000-NA-0115A, 57000-NA-0116C, 57000-NA-0117A, 57000-NA-0119B, 57000-NA-0120, 57000-NA-0121B, 57000-NA-122D, 57000-NA-0123A, 57000-NA-0126C, 57000-NA-0127B, 57000-NA-0128A, 57000-NA-0129A, 57000-NA-0130, 57000-NA-0131A, 57000-NA-0133A, 57000-NA-0135H, 57000-NA-136C, 57000-NA-0137,	07-08-99

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E	Revision E (Reference per SSCD 003132, Rev. F, EFF. 02-21-01). Revision E incorporates the following PIRNs: 57000-NA-0151H, 57000-NA-0161C, 57000-NA-0179, 57000-NA-0180, 57000-NA-0181C, 57000-NA-0182, 57000-NA-0183A, 57000-NA-0184A, 57000-NA-0185A, 57000-NA-0189, 57000-NA-0190B, 57000-NA-0191A, 57000-NA-0192, 57000-NA-0193B, 57000-NA-0194, 57000-NA-0195E, 57000-NA-0196, 57000-NA-0202, 57000-ES-0001A, 57000-ND-0003C	4-18-01
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-	IRN 0003 per SSCD 003664 R1, EFF. 06/07/02	08-29-02
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F	Revision F per SSCD 007441 - EARLY RELEASE SSCD 005453 R1 incorporates PIRNs 57000-NA-0134F, 57000-NA-0175C SSCD 006251 R1 incorporates PIRNs 57000-NA-0148B, 57000-NA-0176H, 57000-NA-0238A, 57000-NA-0241D, 57000-NA-0242, 57000-NA-0252C, 57000-NA-0255, 57000-NA-0258A, 57000-NA-0265 SSCD 006892 R2 incorporates PIRNs 57000-NA-0197D, 57000-NA-0253D, 57000-NA-0254B, 57000-NA-0260B, 57000-NA-0267, 57000-NA-0269B	07-31-03
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G	Revision G per SSCD 008152 – APPROVED Revision G incorporates the following PIRNs: 57000-NA-0188B, 57000-NA-0272A, 57000-NA-0273A, 57000-NA-0274A, 57000-NA-0276E, 57000-NA-0277D, 57000-NA-0278D, 57000-NA-0279, 57000-NA-0285, 57000-NA-0287B, 57000-ND-0005 Rev G closes SSCN 001510 which was incorporated by PIRN 57000-NA-0146A in Revision D. Rev G closes SSCN 002581 which was incorporated by PIRNs 57000-NA-0184A & 5700-NA-0185A in Revision E. Rev G closes SSCN 003410 which was incorporated by PIRN 57000-NA-0223D in IRN 0002. Rev G closes SSCN 003928 which was incorporated by PIRN 57000-NA-0253D in Revision F. Rev G closes SSCN 005389 which was incorporated by PIRN 57000-NA-0254B in Revision F.	08-24-04

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H	Program Release per SSCD 010612 Rev H closes SSCN 002664 which was incorporated by PIRN 57000-NA-0286 in Revision H. Rev H closes SSCN 005144 which was incorporated by PIRN 57000-NA-0264B in Revision H. Rev H closes SSCN 008007 which was incorporated by PIRN 57000-NA-0297A in Revision H.	01-14-08
J	Revision J (Reference per SSCD 011605, EFF. 6/10/09). Revision J incorporates the following PIRNs 57000-NA-0204F, 57000-NA-0302B, 57000-NA-0303E, 57000-NA-0304B, 57000-NA-0309A, 57000-NA-0322A, 57000-NA-0328, 57000-NA-0329, 57000-NA-0331, 57000-NA-0332A, 57000-NA-0333, 57000-NA-0334A, 57000-NA-0336A, 57000-NA-0337A, 57000-NA-0338A, 57000-NA-0339A, 57000-NA-0340	08-19-09
K	Revision K (Reference per SSCD 012256, EFF. 05/26/10). Revision K incorporates the following PIRNs 57000-NA-0335B, 57000-NA-0341A, 57000-NA-0342, 57000-NA-0343, 57000-NA-0344C, 57000-NA-0345C, 57000-NA-0346, 57000-NA-0347, 57000-NA-0348A	07-20-10
L	Revision L (Reference per SSCD 012771, EFF. 06/10/11). Revision L incorporates the following PIRNs 57000-NA-0330A, 57000-NA-0349, 57000-NA-0350B, 57000-NA-0351A, 57000-NA-0353A	07-08-11

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N	Revision N (Reference per SSCD 013728, EFF. 08/02/13). Revision N incorporates the following PIRNs 57000-NA-0359, 57000-NA-0360A, 57000-NA-0361, 57000-NA-0362A, 57000-NA-0364C, 57000-NA-0365, 57000-NA-0366, 57000-NA-0367, 57000-NA-0369A, 57000-NA-0370	08-09-13
P	Revision P (Reference per SSCD 014225, EFF. 10/27/14). Revision P incorporates the following PIRNs 57000-NA-0352C, 57000-NA-0363C, (SSCN 012929) with PIRN 57000-NA-0363C, 57000-NA-0373B, 57000-NA-0374A, 57000-NA-0375, 57000-NA-0376, 57000-NA-0377, 57000-NA-0378, 57001-NA-0096B	11-12-14
R	Revision R (incorporating SSCN 014186 & 014480 and releasing per SSCN 015165, EFF. 11/4/15). Revision R is a total document update.	06-22-16

ERU: /s/ Sheree' Phillips & Beth Mason 06-22-16

PREFACE

This document defines sets of requirements that apply to International Space Station (ISS) pressurized volume payloads, dependent on their interfaces and design. The requirements in this document address launch/ascent, on-orbit, and descent/return physical interfaces and environments. This document is under the control of the Space Station Program Control Board (SSPCB). Any changes or revisions to this document will be delegated to the Multilateral Vehicle Control Board (MVCB) for approval.

ISS PROGRAM / PARTNER CONCURRENCE

NASA: 4/26/16
Kirk A. Shireman, ISS Program Manager — Date

ESA: See R1 Directive Signature — 6/1/16
Jesus Jimenez, Head of Columbus and Payload Engineering Section, Directorate of Human Spaceflight and Exploration — Date

JAXA: See R1 Directive Signature — 6/20/16
Yusuke Matsumura, Manager for Mission Engineering Integration, JEM Mission Operations and Integration Center, Human Spaceflight Technology Directorate — Date

DOCUMENT CONCURRENCE

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NASA Approval:	Paul Rathbun	10/27/15	Michael D. Miller	10/27/15
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APPENDICES

1.0 INTRODUCTION

1.1 PURPOSE

This Interface Requirements Document (IRD) is the principle source for interface design requirements for all National Aeronautics and Space Administration (NASA) developed payloads operating in the pressurized volume of the ISS, and for ESA and JAXA payloads operated in the USOS (all non-Russian modules except JEM and Columbus). Payload developers must verify the applicable requirements in this document to ensure the safety of the ISS crew, transport vehicles, on-orbit ISS systems hardware, and neighboring payloads. This document also provides design guidance that ensures the basic operation of the payload and affects the payload's mission success. It is the responsibility of the payload developer (PD) to design in accordance with the design guidance. ESA and JAXA payloads operated in their modules follow COL-RIBRE-SPE-0164 and NASDA-ESPC-2898, JPAH Vol. 1, respectively.

1.2 SCOPE

This document applies to all pressurized volume payloads, including sortie payloads which launch and return on the same transport vehicle and never transfer to the ISS, and any unpressurized payloads that launch in the pressurized volume of a transport vehicle. This document also applies to crossover payloads which transfer to the ISS for science operations and return on the same transport vehicle. Payloads that transfer outside the ISS from the pressurized volume must also meet all applicable requirements from SSP 57003, External Payload Interface Requirements Document. Command and Data Handling (C&DH) interface requirements in this document also apply to NASA- developed Japanese Experiment Module (JEM) Exposed Facility (EF) and Columbus (COL) Exposed Payload Facility (EPF) payloads. This document does not include interface requirements for the Russian partner modules.

Note 1: NASA payloads on the JEM EF must also comply with unique JEM Payload Accommodation Handbook, Volume 3, design requirements for C&DH.

Note 2: NASA payloads on the Columbus EPF must also comply with unique COL-RIBRE-SPE-0165, Columbus External Payload IRD, design requirements for C&DH.

This document addresses transportation requirements for payloads that are passively stowed in the Russian Space Agency (RSA) Progress or Soyuz, the Japan Aerospace Exploration Agency (JAXA) H-IIB Transfer Vehicle (HTV), the Space Exploration Technologies (SpaceX) Dragon, and the Orbital ATK Cygnus vehicles. This document also addresses transportation requirements for powered payloads that are hard mounted middeck lockers in the SpaceX Dragon and the Orbital ATK Cygnus vehicles. Pressurized payload power is only available on these two launch vehicles.

1.3 USE

This document provides interface design and verification requirements on ISS pressurized payloads and also provides interface design guidance necessary for the successful operation of the payload. The PD must also provide data deliverables applicable to their payload's design. These requirements, guidelines, and data deliverables are allocated to a payload through the payload unique ICD. The PD and the ISS Program must jointly agree on the interfaces and identify requirements as applicable if the interface exists, and not applicable if the interface does not exist for the payload configuration documented in the ICD. This applies to physical and environmental interfaces. For requirements where exceptions are required because the payload will not meet an applicable requirement, the PD must provide an exception request to the ISS Program for evaluation. Implementation of design guidance is the responsibility of the PD as part of the payload's internal development and verification campaign. Resource allocations such as electric power or coolant are given as design guidelines (notated as "should"). When the total requested resource value exceeds the module capability, operational constraints may be applied.

All payloads must assess the general requirements in Sections 3.0 and 4.0. Depending on their transportation configuration and on-orbit configuration, a payload will have to assess requirements from at least one of the appendices. Each appendix has a Section 3 and Section 4, with requirements/guidelines and verification respectively, but with the appendix letter appended in front (for example, N.3.5.1 and N.4.3.5.1). Note that some appendices have requirement pointers to select requirements in other appendices within this book (for example, an EXPRESS subrack payload might be directed to Appendix N for Integrated Racks). This is done to avoid duplication of a requirement.

1.4 CONTROL AND MAINTENANCE

This IRD is controlled through the authority of the Multilateral Vehicle Control Board (MVCB). Changes to this IRD are made using the Preliminary Interface Revision Notice (PIRN) process. For the purposes of Certification of Flight Readiness (CoFR), PIRNs are applicable when the final signature is received from NASA.

2.0 DOCUMENTATION

Applicable and reference documents can be found in Section 5.0.

3.0 PAYLOAD INTERFACE REQUIREMENTS AND GUIDANCE

This document provides requirements, guidance, and information to be used by the payload developer to successfully integrate a payload into the ISS systems. This IRD includes several informational pointers to requirements in SSP 51700, Payload Safety Policy and Requirements for the International Space Station. These requirements are handled through the safety process. This IRD does not include a complete set of those safety requirements.

Unless specified as applicable to the USL, JEM, or COL, a requirement is applicable in all ISS modules except the Russian Segment.

Verification of Program Furnished Equipment by the Payload Developer is not required. However, the integrated experiment assembly, using Program Furnished Equipment, does need to be verified.

Responsibilities of the payload developer are allocated as follows:

A. "**Shall**" is intended to express a provision that is mandatory to ensure ISS systems, crew and other payloads are protected. Payload developers are expected to (1) meet these requirements found in both Section 3.0 of the main volume and in Section 3.0 of the appropriate appendices and (2) submit verification to the Program as described in Section 4.0 of the main volume and in Section 4.0 of the appropriate appendices.

B. "*Should*" is used to denote a guideline. Guidelines are provisions intended to ensure compatibility with a provided interface or service. The Program does not collect verification or process exceptions from the payload developer for these guidelines. Payload developers are expected to take the applicable guidelines into account during design to ensure the highest probability for mission success of the payload. In addition to affecting mission success, these guidelines also are put in place to make maximum use of critical Program resources such as crew time and upmass. Failure to meet the guidelines will inherently incur risk that may or may not be tolerable to the funding organization and may have adverse impacts on critical Program resource. In some cases, the funding organization, the payload developer, and the ISS Research Integration Office may agree to elevate a "*should*" guideline to a "**shall**" requirement. This will be documented in the payload's unique requirement set, and the payload developer will be required to submit verification to the Program for these items. Each guideline has an associated verification submittal statement that is intended to assist the payload developer with a recommended method for verification. The "Verification Submittal" associated with the guideline verification is used only in the case when a guideline is elevated to a requirement.

C. <u>Data Deliverable</u> specifies information that is mandatory for the payload developer to provide to the ISS Program. This information is used for system integration analyses to ensure the functionality of ISS systems and the compliance with system-level requirements, the appropriate use of ISS resources, and to ensure authorizations have been obtained from selected Program offices such as the Radio Frequency Manager and IPLAT.

D. "Must", "will", "may", and so on, are associated with informational statements only and do not imply any additional verification be provided to the Program.

3.1 STRUCTURAL/MECHANICAL, MICROGRAVITY, ANGULAR MOMENTUM DISTURBANCE, AND PROTRUSION INTERFACE REQUIREMENTS

3.1.1 STRUCTURAL/MECHANICAL

3.1.1.1 LOADS REQUIREMENTS

3.1.1.1.1 ON-ORBIT LOADS

Payloads *should* provide positive margins of safety for on-orbit loads of 0.2 g acting in any direction.

3.1.1.1.2 CREW-INDUCED LOADS

Payload safety-critical structures **shall** (and other payload structures *should*) provide positive margins of safety when exposed to the crew-induced loads defined in Table 3.1.1.1.2-1. Items mounted to a Bogen Arm or that are handheld/worn are exempt from this requirement.

TABLE 3.1.1.1.2-1 CREW-INDUCED LOADS

CREW SYSTEM OR STRUCTURE	TYPE OF LOAD	LOAD	DIRECTION OF LOAD
Levers, Handles, Operating Wheels, Controls	Push or Pull concentrated on most extreme edge	222.6 N (50 lbf), limit	Any direction
Small Knobs	Twist (torsion)	14.9 N-m (11 ft-lbf), limit	Either direction
Exposed Utility Lines (Gas, Fluid, and Vacuum)	Push or Pull	222.6 N (50 lbf)	Any direction
Rack front panels and any other normally exposed equipment	Load distributed over a 4 inch by 4 inch area	556.4 N (125 lbf), limit	Any direction

Legend:
ft = feet, m = meter, N = Newton, lbf = pounds force

3.1.1.1.3 SEAT TRACK ALLOWABLE LOADS AND MOMENTS

Payloads mounted to seat tracks **shall** limit loads and moments to less than the values shown in Table 3.1.1.1.3-1 for each individual axis, as well as the RSS values. X/Y/Z directions with respect to the seat track are shown in Figure 3.1.1.1.3-1. These limits pertain to the seat track only, and only at a single attach point. They do not account for the effect of multiple attachment points to the seat track. As a general guideline, a spacing of 20 inches between seat track attachment points will minimize the interaction between load points. The limits in the table below assume that the attachment payload has two studs engaging the track.

TABLE 3.1.1.1.3-1 SEAT TRACK ALLOWABLE LOADS AND MOMENTS

LOAD LIMITS	MOMENT LIMITS
X = 650 pounds	X = 1490 inch-pounds
Y = 650 pounds	Y = 1490 inch-pounds
Z = 650 pounds	Z = 1490 inch-pounds
RSS = 920 pounds	RSS = 2107 inch-pounds

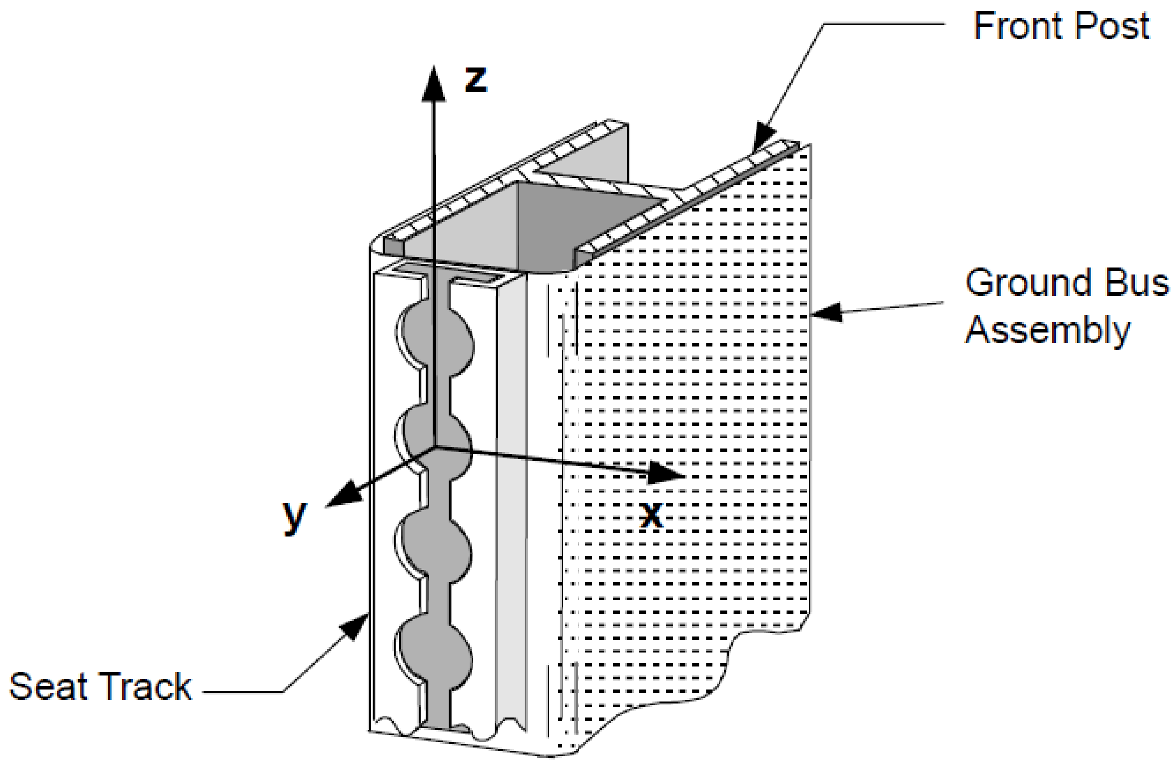


FIGURE 3.1.1.1.3-1 SEAT TRACK ORIENTATION

3.1.1.2 PORTABLE FIRE EXTINGUISHER DISCHARGE

Payloads with Portable Fire Extinguisher (PFE) access ports **shall** maintain positive margins of safety in accordance with SSP 52005 when exposed to the PFE discharge rate shown in Figure 3.1.1.2-1.

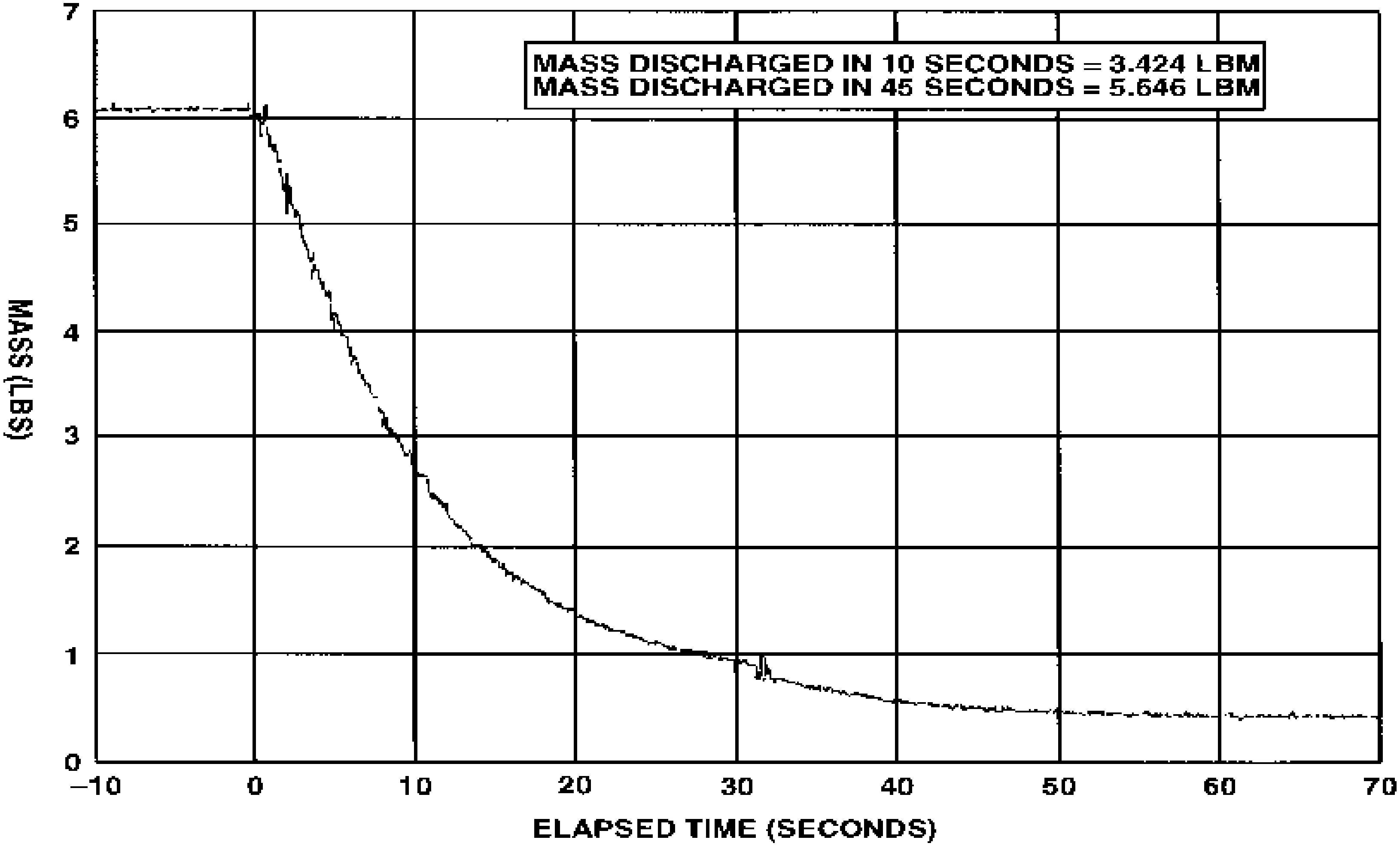


FIGURE 3.1.1.2-1 MANUAL FIRE SUPPRESSION SYSTEM PERFORMANCE CHARACTERISTICS AT THE RACK I/F

3.1.1.3 OVERPRESSURE RELIEF DEVICE

Payloads that have an overpressure relief device(s) **shall** not vent that device directly into the cabin aisle-way.

3.1.1.4 WINDOW PROTECTION

Optical instruments and payloads (camera lenses, telescopes, binoculars, etc.) that are handheld and intended for use with any ISS window **shall** incorporate bumper rings on the front, entrance pupil end of the lens that are coated with a flat black, matte finish, polyvinyl chloride (PVC) [Plastisol] coating (e.g. PolyOne Corporation’s Material DB2656B Black, Product Code FO00003723EV, utilized by U.S. Plastic Coatings Corporation) at least 1.524 mm (0.06 inch) thick to prevent damage to the window panes. Payloads that are designed to be secured/mounted to the WORF facility on the WORF rack payload support shelf prior to retraction of the WORF Bump Shield or opening of the AgCam/ISSAC Bump Shield Door utilizing mounts other than the WORF Small Camera Bracket (SCB) that have hard stops to prevent lenses from entering the 1.27 cm (0.5 inch) Keep Out Zone (KOZ) of the inboard surface of the primary pressure pane of the window are exempt from this requirement.

3.1.1.5 SECURING OF THREADED FASTENERS

Threaded fasteners connecting safety-critical structures (and threaded fasteners used in an application of retaining a rotating device) **shall** be safety cabled or cotter pinned as a means of positive locking. Safety wire can be used if on-orbit removal is not required.

Design Guidance: Drawings must clearly depict the safety wiring or safety cable method and configuration used (per MIL-STD-MS33540, Safety Wiring and Cotter Pinning, General Practices for, as applicable). Threaded inserts must be used in applications that require tapped holes in aluminum, magnesium, plastics, or other materials that are susceptible to galling or thread damage. When self-locking features are used, the screw length must be sufficient to fully engage the locking device with a minimum of two thread protrusion through the locking mechanism. When self-locking devices are used, an allowable range of running torque, or the maximum number of reuses that would still ensure an adequate lock, must be specified. Spring-type or star-type lock washers must not be used. Adjustable fittings or mounting plates which use oversized holes or slotted holes to provide adjustment must not be dependent upon friction between the fitting or mounting plate and the mounting surface to provide locking. Diamond-type serrations must not be used. Random vibrating testing of the as-used configuration may not be used to justify a waiver to this requirement.

3.1.1.6 REDUNDANT THREADED FASTENERS LOCKING REQUIREMENTS

Redundant threaded fasteners (non-fracture critical) in habitable areas or removable on-orbit *should* employ self-locking threaded devices such as safety wire, safety cable, cotter pins, built-in self-locking features, or approved thread-locking compounds.

Design Guidance: Random vibration testing of the as-used configuration may be used as supporting data to request a waiver to this guideline.

3.1.2 MICROGRAVITY

Microgravity requirements for EXPRESS subrack payloads, non-rack payloads, and integrated racks are addressed in their respective appendices.

3.1.3 LIMIT ANGULAR MOMENTUM DISTURBANCE

3.1.3.1 LIMIT DISTURBANCE INDUCED ISS ATTITUDE RATE

Payloads with individual rotating parts with a mass greater than 2 kg or with rotating parts that gimbal **shall** limit any non-transitory disturbance (disturbance duration greater than 10 seconds) induced on the on-orbit Space Station by an individual disturbance source to an angular momentum impulse of less than the per axis values shown in Table 3.1.3.1-1 during any continuous nine minute period. Any non-transitory disturbance source that generates a total angular momentum impulse less than 100 ft-lb-sec (135 N-m-sec) in a 110 minute period can be ignored with respect to this requirement.

TABLE 3.1.3.1-1 MAXIMUM ANGULAR MOMENTUM IMPULSE

Axis	Hx	Hy	Hz
Ft-lb-sec	930	1277	2876
N-m-sec	1261	1732	3900

Note:
(1) Where Hx, Hy, and Hz are the absolute values of the x, y, and z components of the disturbance angular momentum impulse relative to the Assembly Complete center of mass, XISS = -17.66 ft (-5.38m); YISS = -1.32 ft (-0.40 m); and ZISS = +14.80 ft (+4.51 m) in the Space Station Analysis Coordinate System, as defined in SSP 30219, Figure 4.0-1.

3.1.3.2 LIMIT DISTURBANCE INDUCED CMG MOMENTUM USAGE

Payloads with individual rotating parts with a mass greater than 2 kg or with rotating parts that gimbal **shall** limit any disturbance (non-transitory or transitory) induced on the on-orbit Space Station by an individual disturbance source to an angular momentum impulse that produces an estimated Control Moment Gyroscope (CMG) momentum magnitude less than 10,000 ft-lb-sec (13,558 N-m-sec) during any continuous 110 minute period when evaluated per expression in Table 3.1.3.2-1. Any non-transitory disturbance source that generates a total angular momentum impulse less than 100 ft-lb-sec (135 N-m-sec) in a 110 minute period can be ignored with respect to this requirement.

TABLE 3.1.3.2-1 CMG MOMENTUM USAGE CALCULATION

Estimated CMG Momentum Usage	
ft·lb·sec	$\sqrt{(1.25 \times Hx + 1069)^2 + (1.25 \times Hy + 6885)^2 + (1.25 \times Hz + 779)^2} < 10{,}000$
N·m·sec	$\sqrt{(1.25 \times Hx + 1449)^2 + (1.25 \times Hy + 9334)^2 + (1.25 \times Hz + 1056)^2} < 13{,}558$

Notes:
1. Where Hx, Hy, and Hz are the absolute values of the x, y, and z components of the disturbance angular momentum impulse using the Assembly Complete center of mass, XISS = -17.66 ft (-5.38 m); YISS = -1.32 ft (-0.40 m); and ZISS = +14.80 ft (+4.51 m) in the Space Station Analysis Coordinate System, as defined in SSP 30219, Figure 4.0-1.
2. Where 1069, 6885, and 779 ft·lb·sec (and 1449, 9334, and 1056 N·m·sec) are the x, y, and z components, respectively, of the CMG angular momentum allocation for environmental disturbances.

3.1.4 PROTRUSIONS

The ISS Program maintains crew egress and translations paths, and hardware clearance zones for the internal configuration of the ISS modules as specified in SSP 50261-01, Generic Groundrules, Requirements, and Constraints Part 1: Strategic and Tactical Planning, Section 3.12. These egress and translation paths, and clearance zones, are analyzed each increment using models of the ISS interior and models of the payload and system hardware protruding into, or mounted in, the aisles. These egress and translation paths may bend and curve along the length of the modules to avoid obstructions caused by payload and system equipment protruding from racks or being used in the aisle. **Constraints are applied to payload hardware to ensure these paths are maintained as needed by planned operations.** The egress paths and clearance zones include:

- Emergency Egress Path; 32 inches by 45 inches
- Crew Translation Path; 50 inches by 72 inches (USL, JEM, COL), 32 inches by 72 inches (other modules)
- Equipment Translation Path, 50 inches by 50 inches
- Visibility and access to critical equipment and controls
- Clearance around environmental control and life support equipment and functions
- Clearances to allow for rotation of adjacent racks
- Interferences with other payload or system hardware

Constraints which may be associated with payload protrusions include:

- Removal of the protrusion during rack installation, equipment translation, and crew translation
- Removal of the protrusion if RMA is installed on the rack
- Removal of the protrusion to prevent interference with microgravity operations
- Removal or powering off of the payload if the protrusion blocks PFE access or the fire indicator
- Removal of the protrusion to eliminate interference with rack rotation(s)
- May limit the payload location
- May limit operation of the payload

Protrusions have a negative impact on crew operations and are to be minimized. Violations of the translation paths and clearance zones of SSP 50261, Part 1, Section 3.12, which cannot be cleared through constraints may require a Program approved waiver before the payload can be used.

3.1.4.1 PROTRUSION GUIDELINES

Non-permanent protrusions are for equipment that supports and/or provides the resources necessary to run an experiment, typically power/data cables and thermal hoses, and payload hardware which is typically left in place while in use, but does not interfere with crew restraints and mobility aids. Note that Paragraphs 3.12.4.1.6.2 and 3.12.4.2.1 require that payload hardware must be removable using hand operations and standard tools.

A. Payload hardware must be returned to its temporary or permanent stowed configuration when not being used.

B. Protrusions *should* not extend laterally across the edges of the rack or pass between racks.

Protrusions designed to fit inside the envelope shown in Figure N.3.1.3-1 will generally avoid constraints.

3.1.4.2 PROTRUSION DATA REQUIREMENTS

Data Deliverable: Provide a dimensioned drawing or 3D CAD model (see Note 1) identifying all protrusions for on-orbit payload operations including the following:

- A dimensioned drawing of each configuration, if there are multiple operational configurations (including any temporary stowage configurations)
- The swing envelopes of any doors or pullout volumes for any drawers
- The motion path envelope for any hardware that requires deployment and actuation
- List any constraints for placement of the hardware in the aisle

The drawing or model must identify each of the following (as applicable):

a) All PFE access ports
b) Payload power switch
c) Smoke indicator LED
d) All caution and warning labels

For Subrack Payloads:

- At a minimum, provide dimensions from the payload surface that mates to the EXPRESS backplate, to the furthest extensions of the various protrusions (including cables (See Note 2)).

For Facility Payloads:

- At a minimum, provide dimensions from the lower left GSE boss plane to the furthest extension(s) of any protrusions (including cables (See Note 2)).

For Non-rack (Aisle-deployed) Payloads:

- The payload must attach to ISS structure at some point. Provide dimensions from that mating surface to the furthest extension(s) of the hardware setup (including cables (See Note 2)) and the means of attachment (hook and loop fastener, seat track, bungee cord, etc.)

Notes:

1. A 3D CAD model will greatly shorten integration processing time and is encouraged to be provided, if at all possible. For IVA purposes, it is only necessary to show that which

is visible (i.e., the exterior shell and cables) or supports external structure. All interior detail can be deleted in order to limit model size and preserve any proprietary payload internal designs. If a 3D CAD model cannot be provided, then provide the requisite drawings to build a model.

2. While payloads may utilize EXPRESS or Program-provided cables, include in the drawing or model the minimal protrusion of the cable and connector from the payload front panel and the dimension from the payload front panel surface to the minimum bend radius of the cable for payload-provided cables. EXPRESS cable characteristics are provided in Table 3.1.4.2-1.

TABLE 3.1.4.2-1 EXPRESS CABLES, LENGTHS AND BEND RADII

Cable/Hose	Length inch (mm)	P/N	Outside Diameter inch (mm)	Min Bend Radius inch (mm)	Connectors/QDs	
					To Rack	To Payload
Data Cable	24.0 (609.6)	683-44267-1	0.813 (20.64)	2.4 (60.96)	MS27467T15F35P (Connector) M85049/36-14N05 (Backshell)	MS27467T15F35S (Connector) M85049/36-14N05 (Backshell)
	38.0 (965.2)	683-44267-2	0.813 (20.64)	2.4 (60.96)		
	54.0 (1,371.6)	683-44267-3	0.813 (20.64)	2.4 (60.96)		
Power Cable	24.0 (609.6)	683-44024-1	0.25 (6.35)	0.75 (19.05)	MS27467T17F6PN (Connector) (17 shell size) M85049/49-2-16 (Backshell)	NB6GE14-4SNT (Connector) (14 shell size) NB-S-14 (Backshell)
	38.0 (965.2)	683-44024-2	0.25 (6.35)	0.75 (19.05)		
	54 (1,371.6)	683-44024-3	0.25 (6.35)	0.75 (19.05)		
MTL Coolant Hose (Supply)	24.0 (609.6)	683-46094-6	0.86 (21.84)	4.00 (101.6)	683-16348-219	683-16348-219
MTL Coolant Hose (Return)	24.0 (609.6)	683-46094-7	0.86 (21.84)	4.00 (101.6)	683-16348-247	683-16348-247
MTL Coolant Hose (Supply)	60.0 (1,524.0)	683-46094-8	0.86 (21.84)	4.00 (101.6)	683-16348-219	683-16348-219
MTL Coolant Hose (Return)	60.0 (1,524.0)	683-46094-9	0.86 (21.84)	4.00 (101.6)	683-16348-247	683-16348-247
Vacuum Hose	38.5 (977.9)	683-46094-11	1.383 (35.13)	6.00 (152.4)	683-16348-60	683-16348-60
	62.0 (1,574.8)	683-46094-10	1.383 (35.13)	6.00 (152.4)	683-16348-60	683-16348-60
Nitrogen Hose	64.0 (1,625.6)	683-46094-5	0.70 (17.78)	3.00 (76.2)	683-16348-353	683-16348-353

3.1.5 DESCRIPTION OF PAYLOAD

<u>Data Deliverable:</u> Provide a top level description of the payload including the purpose of the experiment, a physical and functional description, modes of operation and unique payload characteristics. Include a drawing or photograph of the hardware identifying the major components and features.

3.2 ELECTRICAL INTERFACE REQUIREMENTS

3.2.1 ELECTRICAL POWER CHARACTERISTICS

Electrical power characteristics are specified in this section for two interfaces, Interfaces B and C, as depicted in Figure 3.2.1-1.

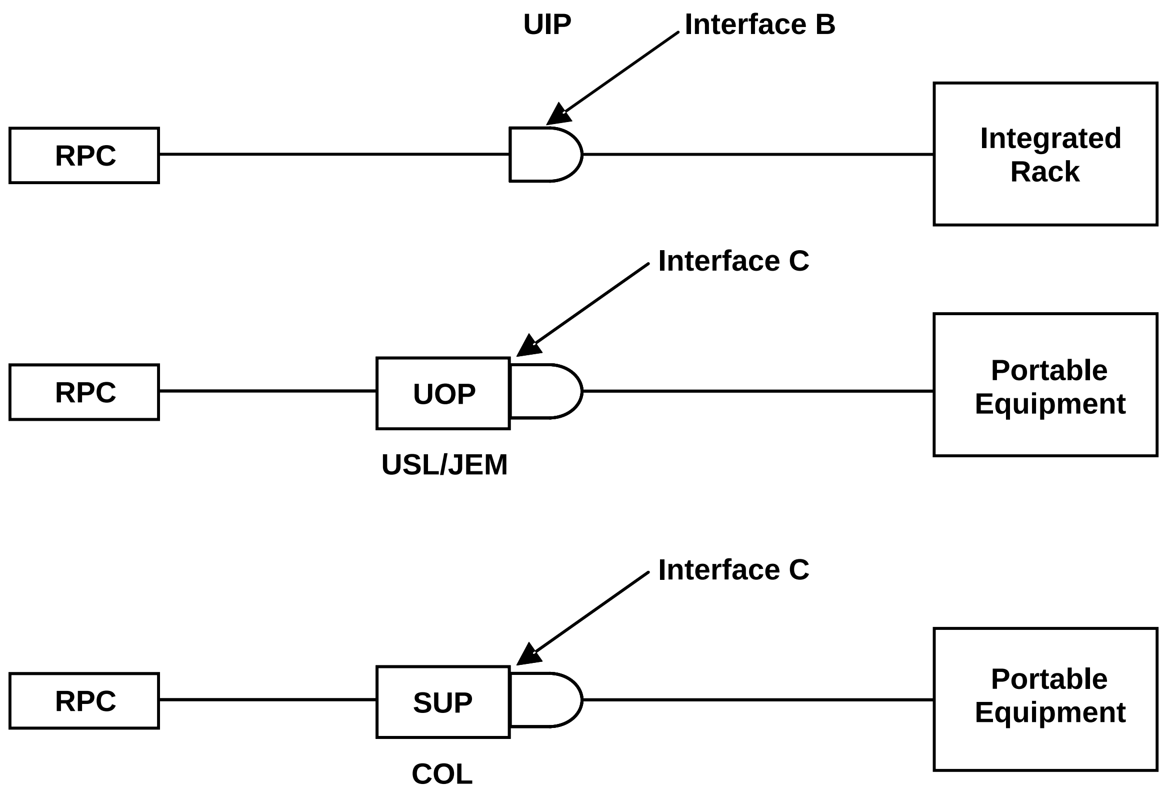


FIGURE 3.2.1-1 ELECTRICAL POWER INTERFACE LOCATIONS

3.2.1.1 POWER BUS ISOLATION

A. Payloads requiring power from two independent power inputs **shall** provide a minimum of 1 MΩ (1 megohm) isolation in parallel with not more than 0.03 μF (0.03 microfarads) of mutual capacitance within internal and external payload equipment at all times such that no single failure is able to cause the independent power inputs to be electrically tied. (Mutual capacitance is defined as line-to-line capacitance, exclusive of the Electromagnetic Interference [EMI] input filter.)

B. Payload internal power systems, and external Electrical Power Consuming Equipment (EPCE), **shall** not use diodes to electrically tie together independent power input or return lines.

3.2.1.2 CIRCUIT PROTECTION

3.2.1.2.1 CIRCUIT PROTECTION DEVICES

Overcurrent protection **shall** be provided at all points in the system where power is distributed to lower level (wire size not protected by upstream circuit protection device) feeder and branch lines in compliance with Table 3.2.1.2.1-1, Table 3.2.1.2.1-2, Table 3.2.1.2.1-3, Table 3.2.1.2.1-4, and Table 3.2.1.2.1-5.

TABLE 3.2.1.2.1-1 FUSE DERATING

Fuse current Rating (amperes)	Derating Factor (1) (2)	Remarks
2 - 15	0.50	Fuses are derated by multiplying the rated amperes by the appropriate Derating Factor listed. Rating at 25 °C ambient. Derating of fuses allows for loss of pressure, which lowers the blow current rating and allows for a decrease of current capability with time.(1)(3)
1 & 1.5	0.45	
0.5 & 0.75	0.40	
0.375	0.35	
0.25	0.30	
0.125	0.25	

(1) If calculations result in fractional values, use the next highest standard fuses rating.
(2) Derating factors are based on data from fuses mounted on printed circuit boards and conformally coated. For other types of mounting, consult the project parts engineer for recommendations.
(3) For cartridge style fuses or any fuses that are not heatsinked, an additional derating of 0.5 percent/°C above 25 °C ambient is required.

Fuse Derating Example:

The principal stress parameter is current:

A board expected to be operating at 90 °C ambient has a calculated maximum current of 1.0 A. The additional derating required due to temperature is calculated as shown:

$$\frac{0.5\%}{℃} \times (90\ ℃ - 25\ ℃) = 32.5\%$$

The total derating factor is calculated as follows:

$$50\% - 32.5\% = 17.5\%$$

The fuse rating is calculated as shown:

$$\frac{1.0\ A}{0.175} = 5.7\ A$$

A fuse with rating equal to or greater than 5.7 A is suitable in this circuit.

TABLE 3.2.1.2.1-2 CIRCUIT BREAKER DERATING

Contact Application	Contact Derating Factor	Maximum Device Thermal Rating
Resistive	0.75	20 °C above the specified operating temperature range
Capacitive	0.75(1)	
Inductive	0.40	
Motor	0.20	
Filament	0.10	
Circuit breaker contacts are derated by multiplying the maximum rated contact current (resistive) by the appropriate contact derating factor. (1) Use series resistance to ensure that circuits do not exceed the derated level.		

Circuit Breaker Derating Example:

The principal stress parameter is contact current.

A circuit breaker is to be selected to control an electrical motor rated at 17 A, full load, 24 Vdc. The circuit breaker is to be installed in an environment with an ambient temperature ranging from 10 °C to 30 °C.

The temperature derating is:

$$30\ ℃ + 20\ ℃ = 50\ ℃$$

The contact current derating is:

$$\frac{17\ A}{0.20} = 85\ A$$

This example, then, requires the use of a circuit breaker with a maximum thermal rating equal to or greater than 50 °C and a maximum contact rating of at least 85 A for this application.

TABLE 3.2.1.2.1-3 AMBIENT OPERATING TEMPERATURE FOR DERATING RELAYS AND SWITCHES

Temperature Extremes Under Which the Relay/Switch May Function				
Temp Range	-65 °C to -21 °C	-20 °C to +39 °C	+40 °C to +84 °C	+85 °C to +125 °C
Factor(1)	0.85	1.0	0.85	0.7

(1) The factors provided pertain only to contact loads, and they are intended for derating specified loads established in the governing specifications (resistive, inductive, motor, and/or lamp loads). The users are cautioned to use the contact voltages and nominal coil voltages (currents) prescribed in the governing specifications. Utilization of reduced coil voltages and abnormal contact voltages can potentially reduce the life of the relay and compromise relay operations.

The steps for relay/switch load derating are:

1. Select the appropriate load (resistive, inductive, motor, or lamp) and rating from the specification.
2. Determine the temperature range in the application. Select the appropriate factor from Table 3.2.1.2.1-3.
3. Determine the cycle rate in the application. Select the appropriate factor from Table 3.2.1.2.1-4.
4. Determine the load application. Select the appropriate factor from Table 3.2.1.2.1-5.
5. Calculate the derated load by multiplying the various factors together.

Derated Load = Load × Temp Factor × Cycle Rate Factor × Application Factor.

Other examples are as follows:

Example 1:

A 1.0 A relay is operated in an environment with a temperature range of +25 °C to +70 °C. The relay is cycled at a rate of 5 cycles per hour. The load application is make, break, and carry of a resistive load.
The worst case temperature is 70 °C. From Table 3.2.1.2.1-3 select 0.85.
The cycle rate is 5 cycles/hour. From Table 3.2.1.2.1-4 select 0.9.
The load application is specified as make, break, and carry. From Table 3.2.1.2.1-5 select 0.8.

Relay derating factor is 0.85 × 0.9 × 0.8 = 0.612. The derated contact load is 0.612 × 1.0 = 0.612 A resistive load.

Example 2:

A 10 A relay is operated in an environment with a temperature range of -40 °C to +35 °C. The relay is turned on for 3 minutes every 2 hours. The load application is carry only (resistive load).

From Table 3.2.1.2.1-3 select 0.85
From Table 3.2.1.2.1-4 select 0.85
From Table 3.2.1.2.1-5 select 1.5

TABLE 3.2.1.2.1-4 CYCLE RATE PER HOUR FOR DERATING RELAYS AND SWITCHES

Derating Factor for Nominal Cycle Rate			
	Cycle Rate Per Hour		
Cycle Rate	<1.0	1.0 to 10	>10
Factor(1)	0.85	0.9	0.85

(1) The factors provided pertain only to contact loads, and they are intended for derating specified loads established in the governing specifications (resistive, inductive, motor, and/or lamp loads). The users are cautioned to use the contact voltages and nominal coil voltages (currents) prescribed in the governing specifications. Utilization of reduced coil voltages and abnormal contact voltages can potentially reduce the life of the relay and compromise relay operations.

TABLE 3.2.1.2.1-5 LOAD APPLICATION RATE FOR DERATING RELAYS AND SWITCHES

Load Application	A	B	C
Factor(1)	1.0	1.5	0.8

Load A Make, break, and/or carry loads with an on-time duration of 0 to 500 milliseconds. Off time is equal to or greater than on time.

Load B Carry-only loads. Relay does not make or break the load. Maximum on time is 5 minutes. Off time is equal to or greater than on time. The word “carry” means that the relay contacts in question are closed, and there is current flowing through the contacts.

Load C Make, break, and/or carry. Those loads that do not fall into the category of loads A through B.

(1) The factors provided pertain only to contact loads, and they are intended for derating specified loads established in the governing specifications (resistive, inductive, motor, and/or lamp loads). The users are cautioned to use the contact voltages and nominal coil voltages (currents) prescribed in the governing specifications. Utilization of reduced coil voltages and abnormal contact voltages can potentially reduce the life of the relay and compromise relay operations.

3.2.1.2.2 WIRE DERATING

The payload wire derating scheme is shown in Figure 3.2.1.2.2-1.

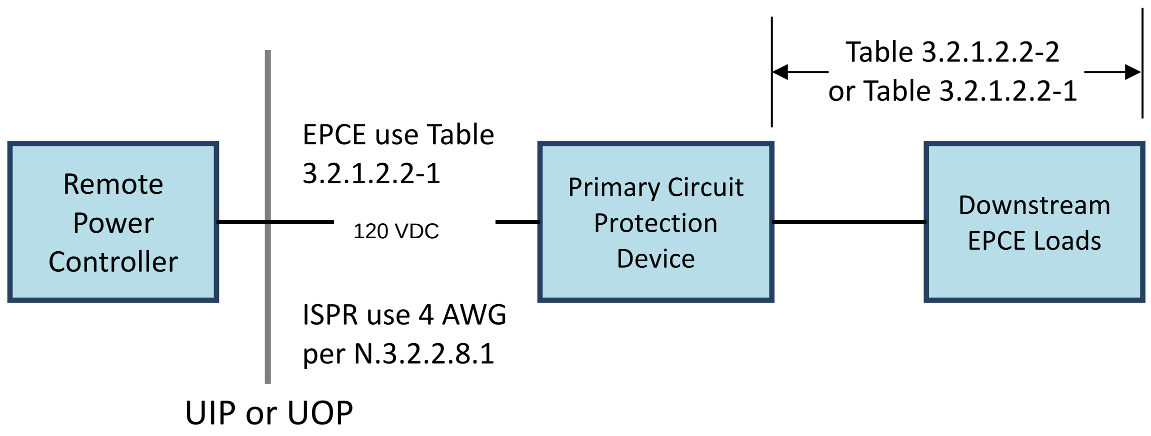


FIGURE 3.2.1.2.2-1 WIRE DERATING REQUIREMENTS FOR INTEGRATED RACKS AND EPCE

A. Wire derating criteria for wires and cables connected to 120 VDC (Interface B to the UIP or Interface C to the UOP) upstream of the payload primary protection device **shall** be per Table 3.2.1.2.2-1 and the criteria that follows.

Note: Integrated racks use 4 AWG per N.3.2.2.8.1 for main and auxiliary power feeds.

B. Wire derating criteria for wires and cables downstream of the payload primary protection device **shall** be per Table 3.2.1.2.2-1 and the criteria that follow, or Table 3.2.1.2.2-2 and the criteria that follow.

Note: For EXPRESS Rack payloads, the 28 Vdc power and return wire must be sized to carry 24 A to the payload’s first overload protection device. This maximum current considers two failures (incorrect setting of the SSPCM output to 20 A and a “Smart Short”).

TABLE 3.2.1.2.2-1 IVA SINGLE WIRE DERATING CRITERIA

Wire Size (AWG)	Maximum Nominal Allowed Single Wire Current (I_{SW}), amperes[1, 2, 3]	Maximum Wire Temperature for the Maximum Single Wire Current [1, 2]	Maximum Allowed Smart Short Current, amperes [4]	Maximum Wire Temperature for the Maximum Smart Short Current	Estimated Maximum Nominal Wire Temperature with Air Flow [7]
26	3.8	118 °C (242 °F)	4.9	179 °C (352 °F)	33.0 °C (91.0 °F)
24	5.4	118 °C (242 °F)	7.0	179 °C (352 °F)	35.3 °C (95.0 °F)
22	7.4	118 °C (242 °F)	9.6	179 °C (352 °F)	35.3 °C (95.0 °F)
20	10.0	118 °C (242 °F)	13.0	179 °C (352 °F)	40.3 °C (104 °F)
18	13.2	118 °C (242 °F)	17.2	179 °C (352 °F)	40.3 °C (104 °F)
16	15.0	118 °C (242 °F)	19.5	179 °C (352 °F)	38.1 °C (100 °F)
14	20.0	118 °C (242 °F)	26.0	179 °C (352 °F)	37.5 °C (99 °F)
12	29.0	118 °C (242 °F)	37.7	179 °C (352 °F)	43.1 °C (109 °F)
10	40.0	118 °C (242 °F)	52.0	179 °C (352 °F)	48.7 °C (119 °F)
8	63.0	118 °C (242 °F)	81.9	179 °C (352 °F)	42.0 °C (107 °F)
6	92.0	118 °C (242 °F)	119.6	179 °C (352 °F)	49.8 °C (121 °F)
4	120.0	118 °C (242 °F)	156.0	179 °C (352 °F)	51 °C (123 °F)
2	170.5	118 °C (242 °F)	221.6	179 °C (352 °F)	50.4 °C[5] (122 °F)
1/0	260.0	118 °C (242 °F)	338.0	179 °C (352 °F)	50.4 °C[6] (122 °F)

1. These currents are for wires on-orbit in cabin ambient at 22 °C (72 °F).
2. Deratings listed are for wire rated for 200 °C maximum temperature.
3. Wire with these currents and temperatures are not to be accessible to the crew.
4. This current is the 130% maximum fault current for circuit protection devices.
5. Maximum current to limit wire touch temperature to 122 °F for size 2 wire is 150 A.
6. Maximum current to limit wire touch temperature to 122 °F for 1/0 size wire is 210 A.
7. Data from Figure 3 of SAE AS 50881 at 60,000 feet altitude
8. When wire is bundled, the maximum design current for each individual wire is derated according to the following:

For N < 15	For N > 15
IBW = ISW × (29 - N)/28	IBW = (0.5) × ISW

Where: N = number of wires
IBW = current, bundle wire
ISW = current, single wire

TABLE 3.2.1.2.2-2 CURRENT CARRYING CAPACITY OF INSULATED PAYLOAD WIRING (AMPERES) (FROM SSP 51700 (TA-92-038))

Wire Gauge	150 °C Wire Rating	175 °C Wire Rating	200 °C Wire Rating
0	310.0	335.0	361.1
2	205.0	225.0	245.8
4	140.0	153.0	171.6
6	107.0	118.0	128.9
8	74.0	82.0	88.4
10	47.5	52.0	56.2
12	34.0	37.0	40.9
14	23.5	25.7	28.7
16	17.4	19.1	21.4
18	15.8	17.4	19.1
20	11.7	12.8	13.9
22	8.7	9.5	10.4
24	6.3	6.8	7.5
26	4.4	4.9	5.3

Notes:
1. Wire rating information is derived from extensive testing of MB0150-048 Orbiter wiring at JSC and applies to equivalent copper wiring with any type of insulation. For convenience, information pertaining to wire with insulation ratings of 150 °C, 175 °C, and 200 °C are shown. For wire ratings other than these, refer to JSC engineering publication TM 102179, “Selection of Wires and Circuit Protection Devices for NSTS Orbiter Vehicle Payload Electric Circuits”. Wire sizes smaller than 26 gauge are not recommended for use in payloads.
2. An ambient temperature of 22.2 °C is assumed for pressurized locations.
3. Current Carrying Capacity of Wire – Represents the maximum sustained current in amperes which the wire can carry in the specified environment and not experience a temperature that exceeds the temperature rating of the insulation material.
4. This table does not reflect wire bundle derating, nor does NASA JSC believe bundle derating to normally be necessary. This is due to the multitude of inter-related factors involved in bundling which can either enhance or degrade the current-carrying capacity of wire. However, in unique applications where a majority of wires in a bundle are heavily loaded simultaneously, the user may utilize the wire bundle criteria of Table 3.2.1.2.2-1, Note 8.

3.2.1.3 LOSS OF POWER

SSP 51700, paragraph 3.1.4.1 addresses Loss of Power.

3.2.1.4 ELECTRICAL GROUNDING AND ISOLATION

Adherence to the following requirements satisfies the ISS single point grounding scheme.

3.2.1.4.1 PAYLOAD POWER ISOLATION

Users of 120 Vdc or 28 Vdc power **shall** be DC isolated from chassis, structure, equipment conditioned power return/reference, and signal returns by a minimum of 1 megohm.

3.2.1.4.1.1 SINGLE POINT GROUND

Each isolated electrical power source **shall** be connected to structure at no more than one point.

3.2.1.4.1.2 ELECTRICAL POWER ISOLATION

Each isolated electrical power source **shall** be DC isolated from chassis, structure, equipment conditioned power return/reference, and signal circuits by a minimum of 1 megohm, individually, except at the single point ground.

3.2.1.4.1.3 SIGNAL CIRCUIT RETURN GROUNDING

Circuit conductors **shall** be DC isolated from chassis, structure, and equipment conditioned power return/reference, by a minimum of 1 megohm, individually, when not terminated by the signal circuit's single point ground/reference. Balanced, differential circuits isolated from chassis, structure, and user conditioned power return/reference by a minimum of 6000 ohms complies with this requirement.

Note: Signals circuits with frequency components equal to or above four megahertz may use controlled impedance transmission and reception media such as (but not limited to):

- shielded twisted 72 ohm cable
- "twin ax" cable balanced and referenced to primary structure at a single point
- "triax" cable using the center and inner shield conductors for unbalanced transmission, referenced to primary structure at a single point with the outer shield multipoint grounded as an "overshield".
- "coax" cable with the shield terminated 360 degrees at each end and at available intermediate point (permitted for signals with the lowest frequency component equal to or above 4 MHz).

3.2.1.4.1.4 ALTERNATING CURRENT POWER RETURN

A. Each AC power supply line **shall** return current on a neutral wire routed with the supply line.

B. The neutral wire **shall** be isolated from chassis at the load.

3.2.1.4.1.5 ANALOG, DIFFERENTIAL CIRCUIT RETURN

Each differential analog circuit **shall** employ a separate return.

3.2.1.4.1.6 DISCRETE RETURNS

Low level discrete signals **shall** use individual returns.

3.2.1.4.1.7 PULSE OR CLOCK CIRCUIT RETURNS

All digital, pulse, or clock circuits that do not use fiber optic cabling **shall** use individual returns.

3.2.2 ELECTROMAGNETIC COMPATIBILITY

This section establishes the design requirements for the control of the electromagnetic emission and susceptibility characteristics of ISS payloads. Electromagnetic Effects (EME) and EMI requirements and design guidelines are provided to protect ISS systems from unintended electrical noise and to ensure payload compatibility. The payload developer is referred to SSP 30237, Space Station Electromagnetic Emission and Susceptibility Requirements, which establishes the requirements and verification methods for electromagnetic emission and susceptibility characteristics of the payload.

In addition to requirements and verification, SSP 30237 provides additional guidance regarding verification methods. The requirements of this document are applicable to COTS. However, test data (or certificate of compliance, if applicable) collected during testing to show compliance with commercial EMI standards may be submitted for verification in lieu of testing.

3.2.2.1 ELECTROMAGNETIC EMISSION REQUIREMENTS

3.2.2.1.1 CE01 LIMITS

Payloads connecting to a 120 Vdc or 28 Vdc power source **shall** comply with the low frequency conducted emissions (CE) (CE01) limits defined in SSP 30237, 3.2.1.1.2.

3.2.2.1.2 CE03 LIMITS

Payloads connecting to a 120 Vdc or 28 Vdc power source **shall** comply with the high frequency CE (CE03) defined in SSP 30237, 3.2.1.2.2.

3.2.2.1.3 RE02 LIMITS

Payloads connecting to any power source or that are battery powered **shall** comply with the radiated emissions (RE) (RE02) limits defined in SSP 30237, paragraph 3.2.3.1.2.1, at 100 MHz and higher frequencies.

3.2.2.2 ELECTROMAGNETIC SUSCEPTIBILITY REQUIREMENTS

Safety-critical circuits are:

1. Circuits whose loss of function due to EME could result in a critical or catastrophic hazard or,
2. Circuits whose malfunction or degradation of performance because of EME that could result in a critical or catastrophic hazard or,
3. Circuits that control inhibits whose loss due to EME could result in critical or catastrophic hazards.

Note: Performance of conducted susceptibility tests are required to satisfy certain power quality stability requirements. Payloads that perform such testing but are not required to comply with the conducted susceptibility limits do not require exceptions if susceptibilities are noted during testing.

3.2.2.2.1 CS01 LIMITS

Payload safety-critical circuits connecting to a 120 Vdc or 28 Vdc ISS source **shall** not (and other payload circuits *should* not) exhibit any malfunction, degradation of performance, or deviation from specified indications beyond the tolerances indicated in the individual equipment or subsystem specification when subjected to electromagnetic energy injected onto its power leads less than or equal to the values as shown in the tables below. Table 3.2.2.2.1−1 is applicable for equipment powered by ISS 120 Vdc sources. Table 3.2.2.2.1−2 is applicable for equipment powered by internal 28 Vdc sources. (From SSP 30237, 3.2.2.1)

TABLE 3.2.2.2.1−1 120 VDC CS01 ELECTROMAGNETIC ENERGY INJECTION

Frequency	Voltage
30 Hz to 2 kHz	5 Volts root mean square (Vrms) or 10 percent of the supply voltage (E1), whichever is less
2 kHz to 50 kHz	Decreasing log linearly with increasing frequency from 5 Vrms, or 10 percent E1 whichever is less, to either 1 Vrms or 1 percent of E1, whichever is less

TABLE 3.2.2.2.1−2 28 VDC CS01 ELECTROMAGNETIC ENERGY INJECTION

Frequency	Voltage
30 Hz – 2 kHz	0.7 Vrms
2 kHz – 50 kHz	Decreasing log-linearly from 0.7 Vrms to 0.28 Vrms at 50 kHz

3.2.2.2.2 CS02 LIMITS

Payload safety-critical circuits connecting to a 120 Vdc or 28 Vdc ISS source **shall** not (and other payload circuits *should* not) exhibit any malfunction, degradation of performance, or deviation from specified indications beyond the tolerances indicated in the individual equipment or subsystem specification when subjected to the values as shown in the tables below. Table 3.2.2.2.2-1 is applicable for equipment powered by ISS 120 Vdc sources. Table 3.2.2.2.2−2 is applicable for equipment powered by internal 28 Vdc sources. (From SSP 30237, 3.2.2.2)

TABLE 3.2.2.2.2−1 120 VDC CS02 ELECTROMAGNETIC ENERGY INJECTION

Frequency	Voltage
50 kHz – 50 MHz	1 Vrms or 1 percent of E1, whichever is less

TABLE 3.2.2.2.2−2 28 VDC CS02 ELECTROMAGNETIC ENERGY INJECTION

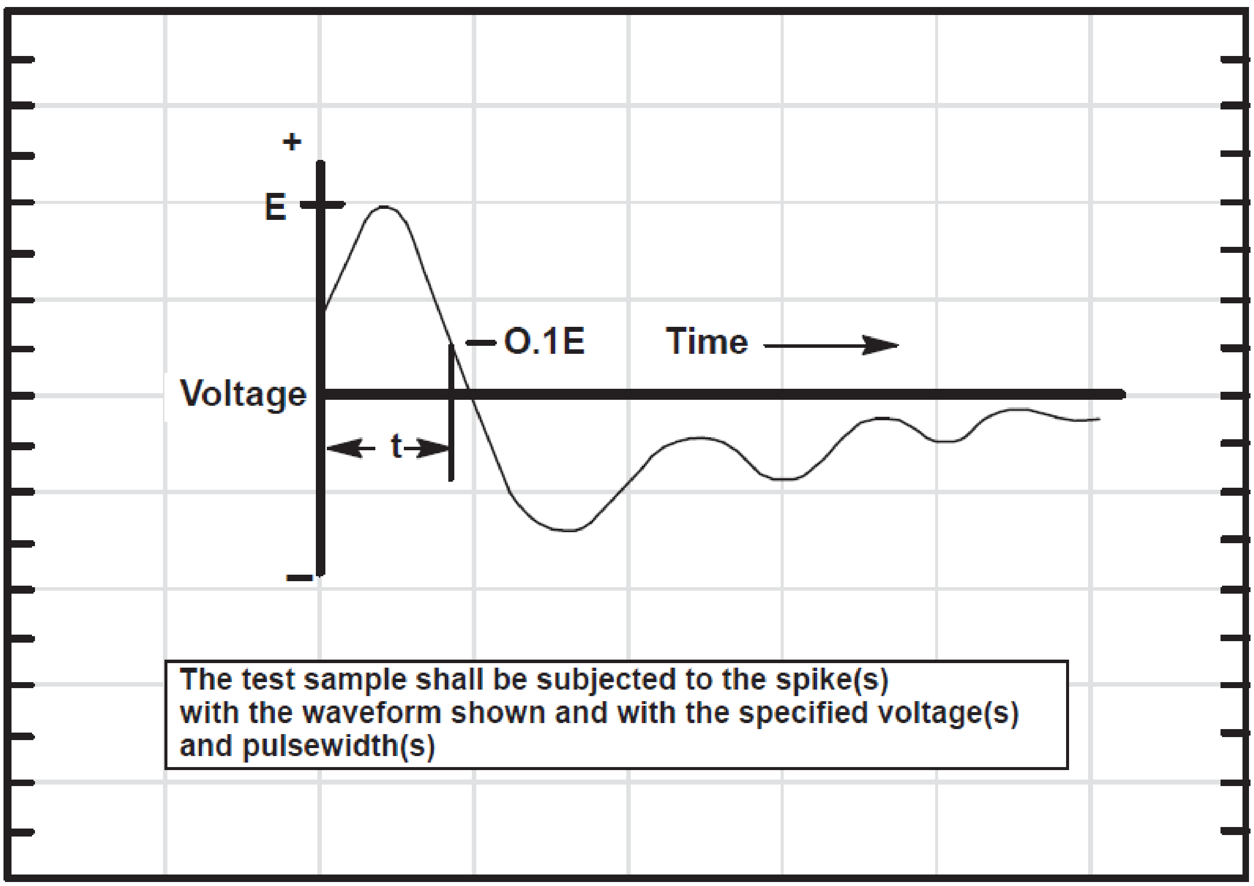
Frequency	Voltage
50 kHz – 50 MHz	0.28 Vrms

3.2.2.2.3 CS06 LIMITS

Payloads with safety-critical circuits connecting to a 120 Vdc ISS source **shall** not (and other payload circuits *should* not) exhibit any malfunction, degradation of performance, or deviation from specified indications beyond the tolerances indicated in the individual equipment or subsystem specification when the test spikes, each having the waveform shown on Figure 3.2.2.2.3-1, are applied to the DC power input leads.

Note: CS06 is applicable to DC power leads of equipment and subsystem powered by 120 Vdc sources, including grounds and returns, which are not grounded internally to the equipment or subsystem. (From SSP 30237, 3.2.2.3)

Note: Both the positive and negative spike will be applied to each lead under test. Each spike will be applied one time per lead instead of multiple spikes over the course of two minutes. The values of E and t are given below.



SPIKE #1 E = ± Twice the nominal line voltage, t = 10 microseconds ± 20 percent

FIGURE 3.2.2.2.3-1 CS06 EQUIPMENT LIMIT

Note: The waveform amplitude is imposed on top of the DC voltage. For example, the peak amplitude for a positive injection on a 120 Vdc EUT will be 360 V (240 V spike plus 120 Vdc)

3.2.2.2.4 RS03 LIMITS

Payload safety-critical circuits that are connected to any power source or that are battery powered **shall** (and other payload circuits *should*) meet the radiated susceptibility (RS) 03 limits defined in SSP 30237, paragraph 3.2.4.2.2, at 100 MHz and higher frequencies.

3.2.2.3 TIME-VARYING MAGNETIC FIELDS

Payloads containing devices that intentionally generate magnetic fields (electromagnets) **shall** not intentionally generate time-varying (AC) magnetic flux densities that exceed the levels in Table 3.2.2.3-1 below. This requirement applies at a distance of 7 centimeters (cm) from a point on the enclosure of the rack or equipment case nearest the source of the field. Requirements are not applicable to solenoid valves, solenoid relays, and electrical motors with current of less than 1 ampere.

TABLE 3.2.2.3-1 TIME-VARYING MAGNETIC FIELD LIMIT

Frequency	Magnitude (dBpt)
30 Hz	140
30 Hz to 3.5 kHz	Falling 26.5 dB/decade from 140 to 85
3.5 kHz to 50 kHz	85

3.2.2.4 STATIC MAGNETIC FIELDS

Payloads **shall** not generate static (DC) magnetic flux density exceeding 170 dB above 1 picotesla (3.16 Gauss) at a distance of 7 cm from the surface of the equipment while in the ISS and/or in a non-Russian transport vehicle. This applies to electromagnetic and permanent magnetic devices. This requirement is not applicable to solenoid valves, solenoid relays, and electric motors with current of less than 1 ampere.

3.2.2.5 CABLE/WIRE DESIGN AND CONTROL REQUIREMENTS

Table 3.2.2.5-1 describes the classification of signal types and required wire type to control cable coupled interference. The criteria for classification is further addressed in the following paragraphs. Wiring for signal types **shall** meet the minimum wire type (twisted, twisted shielded, twisted double shielded, etc.) defined in Table 3.2.2.5-1. The wire types given in Table 3.2.2.5-1 are general in nature and do not alleviate the responsible design groups from specifying the wire size, allowable capacitance, and attenuation characteristics.

TABLE 3.2.2.5-1 EMC CLASSIFICATION, WIRE TYPE, AND SHIELD GROUNDING

Frequency f: Rise, Fall Time (ms) $t_r > t_f$	Voltage or Sensitivity	Load Impedance (ohms)	Circuit Class	Minimum Wire Type	Shield Ground 1
Analog	≤ 100 mV	< 600 k	ML	TWS	MPG
(ac, dc)	≤ 100 mV	≥ 600 k	ML	TWDS	MPG
f ≤ 50 kHz	< 6 V	All	ML	TWS	MPG
$t_r > t_f \geq 10\mu s$	6 – 40 V	All	HO	TW	None
	> 40 V	All	EO	TW	None
50 kHz > f	< 100 mV	All	RF	TWDS	MPG
≤4 MHz $t_r > t_f \leq 10\ \mu s$	> 100 mV	All	RF	TWS	MPG
f > 4 MHz[1]	All	All	RF	TWS, Coax or Twin-ax	MPG
BWAD Fiber Optics	All	All	MO FO	TWS Fiber Optics	MPG

Acronyms and Abbreviations:

ML, HO, EO, MO, FO	Arbitrary Nomenclature to define Circuit Classification
MPG	Multiple Point Ground
RF	Radio Frequency
TW	Twisted
TWDS	Twisted Double Shielded
TWS	Twisted Shielded

Notes:

1) Shield grounding must be compatible with the circuit application.
2) The length of termination-to-ground lead for all circuits must be the minimum length practical.
3) The preferred method is to connect the shield peripherally to the back shell of the connector with a continuous impedance electrical bond path through both halves of the connector shell and the connector to mounting surface interface.
4) Digital signals must be classified as RF (and routed as wire type called out in this table).

3.2.2.5.1 SEPARATION REQUIREMENTS

All circuits routed together between equipment or enclosures in a bundle **shall** be of the same classification and be physically separated from other bundles per Table 3.2.2.5.1-1.

Notes: Best practices regarding circuit separation:

- Separate antenna cables from each other and from other wiring.
- Analyze circuits classified by sensitivity to determine if the source voltage will be detrimental to other circuits in the bundle and if it is necessary to isolate such circuit wiring from other wires in the classification.
- Circuits having different circuit classifications or redundancy codes and routed in the same area may not be commonly bundled but may be routed in a common connector if separation is maintained outside the connector.
- Make crossover of cable harnesses of different classifications as close to right angles as possible.
- Metallic channel separation is permitted in lieu of physical separation, provided that the channel separator height is no less than the largest cable bundle diameter requiring

separation. Identify the application of such metallic barriers in lieu of physical separation on all wiring diagrams containing these circuits.

- To determine cable bundle placement in all wire trays use minimum−to−maximum voltage or sensitivity requirements of Table 3.2.2.5.1-1, (e.g., separate to the maximum extent possible EO and RF cable bundles in the placement of adjacent wire bundles. Code such bundles with the circuit classification code, plus a numeric designator code to identify the redundancy classification, such as: ML−1, ML−2, EO−1, EO−2, etc.

TABLE 3.2.2.5.1-1 MINIMUM EDGE−TO−EDGE BUNDLE SEPARATION REQUIREMENTS (IN INCHES) FOR PARALLEL RUNS OF L FEET

Bundle Class	Parallel Bundle Class	Bundle Separation (In Inches)		
		L < 2 ft	2 ft ≤ L ≤ 8 ft	L > 8 ft
ML	HO	0	1	2
	EO	0	1	2
	RF	0	1	2
	MO	0	1	2
HO	EO	0	1	2
	RF	0	1	2
	MO	0	1	2
EO	RF	0	1	2
	MO	0	1	2
MO	RF	0	1	2

3.2.2.5.2 SHIELDING

A. Wire shields **shall** cover the twisted pair or twisted group rather than individual wires.

B. No shield **shall** intentionally carry current except for coax cables used with radio frequencies (4 MHz and above). Shielding within a flight element must be identified in the EME Design Analysis report. Shields originating and terminating within the same equipment may be grounded therein.

3.2.2.5.3 TERMINATIONS

A. Shields **shall** be terminated at both ends and at intermediate break points (ex: connectors) directly to structure or chassis, through connector backshells or direct wire connection.

B. The length of the termination−to−ground lead for RF circuits are to be the minimum practical and **shall** not exceed 3 inches. The preferred method is to connect the shield peripherally to the backshell of an RF connector. This requires a continuous low−impedance electrical bond path through both halves of the connector shell, the connector−to−chassis interface, and the chassis−to−ground. Unused electrical connectors must be covered with a conductive cap.

C. Overall Cable shields over a wire bundle **shall** be terminated peripherally at both ends and at intermediate break points (ex: connectors) directly to structure or chassis, through connector backshells or direct wire connection.

3.2.2.5.4 BREAKOUTS

A. Radio Frequency Interference (RFI) backshells with individual shield grounding provisions *should* be used for multiple shield terminations.

B. RF circuit shields *should* be broken out such that no more than 2 inches of wiring is exposed.

C. The wiring *should* be contained within the connector metal backshell covering.

3.2.2.5.5 WIRE TWISTING

Circuits that interconnect equipment must provide for minimum loop coupling and maximum field cancellation by twisting of return with high side.

A. Both signal and power circuits **shall** be twisted with their respective returns.

B. Multiple circuits using a common return **shall** be twisted as a group.

3.2.2.6 ELECTROSTATIC DISCHARGE

Payload safety-critical circuits **shall** (and other payload circuits *should*) be immune to damage from ESD events defined in Table 3.2.2.6-1 during normal installation, handling, and operations.

Note: Hardware that does not undergo test or analysis to show compliance with the ESD environment will no longer be labeled ESD sensitive.

TABLE 3.2.2.6-1 ESD ENVIRONMENT

Test Level	Discharge Method
8 kV	Contact discharge
15 kV	Air discharge Note: Air discharge testing is applicable to hardware with insulative surfaces (i.e. no exposed conductive surfaces suitable for contact discharge).

Note: This requirement applies, as a minimum, to hardware containing safety-critical circuits. It is recommended that all hardware, regardless of function or designation, perform a test or analysis to show immunity from Electrostatic Discharges (ESD) events. In order to reduce crew time and operational costs, ESD labeling and ESD-handling procedures by the crew will not be used to protect equipment that does not have a demonstrated level of immunity. Hardware that does not undergo test or analysis to show compliance with the ESD environment will no longer be labeled ESD sensitive. This requirement is intended to protect equipment, subsystems, and systems. It is not intended to protect individual electrical or electronic parts, subassemblies, or assemblies. When hardware operations require removal of lids, covers, access panels, or any partial disassembly that could expose internal electrical or electronic parts, subassemblies, or assemblies, ESD protective measures must be included as part of the operational procedure.

3.2.2.7 CORONA

Payload electrical and electronic equipment with voltages (steady-state, transient, internal, or external) greater than 190 volts or equipment containing gas mixtures other than those present in the pressurized module **shall** be designed to preclude damaging or destructive corona in its operating environment and during depressurization/repressurization events. Guidance for minimizing corona is found in MSFC-STD-531, High Voltage Design Criteria.

3.2.2.8 ELECTRICAL BONDING

The Payload must be electrically bonded to provide homogeneous electrical characteristics. Electrical bonds are classified according to purpose. Three classes of bonds are applicable to payloads: Classes H, R, and S, which are described in Table 3.2.2.8-1. Requirements for these bond classes are provided in the following paragraphs.

TABLE 3.2.2.8-1 ELECTRICAL BOND CLASSES

	Shock Hazard	**Radio Frequency**	**Electrostatic Charge**
Bond Class	**Class H**	**Class R**	**Class S**
Purpose of Bond	Protects against fire or shock to personnel. Applies to equipment and structure that may be required to carry fault current in case of an electrical short to case or structure	Protects equipment from RF emissions. Applies to equipment that could generate, retransmit, or be susceptible to RF. Includes antenna mounts and cable shield connections. Covers wide frequency range.	Protects against electrostatic discharge. Applies to any item subject to electrostatic or plasma charging.
Bond Requirement	Requires low impedance and low voltage across joints to prevent shock hazard or fire due to short. Jumpers and straps acceptable.	Requires low RF impedance at high frequency. Direct contact preferred. No jumpers. Short, wide strap may be used as last resort.	Allows moderate impedance. Jumpers and straps acceptable.
DC Bond Resistance Requirement	Bonding resistance requirement, 0.1 ohm or less.	Bonding resistance requirement, 2.5 milliohms or less. Low inductance required.	Typical bonding resistance requirement, 1.0 ohm or less.
Frequency Requirement	Low	High	Low
Current Requirement	High	Low	Low
Low frequency bonds allow use of straps and jumpers. High frequency bonds require low inductance paths. Short straps are sometimes acceptable. High current bonds require large cross sectional areas. Low current bonds allow use of small contact areas.			

3.2.2.8.1 SHOCK HAZARD - CLASS H

Payloads with 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.

3.2.2.8.2 RADIO FREQUENCY BOND - CLASS R

A. Payload elements containing electrical circuits which generate radio frequencies or circuits which are susceptible to RFI **shall** have a low impedance path to structure less than 100 milliohms up to a frequency of 1 MHz.

B. The DC resistance of the Class R bond between the payload and the ISS interface **shall** be less than 2.5 milliohms for each joint.

3.2.2.8.3 STATIC BOND - CLASS S

All conducting items subject to triboelectric (frictional) or any other charging mechanism **shall** have a mechanically secure electrical connection to the payload element structure with a resistance of less than one (1) ohm for each joint.

3.2.2.9 INTENTIONAL RADIATING AND RECEIVING

A Payload that has intentional radio frequency (RF) radiating and/or receiving devices **shall** transmit and/or receive only at the frequency approved and certified by the NASA Johnson Space Center (JSC) Frequency Spectrum Manager (FSM).

3.2.2.10 INTENTIONAL RADIATING AND RECEIVING CERTIFICATION

<u>Data Deliverable</u>: Provide an approved JSC Radio Frequency Authorization (RFA).

Note 1: A payload that has intentional RF radiating and/or receiving devices must be approved and certified by the NASA JSC FSM for the use of a specified frequency band and power levels for radiating and/or receiving signals. Approval can be obtained via electronic submittal through the JSC Frequency Management Home Page, http://ea.jsc.nasa.gov/webapp/fmdb/login.asp. A JSC RFA will be issued to requestor upon completion of the evaluation.

Note 2: ISS payloads will be certified for compatible/non-interference operation with existing ISS radio frequency operations. It is recommended that payloads coordinate with the JSC FSM to obtain intentional radiating and receiving compatible operating frequency options and preliminary certification prior to Preliminary Design Review (PDR).

Note 3: The typical time required for the JSC FSM to complete the ISS RF compatibility and KOZ analyses is 3-5 weeks. In order to meet the verification submittal due date of L-3 months, payload data must be submitted no later than 6 weeks prior to the L-3 month due date.

3.2.2.11 INTENTIONAL RADIO FREQUENCY EMISSION/OPERATION AUTHORITY

<u>Data Deliverable</u>: Provide approved coordination agreements, payload radio frequency parameters, and an equipment operating license for space operation in the specified operating frequency bands, as required by the applicable national or international regulatory agency.

Note 1: Radio frequency is a shared commodity. Any payload containing equipment with intentional radio frequency radiating capability is required to obtain an equipment operating license from the designated authority in accordance with the national or international regulations of the payload. The payload developer must request the frequency range agreed upon by the JSC FSM during the preliminary certification. In addition to fulfillment of regulatory requirements on the part of the payload, review and approval of intentional radio frequency parameters is required to assess and ensure radio frequency compatibility on and in the vicinity of the ISS.

Note 2: National regulatory agency refers to the following examples:

- United States: National Telecommunication and Information Administration (NTIA) or Federal Communications Commission (FCC)
- Non-US: Owner/operators domestic telecommunications ministry/authority or the International Telecommunications Union (ITU)

Note 3: The duration of the regulatory licensing review process is dependent on the national regulatory agency and can take many months from application to receiving the final frequency grant. In order to meet the verification submittal due date of L-4.5 months, the coordination process must start no later than 12 months prior to launch. The equipment operating license, radio frequency parameters, and coordination agreements must be obtained at least 60 days prior to integration into the launch vehicle to allow time for the JSC FSM to complete and issue the RFA.

3.2.3 ELECTRICAL SAFETY REQUIREMENTS

3.2.3.1 POWER SWITCHES/CONTROLS

The following power switches/controls requirements apply to power interfaces with open circuit voltage exceeding 32 Vrms or 32 Vdc.

A. Switches/controls performing on/off power functions for all power interfaces **shall** open (dead-face) all supply circuit conductors except the power return and the equipment grounding conductor while in the power-off position.

B. Power-off markings and/or indications **shall** be used only if all parts, with the exception of overcurrent devices and associated EMI filters, are disconnected from the supply circuit.

C. Standby, charging, or other descriptive nomenclature **shall** be used to indicate that the supply circuit is not completely disconnected for this power condition.

3.2.4 ELECTRICAL DATA REQUIREMENTS

3.2.4.1 ELECTRICAL SCHEMATICS

Data Deliverable: Provide an electrical schematic of the payload including the wiring between the payload and the ISS electrical interface. This schematic *should* include (but not limited to), location and type of circuit protection devices, switches, Ground Fault Circuit Interrupter (GFCI), electrical grounding scheme, EMI Filtered schematics, and DC/DC converters schematics including component values and minimum component resistance. The classification, wire type, twisting, shielding, and shielding grounding requirements are to be identified on all schematics, cable interconnect diagrams, and cable/harness manufacturing and installation documents.

Note: Electrical schematics are not required for battery operated payloads.

3.2.4.2 ELECTRICAL POWER USE

Data Deliverable: Provide peak power (including duration in minutes and frequency of occurrence), maximum continuous power and Keep-Alive power for each operational mode. Repeat as needed to address all modes. Provide a definition of each mode.

3.3 COMMAND AND DATA HANDLING INTERFACE REQUIREMENTS

Command and Data Handling requirements for payloads are addressed in Appendix I. Table I.1.2-1 contains a description of available ISS C&DH Interfaces.

There are multiple data interfaces on-orbit, but not all can be used by every type of payload. Table 3.3-1 maps which services are physically available for each type of payload.

TABLE 3.3-1 AVAILABLE C&DH HARDWARE INTERFACES

	Rack	Subrack	Non-rack	EXPRESS Laptop Computer
MIL-STD-1553B	X		X	
RS-422		X		
Ethernet	X	X	X	X
HRDL	X			
Laptops	X		X	X

3.4 PAYLOAD NTSC VIDEO INTERFACE REQUIREMENTS

Payload NTSC video interface requirements are addressed in section N.3.4.

3.5 THERMAL CONTROL INTERFACE REQUIREMENTS

3.5.1 INTERNAL THERMAL CONTROL SYSTEM (ITCS) INTERFACE REQUIREMENTS

The ISS laboratory modules provide cooling fluid for payload use. The USL, JEM and COL provide Moderate Temperature Loop (MTL) fluid. The USL and JEM also provide Low Temperature Loop (LTL) fluid. The characteristics of the fluid interfaces are described in this section. The fluid composition is addressed in section 3.11.2.

The ITCS coolant loop supply temperatures in each module are defined in Table 3.5.1-1.

TABLE 3.5.1-1 ITCS COOLANT SUPPLY TEMPERATURES

Loop/Lab	USL °F (°C)	COL °F (°C)	JEM °F (°C)
MTL	61 - 65 (16 - 18.3)	61 - 68 (16 - 20)	61 - 73.4 (16 - 23)
LTL	38 - 50 (3.3 - 10)	N/A	34 - 50 (1.1 - 10)

3.5.1.1 ITCS FLUID FILLING

The payload **shall** be delivered on-orbit fully filled with ITCS fluid.

3.5.1.2 ITCS FLUID EXPANSION

A. The payload **shall** provide the capability to compensate for ITCS fluid thermal expansion from the low to the high temperatures in Table 3.5.1.2-1, Temperature Ranges for ITCS Thermal Expansion, when not connected to the ITCS.

TABLE 3.5.1.2-1 TEMPERATURE RANGES FOR ITCS THERMAL EXPANSION

Payload Water Loop or Environment	Fluid Expansion Temperature Range
LTL	34 °F[1] (1.1 °C) to 115 °F (46.1 °C)
MTL	61 °F[1] (16.1 °C) and 115 °F (46.1 °C)

Note 1: The reference fill temperature for transport to orbit and on-orbit.

B. A thermal expansion device that remains connected to the payload's fluid system while the payload is connected to the on-orbit ITCS, **shall** actuate at a pressure no less than 100 psia (690 kPa).

3.5.1.3 ITCS FLUID RETURN TEMPERATURES

A. The maximum MTL coolant return temperature **shall** be no greater than 120°F (49°C).

B. The maximum LTL coolant return temperature **shall** be no greater than 70°F (21°C).

3.5.1.4 ITCS MAXIMUM DESIGN PRESSURE (MDP)

The payload **shall** withstand the LTL and MTL MDP of 121 psia (834 kPa).

3.5.1.5 ITCS DESIGN DATA

Data Deliverable: Provide a schematic of the payload ITCS system including manual and motorized valves, check valves, flow controllers, quick disconnects, heat exchangers, transducers (temperature, flow rate and pressure), pressure accumulators (connected and disconnected), active thermal control components, and areas of isolated fluid.

3.5.1.6 ITCS COOLANT FLOW RATE DATA

Data Deliverable: Provide in tabular format the following information about the payload use of MTL and LTL for each operational mode including worst case; power used and flow rate of MTL and/or LTL.

3.5.2 CABIN AIR HEAT LOAD LIMITS

The sensible heat leak and latent heat load to the cabin air from the payload *should* not exceed the limits specified in Table 3.5.2-1. These limits represent the total cabin air heat load capability for payloads in a given module when the cabin temperature is at 65 °F (18 °C).

TABLE 3.5.2-1 CABIN AIR SENSIBLE AND LATENT HEAT LOAD

	COL Limit	USL Limit	JEM Limit	Cupola Limit
Sensible Heat	500 W	500 W	250 W	250 W(1)
Latent Heat	70 W(2)	70 W	5.3 W	N/A

Note 1: During periods when the Robotic Workstation (RWS) is not in use. No payload heat generation is permitted when RWS is in use.

Note 2: When a reduced crew or no crew is present, a higher latent heat load could be allocated to payloads (the overall maximum latent heat removal of the Columbus is 150 W at 18 °C or maximum 290 W at 27 °C.

3.5.2.1 CABIN AIR HEAT LOAD DATA

Data Deliverable: Provide in tabular format the following information about the cabin air heat load from the payload for each operational mode; power used, sensible heat load to the cabin air from electronics, specimen metabolic heat load due to air exchange with the cabin aisle, and all associated ancillary equipment in the cabin aisle for each operational mode. Also include the latent heat load which is the heat load on the condensing heat exchanger needed to remove the payload water vapor, including humidity from specimen air exchange, from the cabin air. Assume the lower temperature limit for this calculation to be 43 °F (6.1 °C). Boundary conditions to assume are provided in Table 3.9.3-3.

3.6 VACUUM SYSTEM REQUIREMENTS

3.6.1 VACUUM EXHAUST SYSTEM (VES)/WASTE GAS SYSTEM (WGS) REQUIREMENTS

See section N.3.6.1.

3.6.2 VACUUM RESOURCE SYSTEM (VRS)/VACUUM VENT SYSTEM (VVS) REQUIREMENTS

See section N.3.6.2.

3.6.3 VACUUM OUTGASSING REQUIREMENTS

See section N.3.6.3.

3.7 PRESSURIZED GASES INTERFACE REQUIREMENTS

3.7.1 NITROGEN INTERFACE REQUIREMENTS

See section N.3.7.

3.7.2 ARGON INTERFACE REQUIREMENTS

This is a JEM unique interface. See section N.3.8.1.

3.7.3 CARBON DIOXIDE INTERFACE REQUIREMENTS

This is a JEM unique interface. See section N.3.8.2.

3.7.4 HELIUM INTERFACE REQUIREMENTS

This is a JEM unique interface. See section N.3.8.3.

3.7.5 PRESSURIZED GAS SYSTEMS

Payloads with pressurized gas systems which have a total expanded gas volume exceeding 400 liters at Standard Conditions **shall** limit the gas flow after a single failure to less than 240 SLPM after 400 liters at Standard Conditions has been released to the cabin air. This applies to payloads for both on-orbit and transport.

3.8 POTABLE WATER INTERFACE REQUIREMENTS

3.8.1 POTABLE WATER INTERFACE COMPATIBILITY

Payloads using potable water **shall** provide a standard interface with the Potable Water Dispenser (PWD) to obtain the water. Standard bags for interfacing with PWD are the Drink Bag (part number SED48101685-622, or equivalent), or Sample Bag (part numbers SEG46119988-611 or 1053-M-1051-00, or equivalent). Other bags must provide a Luer Lock interface to connect to the PWD Aux Port or a Luer Lock to PWD adapter.

3.8.2 POTABLE WATER DATA

<u>Data Deliverable</u>: Provide an estimate of total potable water needed from ISS and the time period over which it will be used.

3.8.3 SYSTEM BACKGROUND INFORMATION

Potable water is available to payloads in the U.S. section of ISS. Payloads are not allowed to connect directly to the water system. Payloads may obtain water via drink or sample bags from the Galley. De-iodinated water is available from the Galley’s PWD needle dispenser and iodinated water is available from the PWD AUX port.

Note: The PWD needle dispenser provides water at a flow rate approximately 500 ml/min depending on Potable input pressure.

The water allocation for the entire ISS Payload Compliment is approximately 1.2 liters per day. The 1.2 liters per day is based on the following allocations:

1. 0.816 kg/day (1.8 lbm/day) returned to the cabin air as humidity for recycling, based on a weekly average.
2. 0.18 kg/day (0.4 lbm/day) not returned for recycling (returned as trash), based on a weekly average.
3. 0.18 kg/day (0.4 lbm/day) returned for recycling but not as humidity (for example, crew consumption, bagged water left for general use, inline sample filters, and water returned for recycling as a liquid), based on a weekly average.

The water from the ISS is roughly equivalent to de-ionized water. The USOS potable water meets the water quality standards listed in Table 3.8.3-1. The ISS potable water has iodine added to prevent microbial growth and contamination. This iodine is removed before the water is dispensed for drinking by the PWD. Potable water is not the only type of water on the ISS, however potable water is the only type with a payload allocation.

The standard payload potable water interface is the PWD in the U.S. Galley. The PWD can supply hot or ambient water. The interfaces are 1) De-iodinated water via a hollow needle on the PWD and a septum on the drink bag, and 2) Iodinated water via the AUX port on the PWD, using the Water Processing Assembly (WPA) H_2O Transfer Common Hose and the Luer Lock on a sample bag. This is a standard activity using GFE. No procedures or verification is needed. Drink Bags are common on ISS. Sample Bags are similar to drink bags except they are available in different materials, sizes, interfaces, and are more expensive. Drink Bags and Sample Bags are disposable. They must not to be filled more than once. Payloads must use a brand new Drink Bag or Sample Bag every time they connect to the PWD. Connecting a used container to the water system can contaminate it.

TABLE 3.8.3-1 WATER QUALITY REQUIREMENT (2 PAGES)

INORGANIC CONSTITUENTS			
Constituent	Total (mg/l)	Constituent	Total (mg/l)
Ammonia	1.0	Arsenic	0.01
Barium	10.0	Cadmium	0.022
Calcium	30.0	Chlorine	4.0
Chromium	0.23	Copper	1.0
Total Iodine	6.0	Iron	0.3
Total Iodine (at the point of consumption)	0.2	-	-
Lead	0.05	Magnesium	50.0
Manganese	0.3	Mercury	0.002
Nickel	0.3	Nitrate (N03-N)	10.0
Potassium	340.0	Selenium	0.01
Silver	0.4	Sulfate	250.0
Zinc	2.0	-	-
ORGANIC CONSTITUENTS(1)			
Constituent	Total (mg/l)	Constituent	Total (mg/l)
Volatile organics (3) per EPA Method 524.2, rev. 4	See (3)	Semivolatile Organics (3) per EPA Method 625	See (3)
Uncharacterized TOC (UTOC) (1) (2)	See (2)	Total Organic Carbon (TOC)	3.0
BIOCIDE			
Constituent	Total (mg/l)	Constituent	Total (mg/l)
Residual Iodine (maximum)	4.0	Residual Iodine (minimum)	1.0
MICROBIAL COUNT			
Bacteria Count	50 CFU per 1 ml	Coliform Bacteria Count	Non-detectable
PHYSICAL PARAMETERS			
Total solids	100 mg/l	True color	See (2)
Taste	See (2)	Odor	See (2)
pH	4.5 to 8.5	Turbidity	1 NTU
Gas content	No free gas at 98.6 °F, at 1 atm pressure		

TABLE 3.8.3-1 WATER QUALITY REQUIREMENT (2 PAGES)

Notes:

1. UTOC equals TOC minus the sum of analyzed organic constituents expressed in equivalent TOC.
2. "For reference only" contains no value, however, the parameter will be measured during certification testing of the system.
3. Individual contaminant spacecraft water exposure guidelines can be found in JSC-63414. If no value is available in JSC-63414, then conservative water quality limits can be found using U.S. EPA Maximum Contaminant Levels (MCLs). The NASA Water Quality Monitor will be consulted if measurable concentrations of other organics are present and neither JSC-63414 limits nor US EPA MCLs are available.

3.8.4 WATER CONTAINERS

Drink Bags are available on ISS. The quantity needed must be included in the Payload PIA. Sample Bags are available for purchase from the vendor. Source and types of potable water containers are shown in Table 3.8.4-1.

TABLE 3.8.4-1 POTABLE WATER CONTAINERS

	Drink Bags	1 Liter Sample Bag	3 Liter Sample Bag	IV Bag
Source	NASA	Vendor	Vendor	Vendor
Volume	355 ml	1 Liter	3 Liters	50 ml – 3 Liters
Part Number	SED48101685-622	SEG46119988-611 (Teflon bag) SEG46119988-313 (Assembly bag)	1053-M-1051-00 (KSC P/N)	N/A

3.8.4.1 DRINK BAGS

Drink Bags, or Drinking Water Container (part number SED48101685-622) are the preferred way to obtain potable water. The Drink Bags are filled with up to 355 ml of water from the PWD. They connect to the PWD by inserting a hollow needle into the septum. They can be emptied by squeezing. The Drink Bags include a drink straw with a cap.

3.8.4.2 SAMPLE BAGS

Sample Bags are available for purchase from the vendor. The vendor builds bags to NASA standards in several sizes, materials, and interfaces. Standard interfaces such as Luer Locks are available from the vendor. ISS interfaces such as PWD septum must be obtained from NASA. Described in this section are small, 1 liter and large 3 liter sample bags, and IV bags that have been used by payloads.

3.8.4.2.1 ONE-LITER SAMPLE BAG

The 1 liter Sample Bag consists of an assembly bag (part number SEG46119988-313, or equivalent) and a 1 liter Teflon water bag with a Luer Lock fitting (part number SEG46119988-611, or equivalent) that are shown in Figure 3.8.4.2.1-1. To connect to the PWD, an adapter, Luer Lock to PWD needle adapter part number SEG46121618-301, is needed. This bag is intended to return liquid samples. NASA does not supply this bag, so any PD that wishes to use it must purchase it directly from the vendor. The bag is relatively expensive.

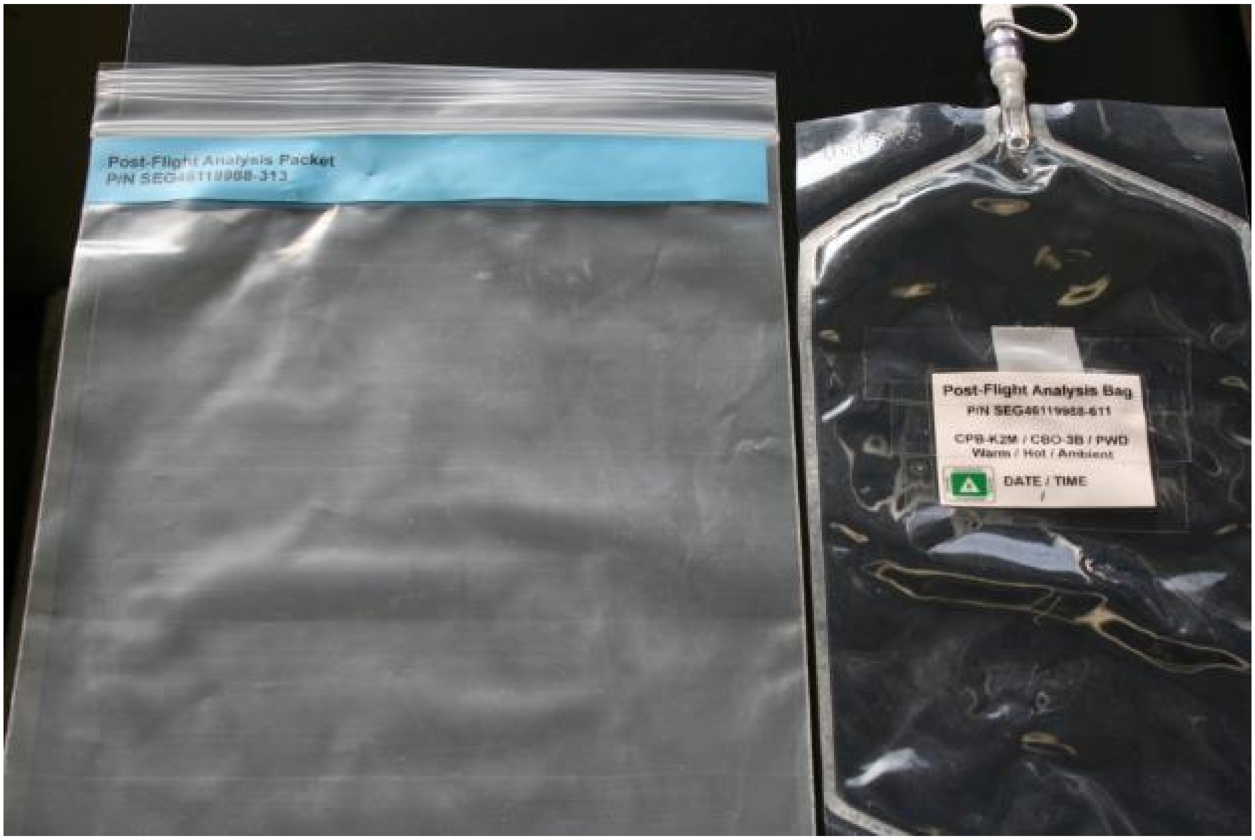


FIGURE 3.8.4.2.1-1 1 LITER SAMPLE BAGS

3.8.4.2.2 THREE LITER SAMPLE BAG

The 3 liter sample bag is a custom bag designed for the VEGGIE payload. The Veg Water Bag Assembly (KSC P/N 1053-M-1051-00, or equivalent) is a fluorinated ethylene propylene (FEP) bag with a maximum capacity of 3 L. Any PD wishing to use one must coordinate with their PIM.

3.8.4.2.3 IV BAGS

IV Bags can be used as sample bags. Rodent Habitat uses a 1 liter and 2 liter IV bag to supply water to the rodents. To use an IV bag, it must have a Luer Lock connection. This allows the use of the Luer Lock to PWD adapter to fill the bag from the PWD.

3.9 ENVIRONMENT INTERFACE REQUIREMENTS

3.9.1 CONDENSATION PREVENTION

Payloads in the pressurized volume **shall** be designed to preclude condensation when exposed to the ISS atmosphere ranging in dewpoint from 4.4 to 15.6 °C (40 to 60 °F) and in relative humidity from 25 to 75%, except when 1) payloads or samples are being transferred from/to Designated Cold Stowage; 2) Designated Cold Stowage is opened to transfer samples or payloads and the interior is exposed to ISS atmosphere. For reference, Figure 3.9.1-1 depicts the temperature/humidity envelope defined by these dewpoint and relative humidity ranges for air (21% oxygen, 79% nitrogen) at one atmosphere pressure (14.7 psia).

Note: Payloads that violate this requirement will have to show that any wetted materials are fungus resistant in accordance with the requirements specified in MIL-STD-810, Test Method Standard Environmental Engineering Considerations and Laboratory Tests, Method 508.6, or as identified in MIL-HDBK-454, General Guidelines for Electronic Equipment, Guideline 4, Fungus-Inert Materials, Table 4-I, Group I.

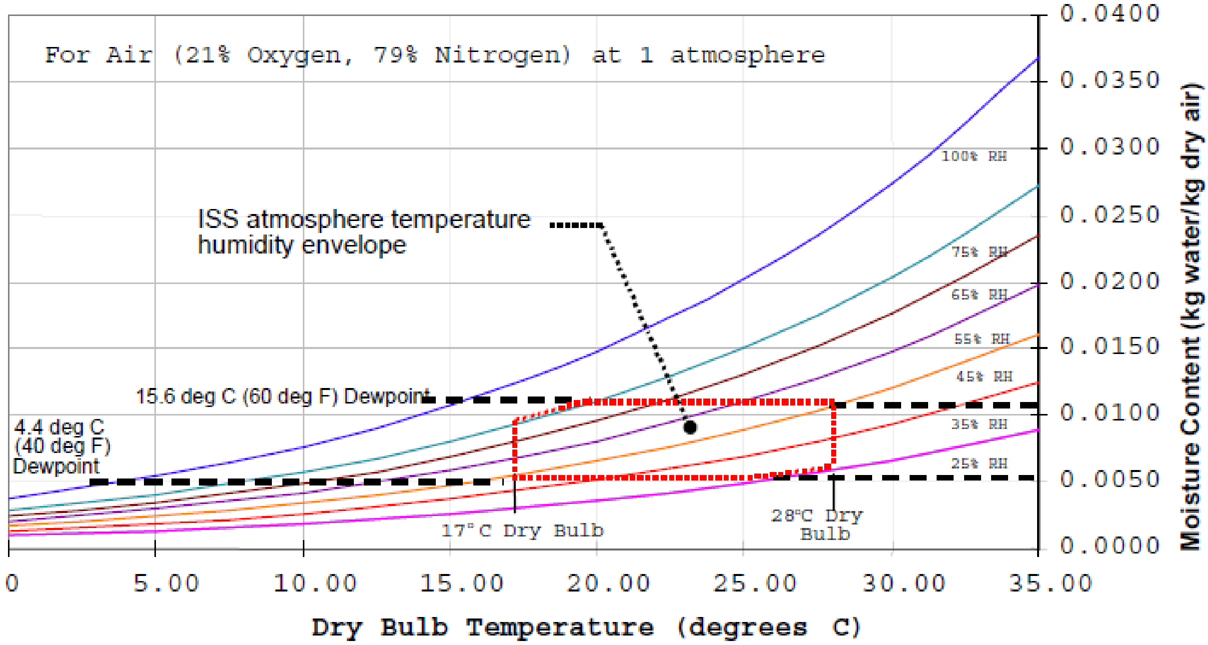


FIGURE 3.9.1-1 ISS TEMPERATURE/HUMIDITY ENVELOPE

3.9.2 WATER-SOLUBLE VOLATILE ORGANIC COMPOUND RELEASES

The payload **shall** provide at least one level of containment to prevent release to the habitable environment of methanol, ethanol, isopropyl alcohol, n-propyl alcohol, n-butyl alcohol, acetone, ethylene glycol, and propylene glycol.

Note 1: Required levels of containment are defined through the safety process.

Note 2: Exceptions to this requirement will require a Volatile Organic Compound Usage Agreement (VUA) and may be approved by the ISS Program for low releases of water-soluble volatile organic compounds to the ISS habitable volume per Table 3.9.2-1. Exceptions to the containment requirement will not be granted for releases greater than 1 g per day.

TABLE 3.9.2-1 LOW RELEASES OF WATER-SOLUBLE VOLATILE ORGANIC COMPOUNDS TO THE ISS HABITABLE VOLUME

VUA Type	Maximum Release Per Day
Cat 1	From 10 mg to 1 g
Cat 2	Less than 10 mg

3.9.3 ADDITIONAL ENVIRONMENTAL CONDITIONS

The environmental information provided in Table 3.9.3-1 and Figure 3.9.3-1 is for design and analysis purposes. The boundary conditions provided in Table 3.9.3-2, Table 3.9.3-3, and Table 3.9.3-4 are for design and analysis purposes.

TABLE 3.9.3-1 ENVIRONMENTAL CONDITIONS

Environmental Condition	Value
Atmospheric Conditions on ISS	
Pressure Extremes	0 to 104.8 kPa (0 to 15.2 psia)
Depressurization Rate	878 Pa/s (7.64 psi/min)
Repressurization Rate	878 Pa/s (7.64 psi/min)
Normal operating pressure	See Figure 3.9.3-1
Oxygen partial pressure	See Figure 3.9.3-1
Nitrogen partial pressure	See Figure 3.9.3-1
Dew point	4.4 to 15.6 °C (40 to 60 °F) ref. Figure 3.9.1-1
Percent relative humidity	25 to 75% ref. Figure 3.9.1-1
Carbon dioxide partial pressure during normal operations with 6 crewmembers plus animals	24–hr average exposure 5.3 mm Hg Peak exposure 7.6 mm Hg
Carbon dioxide partial pressure during crew change out with 11 crewmembers plus animals	24–hr average exposure 7.6 mm Hg Peak exposure 10 mm Hg
Cabin air temperature in USL, JEM, and COL	18.3 to 26.7 °C (65 to 80 °F)
Cabin air temperature in Node 1	18.3 to 29.4 °C (65 to 85 °F)
Air velocity (Nominal)	0.051 to 0.203 m/s (10 to 40 ft/min)
Airborne microbes	Less than 1000 CFU/m^3
Atmosphere particulate level	Average less than 100,000 particles/ft^3 for particles less than 0.5 microns in size, with peak concentrations less than 2×10^6 particles/ft^3
General Illumination	108 Lux (10 fc) measured 30 inches from the floor in the center of the aisle
Ionizing Radiation Dose	Up to 30 Rads(Si) / year
Single Event Effect Ionizing Radiation	SSP 30512, paragraph 3.2.1 with a shielding thickness of 25.4 mm (1000 mils)

TABLE 3.9.3-2 BOUNDARY CONDITIONS FOR THERMAL ANALYSIS

	USL	JEM(3)	Columbus	Worst Case(1)
Heat conduction through mechanical attachment	Allowed(7)	Prohibited(6)	Allowed(7)	Prohibited(6)
Front panel of rack or sub rack				
Heat transfer by radiation	Allowed(7)	Prohibited(6)	Required(5)	Required(5)
Radiative heat sink temperature	Less than 98.6 °F (37 °C)	N/A	95 °F (35 °C)	98.6 °F (37 °C)
Emissivity	Not Specified(4)	N/A	Not Specified(4)	Not Specified(4)
Convective heat transfer with cabin air	Required(5)	Required(5)	Required(5)	Required(5)
Convective Thermal Coefficient, BTU hr^{-1} $°F^{-1}$ ft^{-2} (W m^{-2} $°C^{-1}$)	0.18 (1.0)	0.13 to 0.20 (0.705 to 1.14)	0.18 (1.0)	0.13 to 0.20 (0.705 to 1.14)
Air velocity, ft min-1 (m s-1)	10 to 40 (0.051 to 0.203)	15 to 40 (0.076 to 0.203)	Not Specified(4)	15 to 40 (0.076 to 0.203)
Cabin air temperature	65 to 80 °F (18.3 to 26.7 °C)	65 to 80 °F (18.3 to 26.7 °C)	65 to 80 °F (18.3 to 26.7 °C)	65 to 80 °F (18.3 to 26.7 °C)
Other surfaces (sides, back, top, bottom)				
Heat transfer by radiation(2)	Prohibited(6)	Required(5)	Prohibited(6)	Required(5)
Module wall temperature	N/A	55 to 113 °F (13 to 45 °C)8	N/A	55 to 113 °F (13 to 45 °C)
Module wall emissivity	N/A	0.9 (Silvia F: white paint)	N/A	0.9 (Silvia F: white paint)
Adjacent racks surface temperature	N/A	55 to 113 °F (13 to 45 °C) 8	N/A	55 to 113 °F (13 to 45 °C)
Adjacent racks surface emissivity	N/A	0.6 (anodized aluminum)	N/A	0.6 (anodized aluminum)
Configuration coefficient with module wall or other surrounding racks	N/A	1	N/A	1
Convective heat transfer with cabin air	Prohibited(6)	Prohibited(6)	Prohibited(6)	Prohibited(6)

Notes:
(1) A rack qualified under "worst case" conditions in the above table will be considered qualified for all modules. JEM analysis conditions must be used to verify an ISPR for use in the JEM.
(2) USL and Columbus consider radiation heat transfer to be negligible under these conditions.
(3) MELFI and EXPRESS Racks comply with these boundary conditions.
(4) If Not Specified values are used, the source must be documented in the Analysis Report. Acceptable sources are ISS documents, ISS applicable documents, published values, test data, and calculations included in the Analysis Report.
(5) Verification by analysis is required to include this heat transfer mechanism and the values listed with it.
(6) Verification by analysis is prohibited from including this heat transfer mechanism.
(7) Verification by analysis is allowed, but not required to use this heat transfer mechanism. If this heat transfer mechanism is used you must use the values listed.
(8) The surface temperature will be 35.6 to 120.2 °F (2 to 49 °C) when JEM is depressurized.

TABLE 3.9.3-3 BOUNDARY CONDITIONS FOR CABIN HEAT LEAK ANALYSIS

	USL	JEM[2]	Columbus	Worst Case[1]
Heat conduction through mechanical attachment	Allowed[6]	Prohibited[5]	Allowed[6]	Allowed[6]
Front panel of rack or sub rack				
Heat transfer by radiation	Allowed[6]	Prohibited[5]	Required[4]	Required[4]
Radiative heat sink temperature	Less than 98.6 °F (37 °C)	N/A	95 °F (35 °C)	95 °F (35 °C)
Emissivity	Not Specified[3]	N/A	Not Specified[3]	N/A
Convective heat transfer with cabin air	Allowed[6]	Required[4]	Required[4]	Required[4]
Convective Thermal Coefficient, BTU hr^{-1} $°F^{-1}$ ft^{-2} (W m^{-2} $°C^{-1}$)	Not Specified[3]	0.20 (1.14)	0.18 (1.0)	0.20 (1.14)
Air velocity, ft min^{-1} (m s^{-1})	10 to 40 (0.051 to 0.203)	40 (0.203)	Not Specified[3]	40 (0.203)
Cabin air temperature	65 to 80 °F (18.3 to 26.7 °C)	65 °F (18.3 °C)	65 to 80 °F (18.3 to 26.7 °C)	65 °F (18.3 °C)
Other surfaces (sides, back, top, bottom)				
Heat transfer by radiation	Allowed[6]	Prohibited[5]	Prohibited[5]	Prohibited[5]
Module wall temperature	55 to 109 °F (13 to 43 °C)	N/A	N/A	N/A
Module wall emissivity	Not Specified[3]	N/A	N/A	N/A
Adjacent racks surface temperature	Not Specified[3]	N/A		N/A
Adjacent racks surface emissivity	Not Specified[3]	N/A	N/A	N/A
Configuration coefficient with module wall or other surrounding racks	Not Specified[3]	N/A	N/A	N/A

Notes:

(1) A rack qualified under "worst case" conditions in the above table will be considered qualified for all modules. JEM analysis conditions must be used to verify an ISPR for use in the JEM.

(2) MELFI and EXPRESS Racks will comply with these boundary conditions.

(3) If Not Specified values are used, the source must be documented in the Analysis Report. Acceptable sources are ISS documents, ISS applicable documents, published values, test data, and calculations included in the Analysis Report.

(4) Verification by analysis is required to include this heat transfer mechanism and the values listed with it.

(5) Verification by analysis is prohibited from including this heat transfer mechanism.

(6) Verification by analysis is allowed but not required to use this heat transfer mechanism. If this heat transfer mechanism is used you must use the values listed.

TABLE 3.9.3-4 BOUNDARY CONDITIONS FOR CONDENSATION ANALYSIS

	USL	JEM(2) (3)	Columbus	Worst Case(1)
Heat conduction through mechanical attachment	Allowed(6)	Prohibited(5)	Allowed(6)	Prohibited(5)
Front panel of rack or sub rack				
Heat transfer by radiation	Prohibited (5)	Prohibited(5)	Prohibited (5)	NOTE: Since cabin air and structural temperature are always above dew point under normal conditions, no thermal connectivity is the worst case
Radiative heat sink temperature	N/A	N/A	N/A	
Emissivity	N/A	N/A	N/A	
Convective heat transfer with cabin air	Allowed(6)	Required(4)	Allowed(6)	
Convective Thermal Coefficient, BTU hr^{-1} $°F^{-1}$ ft^{-2} (W m^{-2} $°C^{-1}$)	N/A	0.13 (0.705)	N/A	
Air velocity, ft min^{-1} (m s^{-1})	N/A	15 (0.076)	N/A	
Cabin air temperature	N/A	65 °F (18.3 °C)	N/A	
Other surfaces (sides, back, top, bottom)				
Heat transfer by radiation	Allowed(6)	Prohibited(5)	Allowed(6)	Prohibited(5)

Notes:

(1) A rack qualified under "worst case" conditions in the above table will be considered qualified for all modules. JEM analysis conditions must be used to verify an ISPR for use in the JEM.

(2) JEM condensation must be evaluated under Condensation Analysis Conditions and Rack Thermal Analysis Conditions. The minimum allowable temperature of the ISPR is 13ºC.

(3) MELFI and EXPRESS Racks will comply with these boundary conditions.

(4) Verification by analysis is required to include this heat transfer mechanism and the values listed with it.

(5) Verification by analysis is prohibited from including this heat transfer mechanism.

(6) Verification by analysis is allowed but not required to use this heat transfer mechanism. If this heat transfer mechanism is used you must use the values listed.

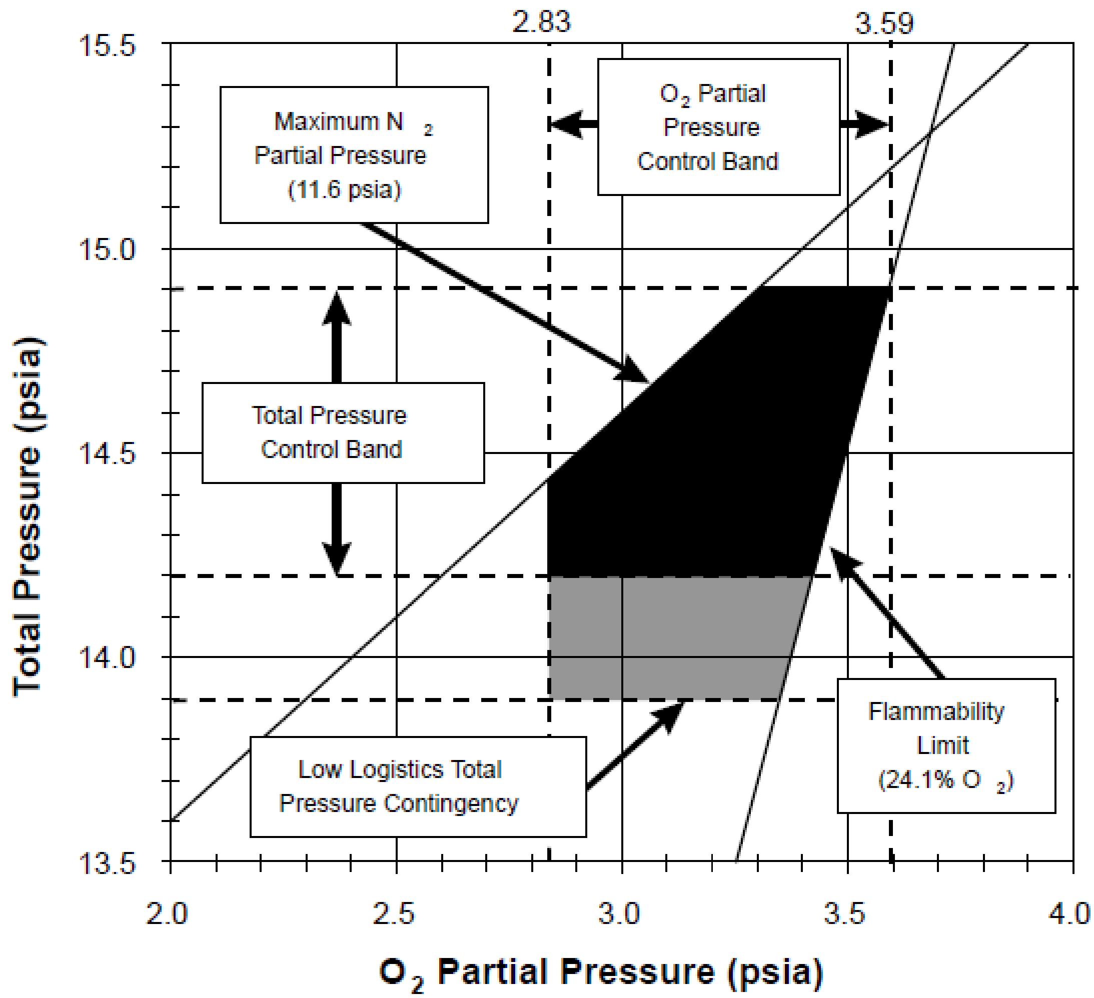


FIGURE 3.9.3-1 OPERATING LIMITS OF THE ISS ATMOSPHERIC TOTAL PRESSURE, AND NITROGEN AND OXYGEN PARTIAL PRESSURES

3.9.4 ACTIVE AIR EXCHANGE

Data Deliverable: Provide listing of constituents and quantities of gases which are released to or removed from the cabin atmosphere to complete Table 3.9.4-1.

TABLE 3.9.4-1 ACTIVE AIR EXCHANGE PROCESSES

Process	Inputs/ Byproducts	Quantity	Duration	Repetitions

3.10 FIRE PROTECTION INTERFACE REQUIREMENTS

Fire protection requirements for racks and EXPRESS subracks are addressed in Sections N.3.10 and F.3.10.

3.11 MATERIALS AND PROCESSES INTERFACE REQUIREMENTS

3.11.1 MATERIALS AND PROCESSES USE AND SELECTION

Materials and processes used in the design and construction of payloads are required to comply with the flammability, toxic offgassing, and fluid systems compatibility requirements in SSP 51700, section 3.10 and the stress-corrosion resistance requirements in SSP 51700 paragraph 3.9.3. Offgassing evaluation of COTS hardware, excluding items containing liquids or gels (such as uncured adhesives, lubricants, cleaning wipes, and marker pens), is required only for items with 5 pounds mass or greater. For payload hardware supplied by organizations with a Materials and Processes Reciprocal Agreement for Payloads approved by the ISSP (International Space Station Program) Safety Review Panel (ISRP) (including heritage agreements grandfathered to the ISS from the Space Shuttle Program), the reciprocal agreement baselines the process for selection and certification of materials used in payload hardware to the safety requirements of SSP 51700 and verification is conducted by the payload materials and processes organization.

Note: It is recommended materials be selected that have already been shown to meet the applicable acceptance test criteria. Test ratings for materials are available in the Materials and Processes Technical Information System (MAPTIS). MAPTIS is accessible via the Internet at http://maptis.nasa.gov. Accessibility to MAPTIS is by registration only.

3.11.2 FLUIDS

3.11.2.1 FLUID CHEMICAL COMPOSITION

Payloads connecting to ISS LTL and MTL fluid systems **shall** use ITCS fluid that meets the requirements specified in SSP 30573, Space Station Program Fluid Procurement and Use Control Specification, Table 4.1-2.8.

3.11.2.2 FLUID SYSTEM CLEANLINESS

Payload fluid systems connecting to the ISS LTL and MTL fluid systems **shall** meet the fluid system cleanliness levels of 300 specified in MIL-STD-1246 or better, and have a 2-micron filter at the flight hardware interface to the non-flight fill system to protect the payload (and ISS coolant loop) from particulates in the fill system.

3.11.2.3 THERMAL COOLING SYSTEM WETTED MATERIALS

A. Payloads using metallic materials in their ISS aqueous fluid systems (LTL or MTL) **shall** only use internal metallic materials made of stainless steels, nickel base, or titanium alloys.

B. Payloads connecting to the LTL or MTL **shall** be composed of wetted materials that do not include aluminum alloys or alloys with greater than 5% copper. This is in accordance with SSP 30573, Table 4.1-2.8, Note 10.

C. Payloads connecting to the LTL or MTL non-metallic wetted surfaces **shall** be composed of materials that are non-nutrient to fungal growth inside the LTL or MTL systems. This is in accordance with SSP 30233, paragraph 4.2.10, Moisture and Fungus Resistance, and SSP 30573, Table 4.1-2.8, Note 11.

3.11.3 CLEANLINESS

Payloads in the pressurized volume **shall** conform to the Visibly Clean-Sensitive (VC-S) cleanliness level (See Glossary of Terms) upon delivery.

3.12 HUMAN FACTORS INTERFACE REQUIREMENTS

The following sections contain the human factors requirements for IVA payloads. As described in Appendix R, the Human Factors Implementation Team (HFIT) provides an optional service for the verification of applicable human factors requirements. The payload must comply with all applicable human factors interface requirements either using the HFIT process or the standard verification process, as described below.

For payloads that choose the HFIT process, a single, consolidated human factors requirement addresses the verification of all applicable human factors requirements within section 3.12, EXCEPT the following sections:

- 3.12.3.2 Intermittent Noise Limits
- 3.12.7 Identification Labeling, verified by ISS Payload Label Approval Team (IPLAT)

For example, if the HFIT process is chosen, there will be a single human factors requirement (in addition to those listed above) listed in the payload's ICD, and HFIT will address minor requirements violations out of board.

If the payload chooses the standard verification process, then each applicable human factors requirement will be listed in the ICD, and any exceptions must be approved by the Vehicle Control Board (VCB).

Note: HFIT determines the applicability of human factors requirements whether or not the payload developer chooses the HFIT process.

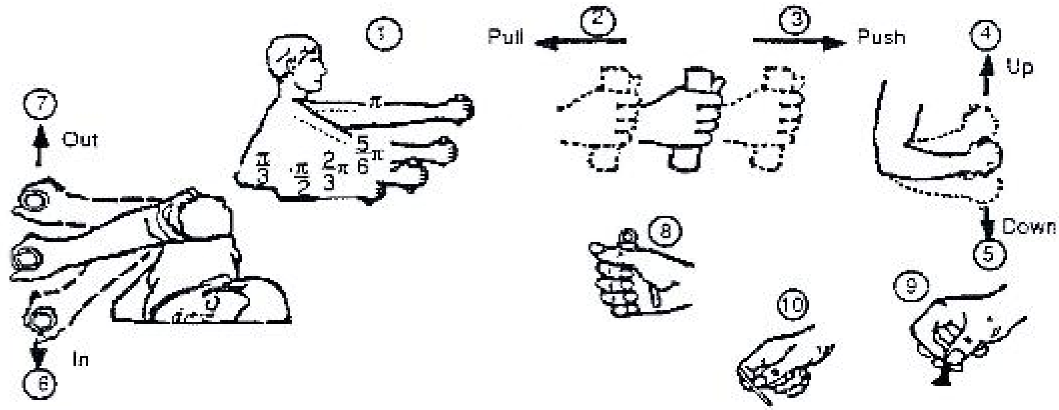
3.12.1 STRENGTH REQUIREMENTS

A. Grip Strength - To remove, replace and operate payload hardware, grip strength required *should* be less than 254 N (57lbf).

B. Linear Forces - Linear forces required to operate or control payload hardware or equipment *should* be less than the strength values for the 5th percentile female, defined as 50% of the strength values shown in Figure 3.12.1-1 and 60% of the strength values shown in Figure 3.12.1-2.

C. Torques - Torques required to operate or control payload hardware or equipment *should* be less than the strength values for the 5th percentile female, defined as 60% of the calculated 5th percentile male capability shown in Figure 3.12.1-3.

D. Forces required for maintenance of payload hardware and equipment *should* be less than the 5th percentile male strength values shown in Figures 3.12.1-1, 3.12.1-2, 3.12.1-3, 3.12.1-4, and 3.12.1-5.



Arm strength (N)														
(1)	(2)		(3)		(4)		(5)		(6)		(7)	
Degree of elbow flexion (rad)	Pull		Push		Up		Down		In		Out	
	L**	R**	L	R	L	R	L	R	L	R	L	R
π	222	231	187	222	40	62	58	76	58	69	36	62
5/6 π	187	249	133	187	67	80	80	89	67	89	36	67
2/3 π	151	187	116	160	76	107	93	116	89	98	45	67
1/2 π	142	165	98	160	76	89	93	116	71	80	45	71
1/3 π	116	107	96	151	67	89	80	89	76	89	53	76

Hand and thumb-finger strength (N)				
	(8) Hand grip		(9)	(10)
	L	R	Thumb-finger grip (Palmer)	Thumb-finger grip (tips)
Momentary hold Sustained hold	250 145	260 155	60 35	60 35

* Elbow angle shown in radians
** L = Left; R = Right

Arm strength (lb)														
(1)	(2)		(3)		(4)		(5)		(6)		(7)	
Degree of elbow flexion (deg)	Pull		Push		Up		Down		In		Out	
	L	R*	L	R	L	R	L	R	L	R	L	R
150	50	52	42	50	9	14	13	17	13	20	8	14
150	42	56	30	42	15	18	18	20	15	20	8	15
120	34	42	26	36	17	24	21	26	20	22	10	15
90	32	37	22	36	17	20	21	26	16	18	10	16
60	26	24	22	34	15	20	16	20	17	20	12	17

Hand, and thumb-finger strength (lb)				
	(8) Hand grip		(9)	(10)
	L	R	Thumb-finger grip (Palmer)	Thumb-finger grip (tips)
Momentary hold Sustained hold	56 33	59. 35	13 8	13 8

* Left; R = Right

FIGURE 3.12.1-1 ARM, HAND, AND THUMB/FINGER STRENGTH (5TH PERCENTILE MALE DATA)

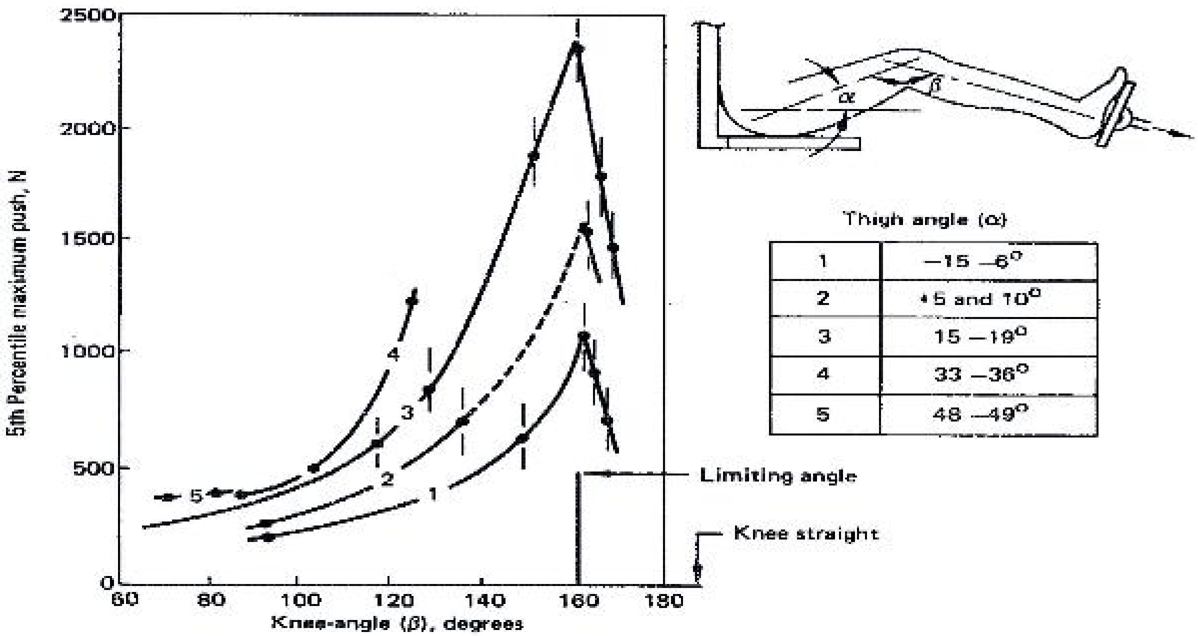


FIGURE 3.12.1-2 LEG STRENGTH AT VARIOUS KNEE AND THIGH ANGLES (5TH PERCENTILE MALE DATA)

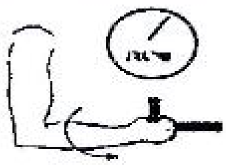
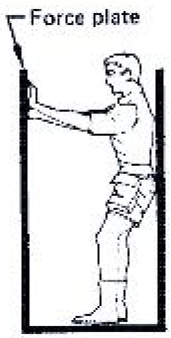
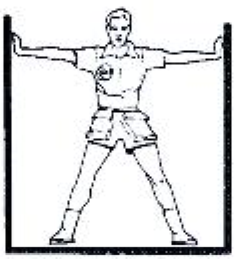
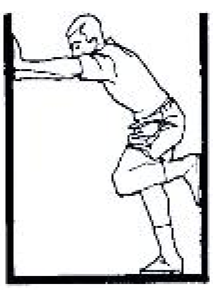
	Unpressurized suit, bare handed	
	Mean	SD
 Maximum torque: Suppination, Nm (lb-in.)	13.73 (121.5)	3.41 (30.1)
 Maximum torque: Pronation, Nm (lb-in.)	17.39 (153.9)	5.08 (45.0)

FIGURE 3.12.1-3 TORQUE STRENGTH

	Force-plate (1) height	Distances (2)	Force, N (lbf) Means	Force, N (lbf) SD
			Both hands	
	100 percent of shoulder height	50	583 (131)	142 (32)
		60	667 (150)	160 (36)
		70	983 (221)	271 (61)
		80	1285 (289)	400 (90)
		90	979 (220)	302 (68)
		100	645 (145)	254 (57)
			Preferred hand	
		50	262 (59)	67 (15)
		60	298 (67)	71 (16)
		70	360 (81)	98 (22)
		80	520 (117)	142 (32)
		90	494 (111)	169 (38)
		100	427 (96)	173 (39)
		Percent of thumb-tip reach *		
	100 percent of shoulder height	50	369 (83)	138 (31)
		60	347 (78)	125 (28)
		70	520 (117)	165 (37)
		80	707 (159)	191 (32)
		90	325 (73)	133 (30)
		Percent of span **		
	Force-plate (1) height	**Distances (2)**	**Force, N (lbf) Means**	**Force, N (lbf) SD**
	50	100	774 (174)	214 (48)
	50	120	778 (175)	165 (37)
	70	120	818 (184)	138 (31)
	Percent of shoulder height		1-g applicable data	

NOTES: (1-g data)
(1) Height of the center of the force plate - 200 mm (8 in) high by 254 mm (10 in) long - upon which force is applied.
(2) Horizontal distance between the vertical surface of the force plate and the opposing vertical surface (wall or footrest, respectively) against which the subject brace themselves.
* Thumb-tip reach - distance from backrest to tip of subject's thumb as thumb and fingertips are pressed together.
** Span - the maximal distance between a person's fingertips as he extends his arms and hands to each side.

FIGURE 3.12.1-4 MAXIMAL STATIC PUSH FORCES

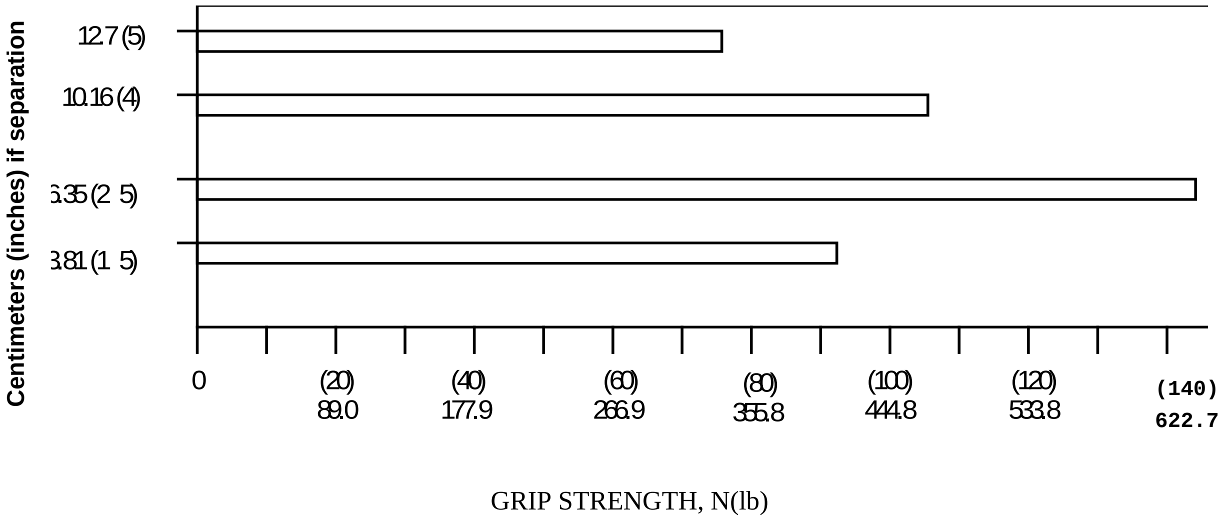


FIGURE 3.12.1-5 MALE GRIP STRENGTH AS A FUNCTION OF THE SEPARATION BETWEEN GRIP ELEMENTS

3.12.2 BODY ENVELOPE AND REACH ACCESSIBILITY

3.12.2.1 ADEQUATE CLEARANCE

Payloads *should* provide clearance for the crew to perform installation, operations, and maintenance tasks, including clearance for hand access, tools and equipment used in these tasks.

3.12.2.2 ACCESSIBILITY

A. Payload hardware *should* be geometrically arranged to provide physical and visual access for all payload installation, operations, and maintenance tasks.

B. IVA clearances for finger access *should* be provided as given in Figure 3.12.2.2-1.

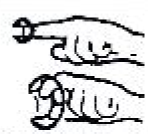
Minimal finger-access to first joint			
Push button access:	Bare hand: Thermal gloved hand:	32 mm dia (1.26 in) 38 mm dia (1.5 in)	
Two finger twist access:	Bare hand: Thermal gloved hand:	object plus 50 mm (1.97 in) object plus 65 mm (2.56 in)	

FIGURE 3.12.2.2-1 MINIMUM SIZES FOR ACCESS OPENINGS FOR FINGERS

3.12.2.3 FULL SIZE RANGE ACCOMMODATION

Payload workstations and hardware having crew nominal operations and planned maintenance *should* be sized to meet the functional reach limits for the 5th percentile Japanese female and yet must not constrict or confine the body envelope for the 95th percentile American male as specified in SSP 50005, International Space Station Flight Crew Integration Standard (NASA-STD-3000/T), section 3.

3.12.3 HABITABILITY

3.12.3.1 HOUSEKEEPING

3.12.3.1.1 CLOSURES OR COVERS

Closures or covers **shall** be provided for any area of the payload where debris, moisture, or other foreign materials could create a hazard.

3.12.3.1.2 BUILT-IN CONTROL

A. Payload containers of liquids or particulate matter **shall** have built-in equipment/methods for control of vaporization, material overflow, or spills.

B. The capture elements, including grids, screens, or filter surfaces **shall** be accessible for replacement or cleaning without dispersion of the trapped materials.

3.12.3.2 INTERMITTENT NOISE LIMITS

Payload Intermittent Noise Sources (See Glossary of Terms) **shall** not exceed the A-weighted Overall Sound Pressure Level (SPL) Limits during the Maximum Noise Duration as specified in Table 3.12.3.2-1 and as shown in Figure 3.12.3.2-1 when the equipment is operating in the loudest expected configuration and mode of operation that can occur on-orbit under any planned operations. The payload will include any supporting adjunct active portable equipment operated outside the integrated rack that is within or interfacing with the crew habitable volume.

Note 1: These acoustic requirements do not apply during failure or maintenance operations.

Note 2: For continuous operations (see Glossary of Terms) payloads are referred to paragraph F.3.12.1 for EXPRESS subrack payloads, paragraph G.3.12.1 for non-rack payloads, and N.3.12.3 for integrated rack payloads.

TABLE 3.12.3.2-1 INTERMITTENT NOISE LIMITS

Noise Limits Measured at 0.6 Meters Distance from the Test Article	
Maximum Noise Duration Per 24 Hour Period	**Total A-weighted Overall SPL (dBA)**
A	B
≤ 8 Hours	49
7 Hours	50
6 Hours	51
5 Hours	52
4.5 Hours	53
4 Hours	54
3.5 Hours	55
3 Hours	57
2.5 Hours	58
2 Hours	60
1.5 Hours	62
1 Hour	65
30 Minutes	69
15 Minutes	72
5 Minutes	76
2 Minutes	78
1 Minute	79
Not Allowed	80

The Noise Duration is the total time that the payload produces intermittent noise above its continuous noise requirement limit during a 24 hour time period (see Figure 3.12.3.2-2). This duration is the governing factor in determining the allowable Intermittent Noise Limits. Multiple sources within an integrated rack are considered as separate sources and can operate during the same 24-hour period.

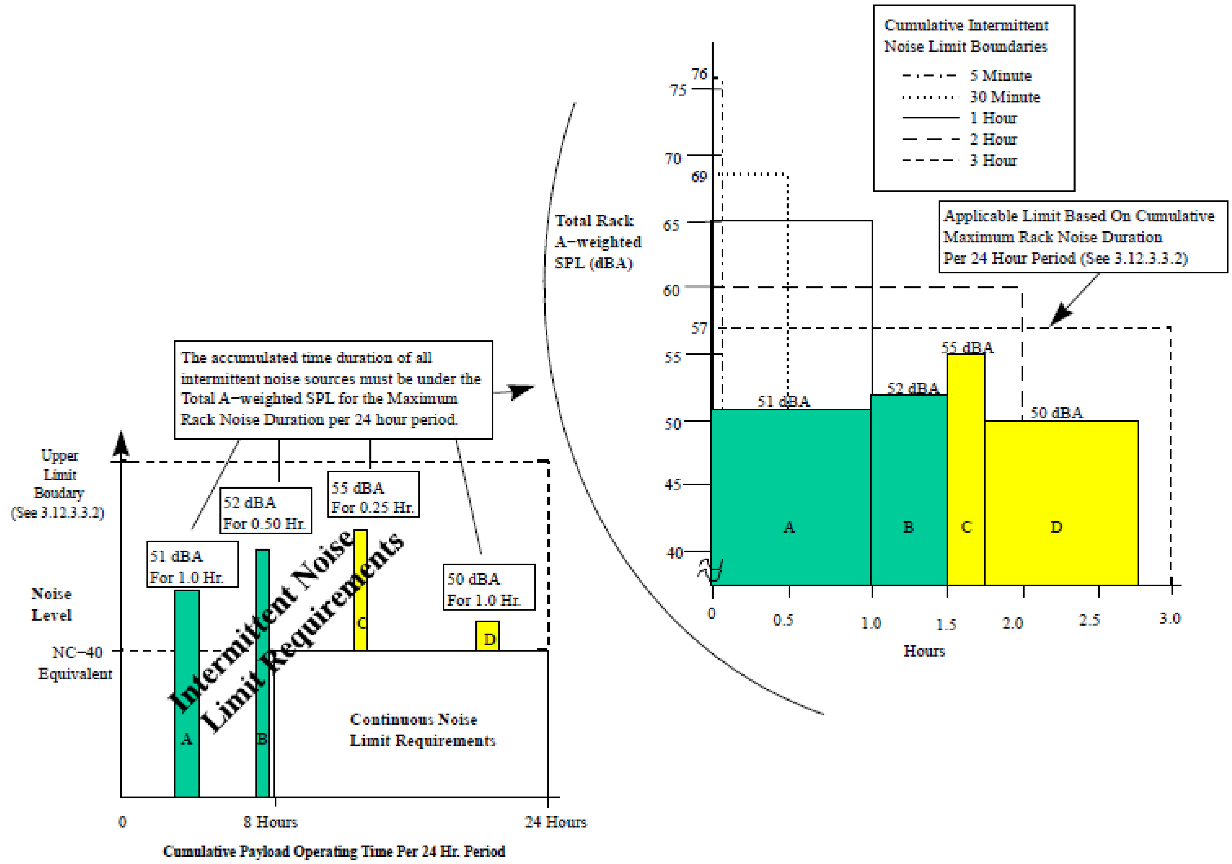


FIGURE 3.12.3.2-1 INTERMITTENT NOISE LIMIT REQUIREMENTS

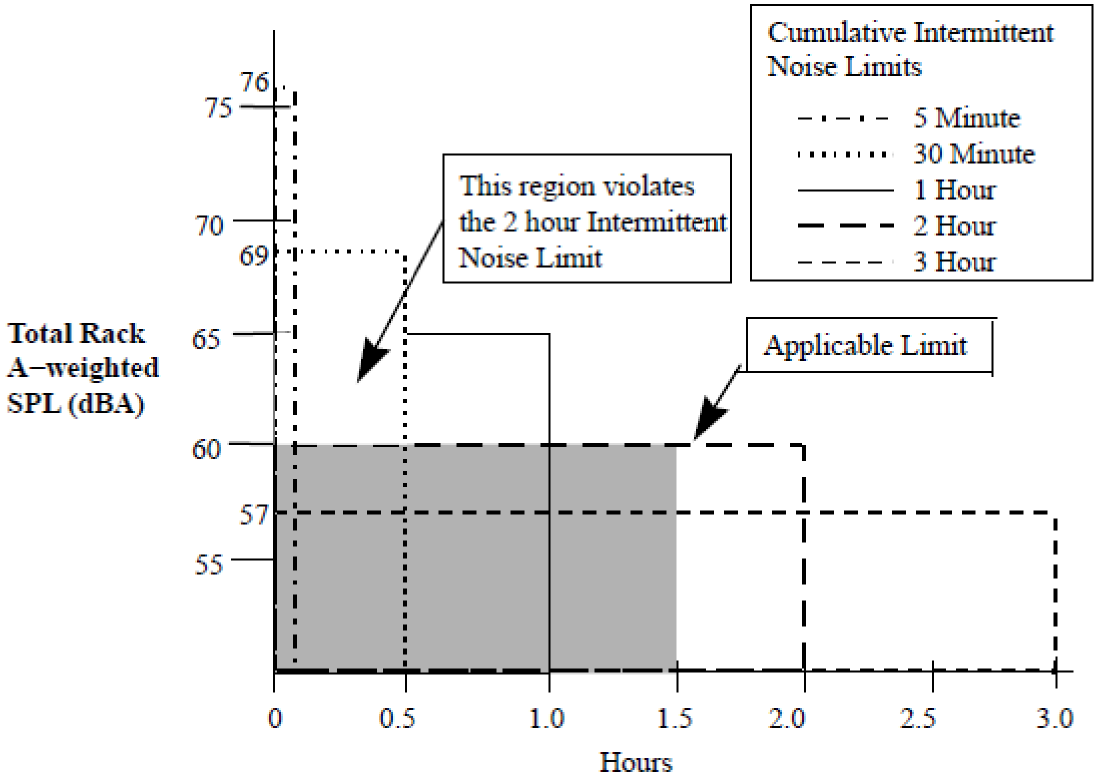


FIGURE 3.12.3.2-2 INTERMITTENT NOISE LIMITS

3.12.3.3 LIGHTING DESIGN

The general illumination of the space station in the aisle is a minimum of 108 lux (10 foot candles) of white light. This illumination is sufficient for ordinary payload operations performed in the aisle (e.g., examining dials or panels, reading procedures, transcription, tabulation, etc.).

A. Payload work surface specularity *should* not exceed 20 percent. Paints listed in Table 3.12.3.3-1 meet this requirement.

B. Lighting levels for tasks to be performed at payload worksites *should* be provided, as defined in Table 3.12.3.3-2.

C. Lighting for fine glovebox operations (e.g., detailed operations, protein crystal growth, surgery/dissection, spot illumination) **shall** be 1450 Lux (135 Foot-Candles), as measured at the task site.

D. Light sources *should* be dimmable.

TABLE 3.12.3.3-1 SURFACE INTERIOR COLORS AND PAINTS

HARDWARE DESCRIPTION	COLOR	FINISH	PAINT SPECIFICATION PER FED-STD-595B
Equipment Rack UIP Recess	White	Semigloss	27925
Equipment Rack UIP Text Characters	Black	Lusterless	37038
UIP Recess	White	Semigloss	27925
UIP Recess Text Characters	Black	Lusterless	37038
Functional Unit Utility Panel Recess (as applicable)	White	Semigloss	27925
Functional Unit Utility Panel Recess Text Characters	Black	Lusterless	37038
Rack Front Aisle Extensions	Off-White	Semigloss	27722
Overhead Rack Face Plates	Off-White	Semigloss	27722
Port Rack Face Plates	Off-White	Semigloss	27722
Starboard Rack Face Plates	Off-White	Semigloss	27722
Deck Rack Face Plates	Off-White	Semigloss	27722
Overhead Rack UIP Closeouts	Off-White	Semigloss	27722
Port Rack UIP Closeouts	Off-White	Semigloss	27722
Starboard Rack UIP Closeouts	Off-White	Semigloss	27722
Deck Rack UIP Closeouts	Off-White	Semigloss	27722
Stowage Trays	Off-White	Semigloss	27722
Stowage Tray Handle Straps (any location)	Natural/Off White Material	Semigloss	none
Common Seat Track	Nickel Plate	Semigloss	none
Glovebox (Aluminum or Plastic)	Medium Gray	Gloss	16329 or 16373
Glovebox (Aluminum)	White	Gloss	17925
Glovebox (Aluminum or Plastic)	Off-White	Gloss	17722
Glovebox (Aluminum)	Tan	Gloss	10475
EXPRESS Rack Control Panels	Off-White	Gloss	17875

TABLE 3.12.3.3-2 PAYLOAD ILLUMINATION LEVELS

Type of Task	Required Lux (Foot-Candles)*
Medium payload operations (not performed in the aisle) (e.g., payload change-out and maintenance)	325 (30)
Fine payload operations (e.g., instrument repair)	1075 (100)
Medium glovebox operations (e.g., general operations, experiment set-up)	975 (90)

* As measured at the task site

3.12.3.4 STATUS INDICATOR LIGHTS

Payload status indicator lights *should* adhere to the following characteristics:

- Green means hardware is functioning nominally (properly)
- Orange means hardware is functioning off-nominally (e.g. payload alerts)
- Yellow and red are not to be used

- Flashing lights are to be avoided

Note: It is important for payload indicator lights (e.g. LEDs) to be consistent with ISS systems implementations, in order for their meaning to be intuitive to the crew. For example, green is to represent nominal operation, not another color, such as red. Also, orange is the color for payload alerts, established by SSP 50313, Display and Graphics Commonality Standard, for displays. Yellow and red, and flashing lights are used by ISS systems.

3.12.4 STRUCTURAL/MECHANICAL INTERFACES

3.12.4.1 PAYLOAD HARDWARE MOUNTING

3.12.4.1.1 EQUIPMENT MOUNTING

Payload equipment items used during nominal operations and planned maintenance **shall** be designed, labeled, or marked to protect against improper installation.

3.12.4.1.2 DRAWERS AND HINGED PANELS

Payload Orbital Replacement Units (ORUs) which are pulled out of their installed positions for routine checkout *should* be mounted on equipment drawers or on hinged panels. It is recommended such drawers or hinged panels remain in the “open” position without being supported by hand.

3.12.4.1.3 ALIGNMENT

Payload hardware having blind mate connectors **shall** provide guide pins or their equivalent to assist in alignment of hardware during installation.

3.12.4.1.4 SLIDE-OUT STOPS

Payloads that have slide or pivot-mounted hardware, which is required to be pulled out of its installed positions, *should* provide limit stops.

3.12.4.1.5 PUSH-PULL FORCE

Payload hardware mounted into a capture-type receptacle that requires a push-pull action *should* require a force less than 156 N (35 lbf) to install or remove.

3.12.4.1.6 ACCESS

Payloads with hardware items (e.g., an ORU) which are planned to be accessed on a daily or weekly basis for inspection or replacement *should* not require the removal of another hardware item or more than one access cover.

3.12.4.1.6.1 SELF-SUPPORTING COVERS

All access covers that are not completely removable *should* be self-supporting in the open position.

3.12.4.1.6.2 PAYLOAD IN-FLIGHT MAINTENANCE AND OPERATIONAL TOOLS

Payloads *should* be designed to be maintainable using Space Station provided on-orbit tools or with payload unique tools that meet the requirements of SSP 50005, paragraph 11.2.3. A list of available tools on-orbit is provided by JSC 28533, International Space Station Catalogue of IVA Government Furnished Equipment (GFE) Flight Crew Equipment (FCE).

3.12.4.2 CONNECTORS

3.12.4.2.1 ONE-HANDED OPERATION

Connectors, latches, handles, fasteners, operating mechanisms and cleaning equipment *should* be designed for one-handed operation or use, and may be operated or used with either hand.

3.12.4.2.2 ACCESSIBILITY

A. For nominal and maintenance operations, it *should* be possible to mate/demate individual connectors without having to remove or mate/demate connectors on other ORUs.

B. Cables, hoses, and other umbilical installations **shall** permit disconnection and reconnection without damage to cable or umbilical connectors.

3.12.4.2.3 EASE OF DISCONNECT

A. Electrical connectors which are mated/demated during nominal operations *should* require no more than two turns to disconnect.

B. Electrical connectors which are mated/demated during ORU replacement operations only *should* require no more than six turns to disconnect.

3.12.4.2.4 INDICATION OF PRESSURE/FLOW

Payload liquid or gas lines not equipped with quick disconnect connectors which are designed to be connected/disconnected under pressure **shall** be fitted with pressure/flow indicators.

3.12.4.2.5 SELF-LOCKING

Payload electrical connectors *should* provide a self-locking feature.

3.12.4.2.6 CONNECTOR ARRANGEMENT

A. Space between connectors and adjacent obstructions *should* be a minimum of 25mm (1 inch) for IVA access.

B. Connectors in a single row or staggered rows which are removed sequentially by the crew (IVA) *should* provide 25mm (1 inch) of clearance from other connectors and/or adjacent obstructions for 270 degrees of sweep around each connector beginning at the start of its removal/replacement sequence.

3.12.4.2.7 CONNECTOR PROTECTION

Payloads *should* provide protection for all de-mated connectors to prevent physical damage and contamination.

3.12.4.2.8 CONNECTOR SHAPE

Payloads with multiple connectors **shall** use different connector shapes, sizes or keying to prevent mating connectors when lines differ in content.

3.12.4.2.9 FLUID AND GAS LINE CONNECTORS

Payload fluid and gas connectors that are mated and de-mated on-orbit **shall** be located and configured so that they can be fully inspected for leakage.

3.12.4.2.10 ALIGNMENT MARKS OR GUIDE PINS

Payloads *should* provide alignment marks in a visible location during mating, or guide pins (or their equivalent) for any mating parts.

3.12.4.2.11 PIN IDENTIFICATION

Each pin *should* be uniquely identifiable in each electrical plug and each socket in each electrical receptacle. It is recommended at least every 10th pin and every 10th pin socket be labeled.

3.12.4.2.12 ORIENTATION

Payloads *should* orient grouped plugs and receptacles so that the aligning pins or equivalent devices are in the same relative position.

3.12.4.2.13 HOSE/CABLE RESTRAINTS

A. Payloads **shall** secure all bundles, hoses, and cables.

B. Payloads *should* restrain all loose cables (longer than 0.33 meters (1 foot)) as follows:

Length (m)	Restraint Pattern (% of length) tolerances ±10%)
0.33-1.00	50
1.00-2.00	33, 67
2.00-3.00	20, 40, 60, 80
>3.00	at least each 0.5 meters

This requirement does not apply to cables and hoses between the Rack UIP to the UIP.

3.12.4.3 FASTENERS

3.12.4.3.1 ENGAGEMENT STATUS

Payloads *should* provide an indication of correct engagement (hooking, latch fastening, or proper positioning of interfacing parts) on all non-threaded fasteners and stowage/equipment drawer/tray latches.

3.12.4.3.2 MOUNTING BOLT/FASTENER SPACING

Payloads *should* provide a minimum clearance of 0.5 inches for the entire circumference of the bolt head and a minimum of 1.5 inches over 180 degrees of the bolt head and provide the tool handle sweep as shown in Figure 3.12.4.3.2-1.

Note: EXPRESS subrack middeck locker equivalent payloads are exempt from meeting this requirement.

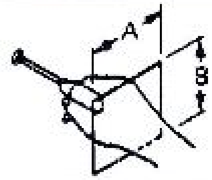
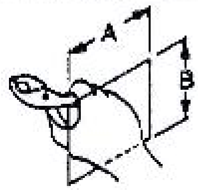
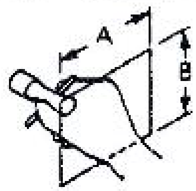
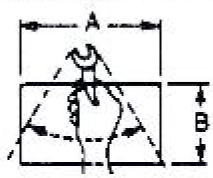
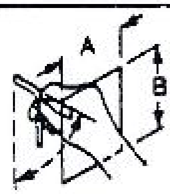
Opening dimensions		Task
	A 117 mm (4.6 in) B 107 mm (4.2 in)	Using common screw-driver with freedom to turn hand through 180°
	A 133 mm (5.2 in) B 115 mm (4.5 in)	Using pliers and similar tools
	A 155 mm (6.1 in) B 135 mm (5.3 in)	Using T-handle wrench with freedom to turn wrench through 180°
	A 203 mm (8.0 in) B 135 mm (5.3 in)	Using open-end wrench with freedom to turn wrench through 62°
	A 122 mm (4.8 in) B 155 mm (6.1 in)	Using Allen-type wrench with freedom to turn wrench through 62°

FIGURE 3.12.4.3.2-1 MINIMAL CLEARANCE FOR TOOL−OPERATED FASTENERS

3.12.4.3.3 MULTIPLE FASTENERS

Payloads *should* use identical type fasteners when multiple fasteners are used on one item.

3.12.4.3.4 QUICK RELEASE FASTENERS

A. Payloads *should* require a maximum of one complete turn to operate any quick release fasteners (quarter-turn fasteners are preferred).

B. Payloads *should* use quick release fasteners that are positive locking in open and closed positions.

3.12.4.3.5 THREADED FASTENERS

Payloads *should* use only right-handed threads on fasteners.

3.12.4.3.6 OVER CENTER LATCHES

A. Nonself-latching - Over center latches *should* include a provision to prevent undesired latch element realignment, interface, or reengagement.

B. Payloads *should* use latch catches that have locking features.

3.12.4.3.7 FASTENER HEAD TYPE

Payloads with fasteners to be installed or removed on-orbit *should* use hex type external or internal grip or combination head fasteners when on-orbit crew actuation is planned, e.g., ORU replacement.

3.12.5 CONTROLS AND DISPLAYS

3.12.5.1 CONTROLS SPACING DESIGN REQUIREMENTS

Payloads with controls *should* maintain the minimum spacing between all controls and adjacent obstructions as shown in Figure 3.12.5.1-1.

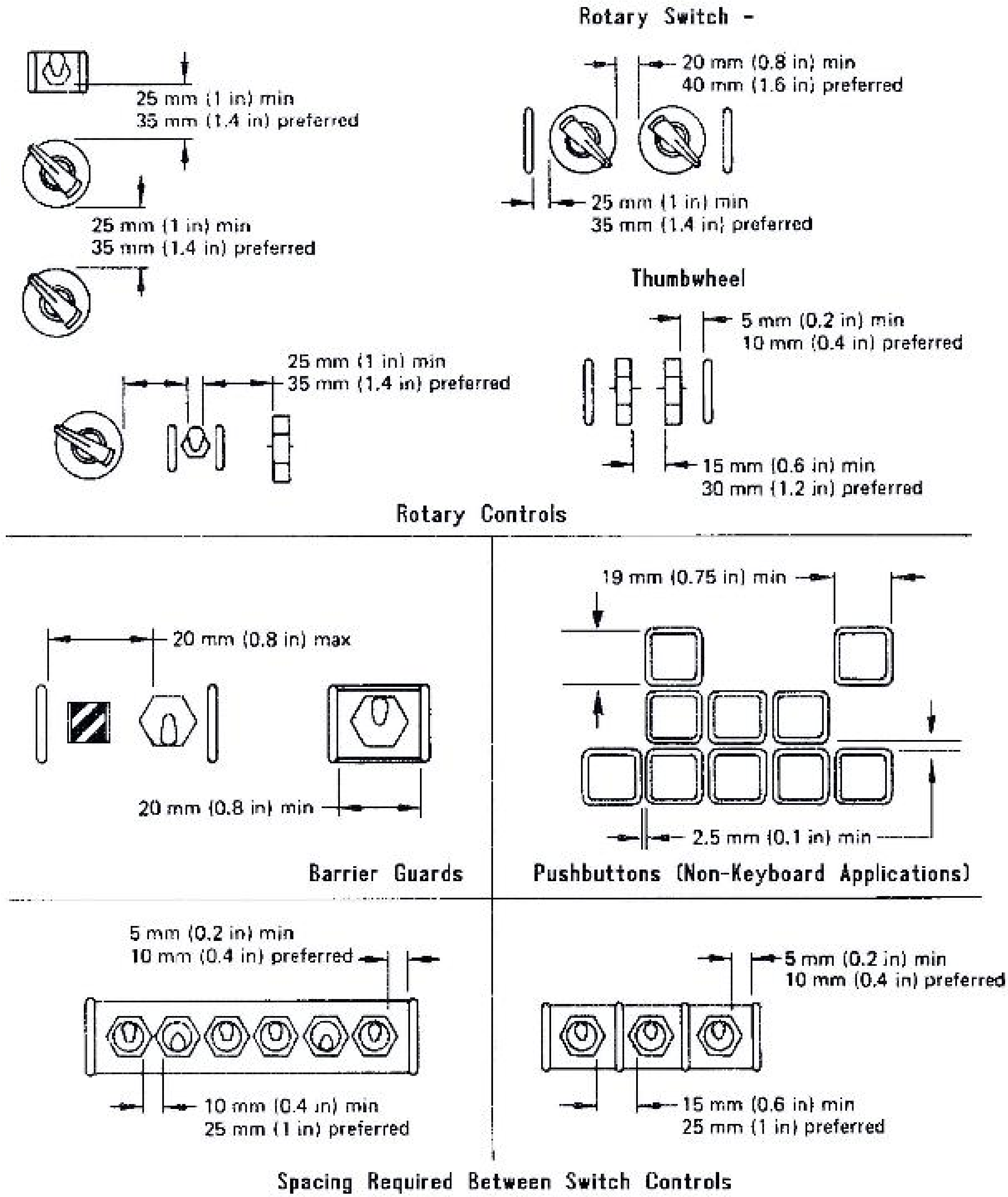


FIGURE 3.12.5.1-1 CONTROL SPACING REQUIREMENTS FOR UNGLOVED OPERATION

3.12.5.2 ACCIDENTAL ACTUATION

3.12.5.2.1 PROTECTIVE METHODS

Payloads with controls *should* provide protection against accidental control actuation using one or more of the protective methods listed in sub-paragraphs 1 through 10 below.

1. Separate infrequently used controls (i.e. those used for calibration) from frequently used controls.
2. Use lever lock switches or switch guard covers for switches related to mission success as switch guards alone may not be sufficient.
3. Protect displays and controls used only for maintenance and adjustments, which could disrupt normal operations if activated, e.g., by being located separately or guarded/covered.
4. Locate and orient the controls so that the operator is not likely to strike or move them accidentally in the normal sequence of control movements.
5. Recess, shield, or otherwise surround the controls by physical barriers that entirely contain the control within the envelope described by the recess or barrier.
6. Cover or guard the controls without using safety or lock wire.
7. Do not cover or obscure the protected control or adjacent controls when the cover or guard is open.
8. Provide the controls with interlocks so that extra movement (e.g., lifting switch out of a locked detent position) or the prior operation of a related or locking control is required.
9. Provide the controls with resistance (i.e., viscous or coulomb friction, spring-loading, or inertia) so that definite or sustained effort is required for actuation.
10. Provide the controls with a lock to prevent the control from passing through a position without delay when strict sequential actuation is necessary (i.e., the control moved only to the next position, then delayed).

3.12.5.2.2 NONINTERFERENCE

Payloads that provide protective devices *should* only use devices that do not cover or obscure other displays or controls.

3.12.5.2.3 BARRIER GUARD AND RECESSED SWITCH PROTECTION

Payloads with toggle switches, rotary switches, and thumbwheels *should* use barrier guards or recessed switches to prevent inadvertent actuation.

3.12.5.2.4 POSITION INDICATION

Payloads with switch protection covers *should* only use switches whose control position is evident without requiring cover removal.

3.12.6 RESTRAINTS AND MOBILITY AIDS

3.12.6.1 CONTENTS RESTRAINTS

Payloads with payload-provided stowage drawers/trays **shall** restrain all stowed payload equipment so that the items do not float away or jam payload mechanisms when the payload drawers/trays are opened or closed.

3.12.6.2 CAPTIVE PARTS

Payloads with fasteners or other items to be removed or installed on-orbit **shall** be designed in such a manner to ensure that all parts (e.g. fasteners, locking pins, knobs, handles, lens covers, access plates, or similar devices) that may be temporarily removed on-orbit are tethered or otherwise held captive.

3.12.6.3 HANDLES AND RESTRAINTS

Payloads with removable or portable items that are larger than 1 ft^3 *should* be provided with handles or other suitable means of grasping, tethering, carrying and restraining. Hand size dimensions are provided in Table 3.12.6.3-1. Figure 3.12.6.3-1 shows where the measurements are taken for hand size dimensions.

TABLE 3.12.6.3-1 HAND SIZE DIMENSIONS

	5^{TH} Percentile Female Inches (mm)	95^{TH} Percentile Male Inches (mm)
Length (420)	6.2 (158)	8.1 (206)
Breadth (411)	2.7 (69)	3.8 (96)
Circumference (416)	6.5 (166)	9.2 (234)

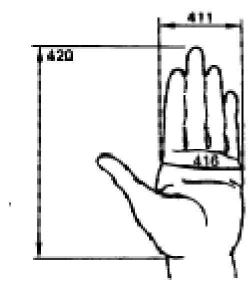


FIGURE 3.12.6.3-1 HAND SIZE DIMENSIONS

3.12.7 IDENTIFICATION LABELING

Payloads **shall** be labeled per the instructions in Appendix O. Appendix O provides instructions for label and decal design and approval.

3.12.8 CREW SAFETY

3.12.8.1 ELECTRICAL PROTECTION

3.12.8.1.1 MISMATCHED

A. Payloads with electrical connectors **shall** design the electrical connectors to prevent inadvertently reversing a connection or mating the wrong connectors if a hazardous condition can be created. Although identification markings or labels are required, the use of identification alone is not sufficient to preclude mis-mating.

B. Payload and on-orbit support equipment, wire harnesses, and connectors **shall** be designed such that no blind connections or disconnections are necessary during payload installation, operation, removal, or maintenance on-orbit unless the design includes scoop proof connectors or other protective features (SSP 51700, paragraph 3.21).

3.12.8.1.2 OVERLOAD PROTECTION

3.12.8.1.2.1 DEVICE ACCESSIBILITY

Payloads with overload protection devices **shall** be designed in such a way that the overload protection devices are inaccessible without opening a door or cover, except that an operating handle or operating button of a circuit breaker, the cap of an extractor-type fuse holder, and similar parts may project outside the enclosure.

3.12.8.1.2.2 EXTRACTOR-TYPE FUSE HOLDER

Payloads with extractor-type fuse holders **shall** be designed so that the fuse is extracted when the cap is removed.

3.12.8.1.2.3 OVERLOAD PROTECTION LOCATION

Payloads with overload protective devices (fuses and circuit breakers), to be replaced or physically reset on-orbit, *should* be designed in such a way that the overload protection device can be seen and replaced or reset without removing other components.

3.12.8.1.2.4 OVERLOAD PROTECTION IDENTIFICATION

Payloads with overload protective devices (fuses and circuit breakers), to be replaced or physically reset on-orbit, **shall** readily identify or key for its proper value each overload protector.

3.12.8.1.2.5 AUTOMATIC RESTART PROTECTION

Powered payloads **shall** use controls that prevent automatic restarting after a payload overload-initiated shutdown.

3.12.8.2 SHARP EDGES AND CORNERS PROTECTION

Payloads within the ISS pressurized volume **shall** employ a design that protects crewmembers from sharp edges and corners and sharp threads on screws or bolts during all crew operations by maintaining minimum edge radii for exposed edges as described in Table 3.12.8.2-1 and exposed corners as described in Table 3.12.8.2-2 and by covering or guarding screw/bolt threads as described in Table 3.12.8.2-3.

Note: This requirement does not apply to soft-good payload items. A definition for soft-good payload items can be found in Appendix B.

TABLE 3.12.8.2-1 MINIMUM BEND RADII FOR EXPOSED EDGES

Edge Thickness (T)	Bend Radius
T ≥ 0.25 inch (6.4 mm)	0.12 inch (3.0 mm) as shown in Figure 3.12.8.2-1
0.12 inch (3.0 mm) ≤ T < 0.25 inch (6.4 mm)	0.06 inch (1.5 mm) as shown in Figure 3.12.8.2-2
0.02 inch (0.5 mm) ≤ T < 0.12 inch (3.0 mm)	Full radius as shown in Figure 3.12.8.2-3
T < 0.02 inch (0.5 mm)	Rolled or curled edge as shown in Figure 3.12.8.2-4

TABLE 3.12.8.2-2 MINIMUM BEND RADII FOR EXPOSED CORNERS

Material Thickness (T)	Bend Radius
T ≤ 1.0 inch (25.0 mm)	0.5 inch (13.0 mm) as shown in Figure 3.12.8.2-5
T > 1.0 inch (25.0 mm)	0.5 inch (13.0 mm) as shown in Figure 3.12.8.2-6

TABLE 3.12.8.2-3 THREADED SCREW AND BOLT PROTRUSIONS

Distance Screw or Bolt Protrudes Beyond Payload Surface (P)	Action Required
P ≤ 0.12 inch (3.0 mm)	None
P > 0.12 inch (3.0 mm)	End of the screw or bolt must be covered or guarded

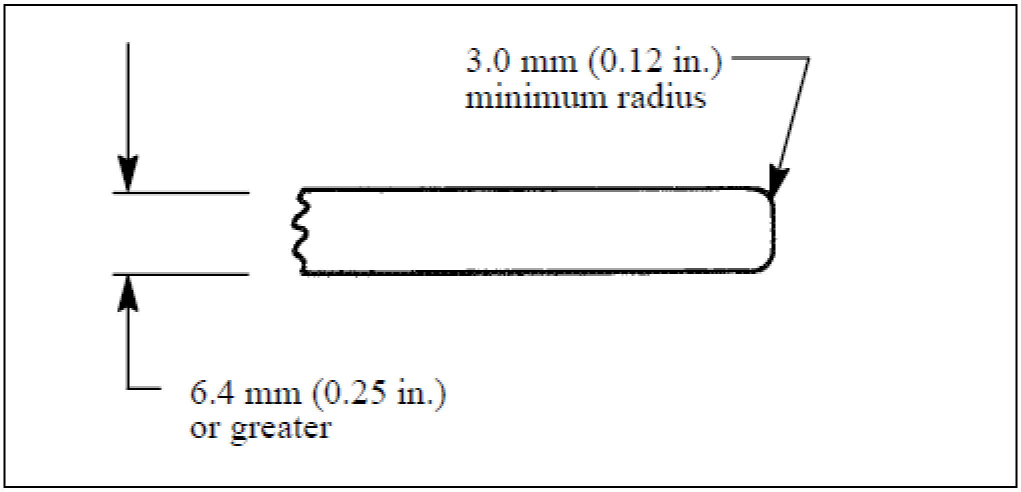


FIGURE 3.12.8.2-1 REQUIREMENTS FOR ROUNDING EXPOSED EDGES 0.25 INCH (6.4 MM) THICK OR THICKER

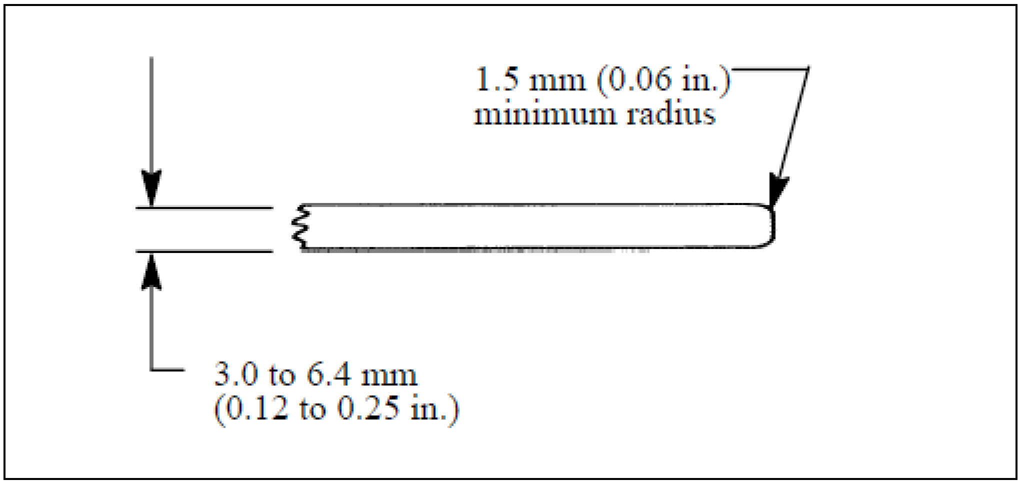


FIGURE 3.12.8.2-2 REQUIREMENTS FOR ROUNDING EXPOSED EDGES 0.12 TO 0.25 INCHES (3.0 TO 6.4 MM) THICK OR THICKER

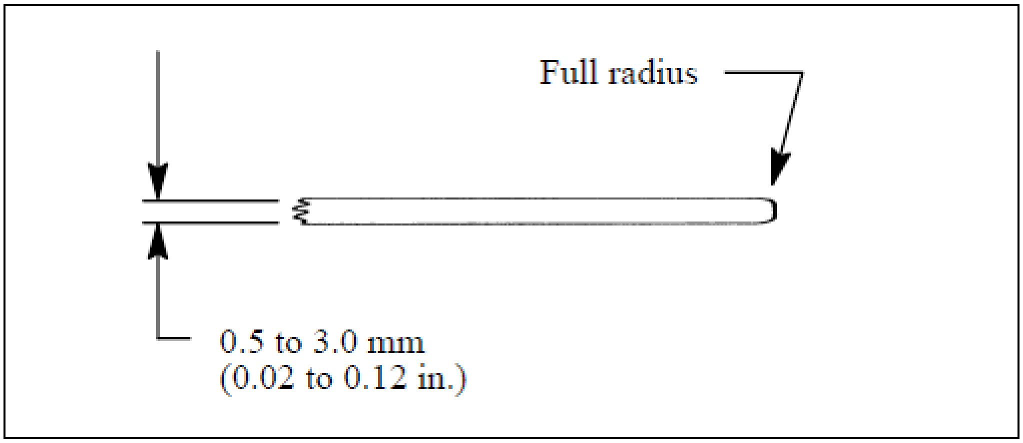


FIGURE 3.12.8.2-3 REQUIREMENTS FOR ROUNDING EXPOSED EDGES 0.02 TO 0.12 INCHES (0.5 TO 3.0 MM) THICK OR THICKER

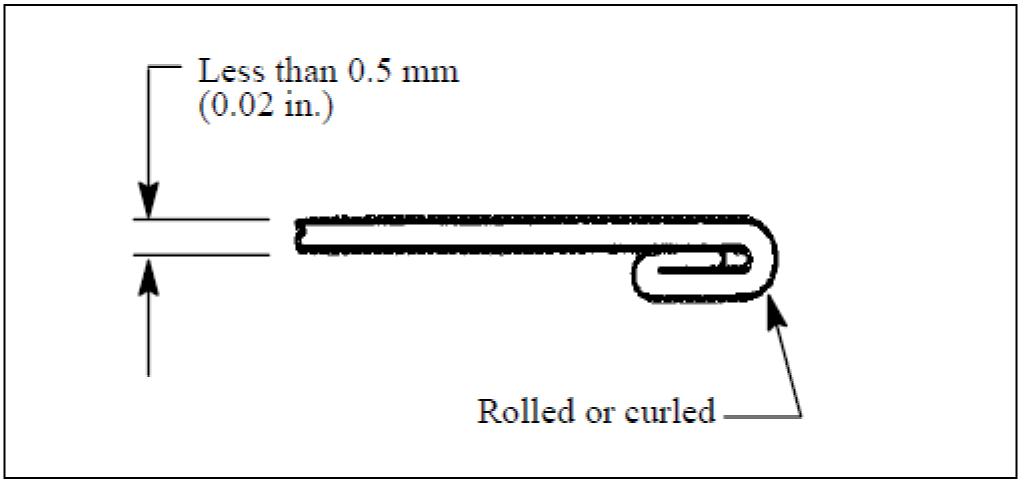


FIGURE 3.12.8.2-4 REQUIREMENTS FOR CURLING OF SHEETS LESS THAN 0.02 INCH (0.5 MM) THICK

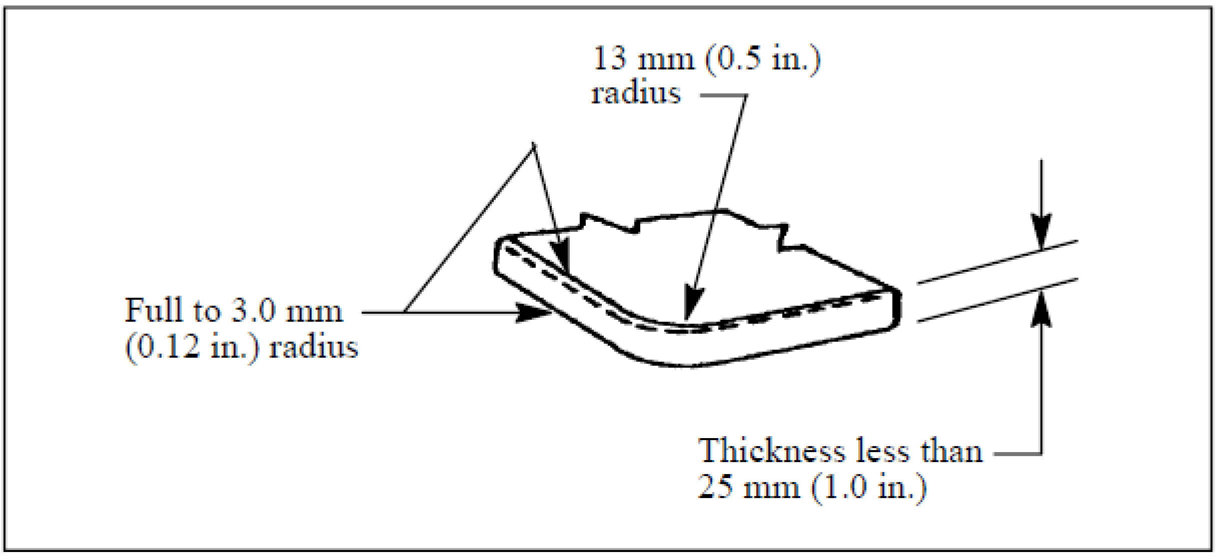


FIGURE 3.12.8.2-5 REQUIREMENTS FOR ROUNDING OF CORNERS LESS THAN 1.0 INCH (25 MM) THICK

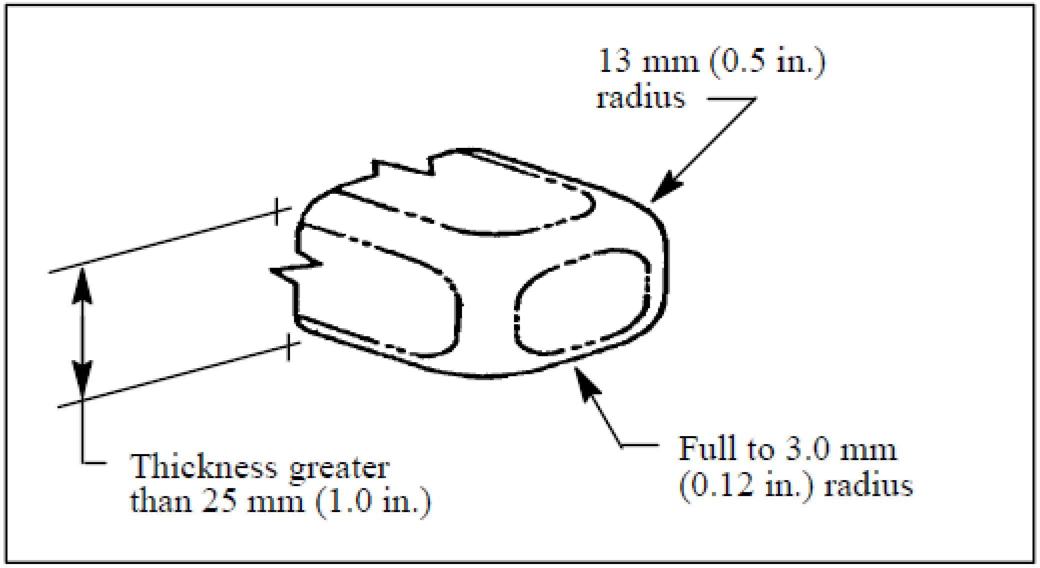


FIGURE 3.12.8.2-6 REQUIREMENTS FOR ROUNDING OF CORNERS GREATER THAN 1.0 INCH (25 MM) THICK

3.12.8.3 HOLES

Payload hardware with crew controls **shall** cover any holes that are round or slotted in the range of 0.4 to 1.0 inch (10.0 to 25.0 mm).

3.12.8.4 LATCHES

Payload hardware with latches **shall** design the latches to prevent entrapment of a crewmember's appendage if the latches pivot, retract, or flex so that a gap of less than 1.38 inches (35 mm) exists.

3.12.8.5 LEVERS, CRANKS, HOOKS, AND CONTROLS

Payloads **shall** locate any levers, cranks, hooks, and controls where they cannot pinch, snag, or cut the crewmembers or their clothing.

3.12.8.6 BURRS

All payload exposed surfaces **shall** be free of burrs.

Note: This requirement does not apply to soft-good payload items. A definition for soft-good payload item can be found in Appendix B.

3.12.8.7 LOCKING WIRES

Payloads **shall** not use safety wire on fasteners which must be unfastened for on-orbit removal or replacement.

4.0 VERIFICATION

This Section contains the formal qualification requirements to verify compliance with the requirements of this document. **Shall** statements are required to be verified for compliance. Verification and verification submittals have been provided for design guidelines (*should* statements) to assist the payload developer, however these items do not require formal verification.

4.1 VERIFICATION METHODS

The following verification methods specified in this section are recommended and approved by the ISS Program; however, these methods may be tailored in the payload unique ICD if mutually agreed upon by the payload developer and the ISS Program if there is rationale for using a different method.

A. INSPECTION - Inspection is a physical measurement or visual evaluation of equipment and associated documentation. Inspection is used to verify construction features, drawing compliance, workmanship, and physical condition.

B. ANALYSIS - Analysis is the technical evaluation process of using techniques and tools such as mathematical models and computer simulation, historical/design/test data, and other quantitative assessments to calculate characteristics and verify specification compliance. Analysis is used to verify requirements compliance where established techniques are adequate to yield confidence or where testing is impractical.

C. DEMONSTRATION - Demonstration is the qualitative determination of compliance with requirements by observation during actual operation or simulation under preplanned conditions and guidelines.

D. TEST - Test is actual operation of equipment, normally instrumented, under simulated or flight equivalent conditions or the subjection of parts or equipment to specified environments to measure and record responses in a quantitative manner.

4.2 RESPONSIBILITY FOR VERIFICATIONS

Unless otherwise specified in the Payload Integration Agreement (PIA), the Payload developer is responsible for the performance of verification activities as specified herein and responsible for providing all required data/test results. Except as otherwise specified in the PIA, the Payload developer may use his own or any other facility suitable for the performance of the verification activities specified herein, unless disapproved by NASA. NASA reserves the right to perform any of the verifications set forth in this document. It is the responsibility of the hardware developer to ensure design drawings, models, etc., used for verification reflect the as–built hardware.

4.3 INTERFACE VERIFICATION METHODS

4.3.1 STRUCTURAL/MECHANICAL, MICROGRAVITY, ANGULAR MOMENTUM DISTURBANCE, AND PROTRUSION INTERFACE REQUIREMENTS

4.3.1.1 STRUCTURAL/MECHANICAL

4.3.1.1.1 LOADS REQUIREMENTS

4.3.1.1.1.1 ON-ORBIT LOADS

An analysis *should* be conducted to verify that the payloads maintain positive margins of safety during a transient or continuous load of 0.2 g.

Verification Submittal: Data Cert

4.3.1.1.1.2 CREW-INDUCED LOADS

An analysis **shall/***should* be performed to show that payload equipment exposed to the crew translation path maintains a positive margin of safety when exposed to the crew-induced loads as defined in paragraph 3.1.1.1.2. As part of their analysis, payloads **shall/***should* use the minimum factors of safety defined in SSP 52005, Payload Flight Equipment Requirements and Guidelines for Safety-Critical Structures, Table 5.1.1-1. The verification **shall/***should* be considered successful when the analysis report shows positive margins exist for yield and ultimate loads for utility lines and for ultimate loads for all other exposed equipment. Items mounted to a Bogen Arm or that are handheld/worn are exempt from this requirement.

Verification Submittal: Analysis Report

4.3.1.1.1.3 SEAT TRACK ALLOWABLE LOADS AND MOMENTS

Verification **shall** be by analysis. The verification **shall** be considered successful when the analysis shows that the loads and moments imparted by the payload to the seat track are below those specified in Table 3.1.1.1.3-1 when the payload is exposed to the crew-induced loads shown in Table 3.1.1.1.2-1.

Verification Submittal: Analysis Report

4.3.1.1.2 PORTABLE FIRE EXTINGUISHER DISCHARGE

An analysis **shall** be conducted to determine the maximum delta pressure from within to outside the payload during PFE discharge and show that the payload maintains positive margins of safety (delta pressure limited to 3.5 kPa (0.5 psi). Verification **shall** be considered successful when the analysis shows that the structures maintain positive margins.

Verification Submittal: Analysis Report

4.3.1.1.3 OVERPRESSURE RELIEF DEVICE

Verification **shall** be by inspection. An inspection of the as-built drawings **shall** be conducted to determine where the overpressure relief device(s) vents. Verification **shall** be considered successful when inspection shows that the overpressure relief device(s) does not vent directly into the cabin aisle-way. Non-compliance with this requirement requires a Non-Compliance Report (NCR).

Verification Submittal: CoC

4.3.1.1.4 WINDOW PROTECTION

Verification **shall** be by inspection. An inspection of the as-built drawings **shall** be conducted to determine that the camera is equipped with bumper rings per 3.1.1.4. Verification **shall** be considered successful when inspection shows that the payload has bumper rings installed.

Verification Submittal: CoC

4.3.1.1.5 SECURING OF THREADED FASTENERS

Verification of threaded fasteners connecting safety-critical structures (and threaded fasteners used in an application of retaining a rotary device) **shall** be by inspection. The verification **shall** be considered successful when the inspection of the payload design shows the threaded fasteners use a means of positive locking, have been proven secure through vibration testing, or attach internal components shown by analysis to be contained if released, as specified in Paragraph 3.1.1.5.

Verification Submittal: CoC

4.3.1.1.6 REDUNDANT THREADED FASTENERS LOCKING REQUIREMENTS

Verification that redundant threaded fasteners (non-fracture critical) employ self-locking threaded devices *should* be by inspection. The verification *should* be considered successful when the inspection of the payload design shows that redundant threaded fasteners (non-fracture critical) in habitable or removable on-orbit employ self-locking threaded devices as described in Paragraph 3.1.1.6.

Verification Submittal: CoC

4.3.1.2 MICROGRAVITY

NVR

4.3.1.3 LIMIT ANGULAR MOMENTUM DISTURBANCE

4.3.1.3.1 LIMIT DISTURBANCE INDUCED ISS ATTITUDE RATE

This requirement **shall** be verified by analysis. The analysis **shall** consist of a comparison of the calculated angular momentum impulse due to individual payload on-board disturbances to the per axis angular momentum allocations to verify that the allocations are not exceeded. The disturbance angular momentum impulse will be calculated as the integral of the disturbance torque relative to the ISS Assembly Complete center of mass over the specified period of time. For constant, continuously increasing, or continuously decreasing disturbance torques over two or more adjacent time periods, the difference in angular momentum impulse of the adjacent time periods **shall** be used. ISS assembly complete mass properties and worst case element location/design parameters, as identified in JSC 26557, Volume I **shall** be used when assessing compliance with this requirement. The verification **shall** be considered successful when analysis shows that the per axis disturbance angular momentum impulses are as specified for each axis.

Verification Submittal: Analysis Report

4.3.1.3.2 LIMIT DISTURBANCE INDUCED CMG MOMENTUM USAGE

This requirement **shall** be verified by analysis utilizing analytical models of the disturbance. This analysis **shall** consist of calculating the angular momentum impulse for each axis due to individual payload on-board disturbances and applying them in the specified equation for estimating worst case CMG momentum usage. The disturbance angular momentum impulse will be calculated as the integral of the disturbance torque relative to the ISS Assembly Complete center of mass over the specified period of time. For constant, continuously increasing, or continuously decreasing disturbance torques over two or more adjacent 110 minute periods, the difference in angular momentum impulse of the adjacent 110 minute periods **shall** be used. ISS assembly complete mass properties and worst case element location/design parameters, as identified in JSC 26557, Volume I **shall** be used when assessing compliance with this requirement. The verification **shall** be considered successful when analysis shows that the estimated worst case CMG momentum usage is less than the specified amount.

Verification Submittal: Analysis Report

4.3.1.4 PROTRUSIONS

NVR

4.3.1.4.1 PROTRUSION GUIDELINES

A. NVR

B. An inspection *should* be performed to determine that on-orbit protrusions do not extend laterally across the edges of the rack or pass between racks. The inspection *should* be of the hardware or the as-built drawings. The verification *should* be considered successful when the inspection shows that no on-orbit protrusions extends extend laterally across the edges of the rack or pass between racks.

Verification Submittal: Data Cert

4.3.1.4.2 PROTRUSION DATA REQUIREMENTS

<u>Data Deliverable</u>

4.3.1.5 DESCRIPTION OF PAYLOAD

<u>Data Deliverable</u>

4.3.2 ELECTRICAL INTERFACE REQUIREMENTS

4.3.2.1 ELECTRICAL POWER CHARACTERISTICS

NVR

4.3.2.1.1 POWER BUS ISOLATION

A. Verification of power bus isolation between two independent power inputs, **shall** be performed by test. The verification **shall** be considered successful when the test shows the payload electrical system (including internal and external payload equipment, and including both the supply and return lines) provides a minimum of 1 MΩ isolation in parallel with not more than 0.03 μ*F* of mutual capacitance between the two independent power buses.

Note: The 1 MΩ isolation must be verified by test and the 0.03 μ*F* of mutual capacitance can be verified by test, analysis, or inspection.

Verification Submittal: Test Report

B. Verification of power input and return isolation without the use of diodes **shall** be verified by analysis. The analysis **shall** show the exclusion of diodes used to isolate the two independent power input or return lines. The verification **shall** be considered successful when analysis shows there are no diodes used, to electrically tie together independent power input or return lines, within the payload and its internal and external EPCE.

Verification Submittal: Analysis Report

4.3.2.1.2 CIRCUIT PROTECTION

4.3.2.1.2.1 CIRCUIT PROTECTION DEVICES

Analysis of electrical circuit schematics **shall** be performed to show overcurrent protection exists at all points in the payload electrical architecture system where power is distributed to lower level (wire size not protected by upstream circuit protection device) feeder and branch lines.The analysis **shall** be considered successful when results show overcurrent protection, in compliance with Tables 3.2.1.2.1-1, 3.2.1.2.1-2, 3.2.1.2.1-3, 3.2.1.2.1-4, and 3.2.1.2.1-5, exists at each point in the payload electrical architecture system where power is distributed to lower level feeder and branch lines.

Verification Submittal: Analysis Report

4.3.2.1.2.2 WIRE DERATING

A. Derating for wire/cable of the payload and all payload EPCE **shall** be verified by analysis. Analysis of the electrical power schematics **shall** be performed to show that the wire gauge of the payload and all payload EPCE upstream of the payload primary protection device meets the derating requirements in Table 3.2.1.2.2-1. The verification **shall** be considered successful when the analysis shows the wire gauge meets the wire derating requirements in Table 3.2.1.2.2-1.

Verification Submittal: Analysis Report

B. Derating for wire/cable of the payload and all payload EPCE **shall** be verified by analysis. Analysis of the electrical power schematics **shall** be performed to show that the wire gauge of the payload and all payload EPCE downstream of the payload primary protection device meets the derating requirements in Table 3.2.1.2.2-1 or Table 3.2.1.2.2-2. The verification **shall** be considered successful when the analysis shows the wire gauge meets the wire derating requirements in Table 3.2.1.2.2-1 or Table 3.2.1.2.2-2.

Verification Submittal: Analysis Report

4.3.2.1.3 LOSS OF POWER

This requirement is verified through the Safety process.

4.3.2.1.4 ELECTRICAL GROUNDING AND ISOLATION

NVR

4.3.2.1.4.1 PAYLOAD POWER ISOLATION

The DC isolation of the payload 120 Vdc or 28 Vdc electrical power **shall** be verified by inspection. The verification **shall** be considered successful when inspection of drawings and quality records (Quality records include workmanship resistance measurements) indicates that the payload electrical power user is DC isolated from chassis, structure, equipment conditioned power return/reference, and signal returns by a minimum of 1 megohm.

Verification Submittal: CoC

4.3.2.1.4.1.1 SINGLE POINT GROUND

Verification that each electrical power source is DC isolated from chassis, structure, equipment conditioned power return/reference, and signal circuits by a minimum of 1 MΩ, individually, except at the single point ground, **shall** be verified by inspection. The verification **shall** be considered successful when inspection of drawings and quality records (Quality records include workmanship resistance measurements) indicates that each isolated electrical power source is connected to structure at no more than one point.

Verification Submittal: CoC

4.3.2.1.4.1.2 ELECTRICAL POWER ISOLATION

The single point ground of each isolated electrical power source **shall** be verified by inspection. The verification **shall** be considered successful when inspection of drawings and quality records (Quality records include workmanship resistance measurements) indicates that each electrical power source is DC isolated from chassis, structure, equipment conditioned power return/reference, and signal returns by a minimum of 1 megohm.

Verification Submittal: CoC

4.3.2.1.4.1.3 SIGNAL CIRCUIT RETURN GROUNDING

Verification that the circuit conductors are DC isolated from chassis, structure, equipment conditioned power return/reference, by a minimum of 1 MΩ, individually, when all grounds are not terminated to the single point ground/reference **shall** be verified by inspection. The verification **shall** be considered successful when inspection of drawings and quality records (Quality records include workmanship resistance measurements) indicates that circuit conductors are DC isolated from chassis, structure, equipment conditioned power return/reference by a minimum of 1 megohm, individually, when not terminated by the signal circuit's single point ground/reference.

Verification Submittal: CoC

4.3.2.1.4.1.4 ALTERNATING CURRENT POWER RETURN

A. Verification **shall** be by inspection. The verification **shall** be considered successful when the inspection of drawings and quality records (Quality records include workmanship resistance measurements) shows that a neutral return wire accompanies the alternating current input wires to individual equipment loads in the distribution of power.

Verification Submittal: CoC

B. Verification **shall** be by inspection. The verification **shall** be considered successful when the inspection of drawings and quality records (Quality records include workmanship resistance measurements) shows that a neutral return wire is isolated from chassis at the load.

Verification Submittal: CoC

4.3.2.1.4.1.5 ANALOG, DIFFERENTIAL CIRCUIT RETURN

Verification **shall** be by inspection. The verification **shall** be considered successful when the inspection of drawings and quality records (Quality records include workmanship resistance measurements) shows that each differential analog circuit employs a separate return.

Verification Submittal: CoC

4.3.2.1.4.1.6 DISCRETE RETURNS

Verification **shall** be by inspection. The verification **shall** be considered successful when the inspection of drawings and quality records (Quality records include workmanship resistance measurements) shows that each low level discrete signal uses an individual return.

Verification Submittal: CoC

4.3.2.1.4.1.7 PULSE OR CLOCK CIRCUIT RETURNS

Verification **shall** be by inspection. The verification **shall** be considered successful when the inspection of drawings and quality records (Quality records include workmanship resistance measurements) shows that all digital, pulse, or clock circuits that do not use fiber optic cabling use individual returns.

Verification Submittal: CoC

4.3.2.2 ELECTROMAGNETIC COMPATIBILITY

NVR

4.3.2.2.1 ELECTROMAGNETIC EMISSION REQUIREMENTS

4.3.2.2.1.1 CE01 LIMITS

The verification **shall** be by test. Tests **shall** be conducted using the methods in SSP 30238 with flight or flight-like cables. Flight-like cables have the same configuration with the same methods of shield termination. Equipment Under Test (EUT) must be bonded to the copper bench top in the same manner as it is bonded to vehicle structure during flight.

Verification **shall** be considered successful when test results shows that the equipment complies with the applicable emissions limits.

Verification Submittal: EMI test reports along with any supporting analyses.

4.3.2.2.1.2 CE03 LIMITS

The verification **shall** be by test. Tests **shall** be conducted using the methods in SSP 30238 with flight or flight-like cables. Flight-like cables have the same configuration with the same methods of shield termination. EUT must be bonded to the copper bench top in the same manner as it is bonded to vehicle structure during flight.

Verification **shall** be considered successful when test results shows that the equipment complies with the applicable emissions limits.

Verification Submittal: EMI test reports along with any supporting analyses.

4.3.2.2.1.3 RE02 LIMITS

The verification **shall** be by test. Tests **shall** be conducted using the methods in SSP 30238 with flight or flight-like cables. Flight-like cables have the same configuration with the same methods of shield termination. EUT must be bonded to the copper bench top in the same manner as it is bonded to vehicle structure during flight.

Verification **shall** be considered successful when test results shows that the equipment complies with the applicable emissions limits.

Verification Submittal: EMI test reports along with any supporting analyses.

4.3.2.2.2 ELECTROMAGNETIC SUSCEPTIBILITY REQUIREMENTS

NVR

4.3.2.2.2.1 CS01 LIMITS

The verification **shall**/*should* be by test. The payload **shall**/*should* be monitored during susceptibility testing for indications of degradation or malfunction. This monitoring is normally accomplished through the use of built-in-test (BIT), visual displays, aural outputs, and other measurements of signal outputs and interfaces.

Monitoring of payload performance through installation of special circuitry in the payload is permissible; however, these modifications must not influence test results. Prior to testing, susceptible operation **shall**/*should* be defined; some anomalous behavior may be present but hardware may continue to meet operational and performance requirements despite anomaly. When susceptibilities are noted, the threshold of susceptibility **shall**/*should* be determined by reducing the interference signal below the level where the equipment recovers, and then slowly increasing the level until the susceptibility occurs. The threshold, frequency of occurrence and equipment response **shall**/*should* be recorded in the EMI test report.

Tests **shall**/*should* be conducted using the methods in SSP 30238 with flight or flight-like cables. Flight-like cables have the same configuration with the same methods of shield termination. EUT **shall**/*should* be bonded to the copper bench top in the same manner as it is bonded to vehicle structure during flight.

Verification **shall**/*should* be considered successful when the equipment meets its operational and performance requirements when exposed to the applicable susceptibility test levels. The verification is also considered successful when the audio power source specified in SSP 30238, adjusted to dissipate 50 Watts in a 0.5 ohm load, cannot develop the required voltage at the EUT power input terminals and the EUT is not susceptible to the output of the signal source.

If this test is performed as part of power quality voltage transient testing, the power quality test results can be submitted for verification in lieu testing.

Verification Submittal: EMI test reports along with any supporting analyses.

4.3.2.2.2.2 CS02 LIMITS

The verification **shall**/*should* be by test. The payload **shall**/*should* be monitored during susceptibility testing for indications of degradation or malfunction. This monitoring is normally accomplished through the use of BIT, visual displays, aural outputs, and other measurements of signal outputs and interfaces.

Monitoring of payload performance through installation of special circuitry in the payload is permissible; however, these modifications must not influence test results. Prior to testing, susceptible operation **shall**/*should* be defined; some anomalous behavior may be present but hardware may continue to meet operational and performance requirements despite anomaly. When susceptibilities are noted, the threshold of susceptibility **shall**/*should* be determined by reducing the interference signal below the level where the equipment recovers, and then slowly increasing the level until the susceptibility occurs. The threshold, frequency of occurrence and equipment response **shall**/*should* be recorded in the EMI test report.

Tests **shall**/*should* be conducted using the methods in SSP 30238 with flight or flight-like cables. Flight-like cables have the same configuration with the same methods of shield termination. EUT test **shall**/*should* be bonded to the copper bench top in the same manner as it is bonded to vehicle structure during flight. The test signal is applied to the equipment power line near the equipment input terminals as specified in SSP 30238.

Verification **shall**/*should* be considered successful when the equipment meets its operational and performance requirements when exposed to the applicable susceptibility test levels. The verification is also considered successful when a 1 Watt source of 50 ohms impedance cannot develop the required voltage at the EUT power input terminals and the EUT is not susceptible to the output of the signal source.

If this test is performed as part of power quality voltage transient testing, the power quality test results can be submitted for verification in lieu testing.

Verification Submittal: EMI test reports along with any supporting analyses.

4.3.2.2.2.3 CS06 LIMITS

The verification **shall**/*should* be by test. The payload **shall**/*should* be monitored during susceptibility testing for indications of degradation or malfunction. This monitoring is normally accomplished through the use of BIT, visual displays, aural outputs, and other measurements of signal outputs and interfaces.

Monitoring of payload performance through installation of special circuitry in the payload is permissible; however, these modifications must not influence test results. Prior to testing, susceptible operation **shall/***should* be defined; some anomalous behavior may be present but hardware may continue to meet operational and performance requirements despite anomaly. When susceptibilities are noted, the threshold of susceptibility **shall/***should* be determined by reducing the interference signal below the level where the equipment recovers, and then slowly increasing the level until the susceptibility occurs. The threshold, frequency of occurrence and equipment response **shall/***should* be recorded in the EMI test report.

Tests **shall/***should* be conducted using the methods in SSP 30238 with flight or flight-like cables. Flight-like cables have the same configuration with the same methods of shield termination. EUT **shall/***should* be bonded to the copper bench top in the same manner as it is bonded to vehicle structure during flight.

Verification **shall/***should* be considered successful when the equipment meets its operational and performance requirements when exposed to the applicable susceptibility test levels.

If this test is performed as part of power quality voltage transient testing, the power quality test results can be submitted for verification in lieu testing.

Verification Submittal: EMI test reports along with any supporting analyses.

4.3.2.2.2.4 RS03 LIMITS

The verification **shall/***should* be by test. The payload **shall/***should* be monitored during susceptibility testing for indications of degradation or malfunction. This monitoring is normally accomplished through the use of BIT, visual displays, aural outputs, and other measurements of signal outputs and interfaces.

Monitoring of payload performance through installation of special circuitry in the payload is permissible; however, these modifications must not influence test results. Prior to testing, susceptible operation **shall/***should* be defined; some anomalous behavior may be present but hardware may continue to meet operational and performance requirements despite anomaly. When susceptibilities are noted, the threshold of susceptibility **shall/***should* be determined by reducing the interference signal below the level where the equipment recovers, and then slowly increasing the level until the susceptibility occurs. The threshold, frequency of occurrence and equipment response **shall/***should* be recorded in the EMI test report.

Tests **shall/***should* be conducted using the methods in SSP 30238 with flight or flight-like cables. Flight-like cables have the same configuration with the same methods of shield termination. EUT **shall/***should* be bonded to the copper bench top in the same manner as it is bonded to vehicle structure during flight.

Verification **shall/***should* be considered successful when the equipment meets its operational and performance requirements when exposed to the applicable susceptibility test levels.

If this test is performed as part of power quality voltage transient testing, the power quality test results can be submitted for verification in lieu testing.

Verification Submittal: EMI test reports along with any supporting analyses.

4.3.2.2.3 TIME-VARYING MAGNETIC FIELDS

The AC magnetic fields requirement for payload equipment **shall** be verified by test. Test **shall** be performed using the MIL-STD-461, Interface Standard Requirements for the Control of Electromagnetic Interference Characteristics of Subsystems and Equipment, RE101 Method, with the following modifications:

1. Test setup guidelines **shall** be per SSP 30238, Figure 3.2.3.1.4-1 or 3.2.3.1.4-2, not the setup identified by MIL-STD-461.
2. Guidelines of SSP 30238, Figures 3.2.3.1.4-1 and 3.2.3.1.4-2, requirement of 7 cm separation does not apply to RE101.
3. Measurements are required from 30 Hz to 50 kHz rather than 100 kHz required by MIL-STD-461.
4. Measurements are performed at 7 cm from a point on the enclosure of the generating equipment nearest the source of the field. In the event emissions are out-of-specification, measurements **shall** be performed at 10 cm from a point on the enclosure of the generating equipment and at 10 cm increments away perpendicular to the enclosure (surface) of the generating equipment until data proves the AC magnetic fields are 6 dB less than the requirement in paragraph 3.2.2.3.
5. Emissions greater than 20 dB below the specified limits **shall** be recorded in the EMI test report. In cases where the noise floor and ambient are not 20 dB below specified level, only those emissions above the noise floor/ambient are required to be recorded.

The verification **shall** be considered successful when test results show the generated AC magnetic fields do not exceed the magnetic field emission limits of paragraph 3.2.2.3. A certificate of compliance stating the AC magnetic field does not exceed the design requirement will be sufficient for equipment that meets the requirement.

Note: Requirements are not applicable to solenoid valves, solenoid relays, and electric motors with current of less than 1 Amp.

Verification Submittal: Test Report along with any supporting analyses.

4.3.2.2.4 STATIC MAGNETIC FIELDS

The DC magnetic fields requirement for payload equipment as defined in 3.2.2.4 **shall** be verified by test. The measurement of DC magnetic fields **shall** be performed at 7 cm from a point on the enclosure of the generating equipment nearest the source of the field. For payloads and equipment that exceed the design requirement of paragraph 3.2.2.4, measurements **shall** be performed at 10 cm from a point on the enclosure of the generating equipment until data proves the DC magnetic fields are less than 164 dBpT. The verification **shall** be considered successful when test results show the generated DC magnetic fields do not exceed the design requirement of paragraph 3.2.2.4. A certificate of compliance stating the DC magnetic field does not exceed the design requirement will be sufficient for equipment that meets the requirement.

Note: Requirements are not applicable to solenoid valves, solenoid relays, and electric motors with power consumption of less than 1 ampere.

Verification Submittal: Test Report along with any supporting analyses.

4.3.2.2.5 CABLE/WIRE DESIGN AND CONTROL REQUIREMENTS

Verification **shall** be by inspection. The verification **shall** be considered successful when the inspection of drawings and quality records (Quality records include workmanship measurements) indicates that external wiring meets the minimum wire type (twisted, twisted shielded, twisted double shielded, etc.) as defined in Table 3.2.2.5-1.

Verification Submittal: CoC

4.3.2.2.5.1 SEPARATION REQUIREMENTS

Verification **shall** be by inspection. The verification **shall** be considered successful when inspection of drawings and quality records (Quality records include workmanship measurements) indicates that all circuits routed together in a bundle are of the same EMC classification and that each bundle type is physically separated from other bundles per Table 3.2.2.5.1-1.

Verification Submittal: CoC

4.3.2.2.5.2 SHIELDING

A. Verification **shall** be by inspection. The verification **shall** be considered successful when inspection of drawings and quality records (Quality records include workmanship measurements) indicates that wire shields cover the twisted pair or twisted group rather than individual wires.

Verification Submittal: CoC

B. Verification **shall** be by analysis. The verification **shall** be considered successful when analysis of the shielded circuit indicates that the shield does not intentionally carry current.

Verification Submittal: Analysis Report

4.3.2.2.5.3 TERMINATIONS

A. Verification **shall** be by inspection. The verification **shall** be considered successful when inspection of drawings and quality records (Quality records include workmanship measurements) indicates that wire shields are terminated at both ends and at intermediate break points directly to structure or chassis, through connector backshells or direct wire connection.

Verification Submittal: CoC

B. Verification **shall** be by inspection. The verification **shall** be considered successful when inspection of drawings and quality records (Quality records include workmanship measurements) indicates that wire shields length of termination do not exceed 3 inches.

Verification Submittal: CoC

C. Verification **shall** be by inspection. The verification **shall** be considered successful when inspection of drawings and quality records (Quality records include workmanship measurements) indicates that overall shields are terminated peripherally at each end.

Verification Submittal: CoC

4.3.2.2.5.4 BREAKOUTS

A. Verification *should* be by inspection. The verification *should* be considered successful when inspection of drawings and quality records (Quality records include workmanship measurements) indicates that multiple shield terminations use RFI backshells with individual shield grounding provisions.

Verification Submittal: CoC

B. Verification *should* be by inspection. The verification *should* be considered successful when inspection of drawings and quality records (Quality records include workmanship measurements) indicates that RF circuit shields are broken out such that no more than 2 inches of wiring is exposed.

Verification Submittal: CoC

C. Verification *should* be by inspection. The verification *should* be considered successful when inspection of drawings and quality records (Quality records include workmanship measurements) indicates that the wiring is contained within the connector metal backshell covering.

Verification Submittal: CoC

4.3.2.2.5.5 WIRE TWISTING

A. Verification **shall** be by inspection. The verification **shall** be considered successful when inspection of drawings and quality records (Quality records include workmanship measurements) indicates that signal and power circuits are twisted with their respective returns.

Verification Submittal: CoC

B. Verification **shall** be by inspection. The verification **shall** be considered successful when inspection of drawings and quality records (Quality records include workmanship measurements) indicates that multiple circuits using a common return are twisted together as a group.

Verification Submittal: CoC

4.3.2.2.6 ELECTROSTATIC DISCHARGE

The susceptibility of the payload circuit to Electrostatic Discharge **shall**/*should* be verified by test or analysis. The analysis **shall**/*should* be based on payload EPCE design and analysis data. The test **shall**/*should* be conducted using the methods in SSP 30238 with flight or flight-like cables. Flight-like cables have the same configuration with the same methods of shield termination. EUT must be bonded to the copper bench top in the same manner as it is bonded to vehicle structure during flight. The verification **shall**/*should* be considered successful when test or analysis results show that the payload equipment complies with the applicable ESD immunity limits.

TEST POINTS

Test points for contact discharge **shall**/*should* be identified in the ESD test report or analysis submitted to show compliance with the ESD environment. Typical test points include keyboards, switches, knobs, buttons, indicators, connector shells, and other installer or operator accessible areas.

DISCHARGE CIRCUIT

The ESD event is created by discharging a 150 picofarad capacitor through a 330 ohm resistor with a circuit inductance not to exceed 5 microhenry.

Note: IEC 61000-4-2 provides more information on discharge circuits, waveforms, and test point selection.

Verification Submittal: Test Report or Analysis Report

4.3.2.2.7 CORONA

Verification **shall** be by test or analysis or inspection. Test is required for equipment containing high voltages (> 190 V peak) that may be exposed to partial pressures (> 1.0×10^{-1} N/m^2). However, analysis or inspection can be performed in lieu of testing if the equipment is operated at vacuum or the high voltage components and circuits are encapsulated or contained within a hermetically sealed chassis containing a dry, high dielectric gas.

Verification is considered successful when any of the following are met:

1. Testing shows that coronal discharges do not occur in equipment operating at pressures greater than 1.0×10^{-1} N/m^2.
2. Analysis shows that the equipment design maintains an internal pressure of 1.0×10^5 N/m^2 inside the sealed chassis over the operational lifetime of the equipment.
3. Inspection of design shows that the high voltage circuits or components are encapsulated in an insulating medium with dielectric strength of 10 kV/mm or greater

Verification Submittal: Test Report or Analysis Report, or CoC for inspection.

4.3.2.2.8 ELECTRICAL BONDING

NVR

4.3.2.2.8.1 SHOCK HAZARD - CLASS H

Verification **shall** be by analysis and inspection. The verification **shall** be considered successful when an analysis of the bond current carrying capability shows that the bond path can carry fault currents until upstream switchgear clears the electrical fault. The verification **shall** be considered successful when inspection of drawings and quality records (Quality records include workmanship resistance measurements) indicates that areas to be bonded are identified as well as proper bonding processes, procedures, and materials.

Verification Submittal: Analysis Report

4.3.2.2.8.2 RADIO FREQUENCY BOND - CLASS R

A. Verification **shall** be by analysis. The verification **shall** be considered successful when an analysis indicates that the bond path provides a low impedance path to structure.

Verification Submittal: Analysis Report

B. Verification **shall** be by inspection. The verification **shall** be considered successful when inspection of drawings and quality records (Quality records include workmanship resistance measurements) indicates that areas to be bonded are identified as well as proper bonding processes, procedures, and materials, and the DC resistance across each joint is less than 2.5 milliohms.

Verification Submittal: CoC

4.3.2.2.8.3 STATIC BOND - CLASS S

Verification **shall** be by test. The verification **shall** be considered successful when the test shows that the payload conducting items subject to triboelectric (frictional) or any other charging mechanism have a mechanically secure electrical connection to the payload element structure with a resistance of less than one (1) ohm for each joint.

Submittal: Test Report

4.3.2.2.9 INTENTIONAL RADIATING AND RECEIVING

The verification **shall** be by test. The test **shall** be of the radiating and/or receiving devices to determine the frequency of transmission and/or reception. The verification **shall** be considered successful when the test shows that the transmission and/or reception is only at the frequency specified in the approved JSC RFA.

Note 1: A Payload still must meet EMI Radiation Emissions requirements per SSP 30237 outside the intentional radiating frequency band.

Note 2: The JSC RFA consists of (1) ISS onboard RF compatibility and radiation hazard keep-out zone analysis and required payload implementation of mitigations and (2) verification of equipment operating license conditions for ISS operation based on equipment operating license conditions.

Verification Submittal: Test Report

4.3.2.2.10 INTENTIONAL RADIATING AND RECEIVING CERTIFICATION

Data Deliverable

4.3.2.2.11 INTENTIONAL RADIO FREQUENCY EMISSION/OPERATION AUTHORITY

Data Deliverable

4.3.2.3 ELECTRICAL SAFETY REQUIREMENTS

4.3.2.3.1 POWER SWITCHES/CONTROLS

A. Switches/controls requirement **shall** be verified by inspection. An inspection electrical circuit schematics **shall** be performed to ensure the switches/controls performing on/off functions for all power interfaces open (dead-face) all supply circuit conductors, except the power return and equipment grounding conductor, while in the power-off position. Verification **shall** be considered successful when inspection of electrical circuit schematics shows the switches/controls performing on/off power functions for all power interfaces open (dead-face) all supply conductors except the power return and equipment grounding conductor, while in the power-off position.

Verification Submittal: CoC

B. Power-off markings and/or indications requirement **shall** be verified by inspection. The inspection **shall** ensure power-off markings and/or indications exist when all electrical connections with the power supply circuit are disconnected. The verification **shall** be considered successful when the inspection shows power switches/controls power-off markings and/or indication(s) exist when all electrical connections with the power supply circuit are disconnected.

Verification Submittal: CoC

C. Standby, charging and descriptive nomenclature requirement **shall** be verified by inspection. The inspection **shall** ensure the existence of descriptive nomenclature such as standby, charging, or that necessary to indicate the power supply circuit is not completely disconnected for this power condition. The verification **shall** be considered successful when inspection shows descriptive nomenclature exists to indicate the power supply circuit is not completely disconnected.

Verification Submittal: CoC

4.3.2.4 ELECTRICAL DATA REQUIREMENTS

4.3.2.4.1 ELECTRICAL SCHEMATICS

<u>Data Deliverable</u>

4.3.2.4.2 ELECTRICAL POWER USE

<u>Data Deliverable</u>

4.3.3 COMMAND AND DATA HANDLING INTERFACE VERIFICATION REQUIREMENTS

NVR

Command and Data Handling requirements for payloads are addressed in Appendix I.

4.3.4 PAYLOAD NTSC VIDEO INTERFACE REQUIREMENTS

Payload NTSC video interface verification requirements are addressed in section N.4.3.4.

4.3.5 THERMAL CONTROL INTERFACE REQUIREMENTS

4.3.5.1 INTERNAL THERMAL CONTROL SYSTEM (ITCS) INTERFACE REQUIREMENTS

NVR

4.3.5.1.1 ITCS FLUID FILLING

Verification that the payload is fully filled with ITCS fluid **shall** be performed by test during final fluid filling of the payload. Final fluid filling of the payload **shall** be performed by evacuating the payload fluid lines to 0.5 torr (67 Pa) or less prior to introduction of the ITCS fluid charge. The verification **shall** be considered successful when the vacuum test demonstrates the payload can maintain less than 0.5 torr (67 Pa) for five minutes with the vacuum source isolated (vacuum decay check). Final fluid fill **shall** be initiated immediately after the successful vacuum decay check. The ITSC fluid in the payload **shall** be circulated with the PRCU, or GSE with equivalent gas bubble removal capability, for 72 hours after the filling is complete.

Note: Final integrated rack, non-rack payload or ORU coolant charging may be performed at KSC if the Payload Developer submits an Operations and Maintenance Requirements and Specification Document (OMRSD) via the Payload Data Library (PDL) KSC Technical Requirements Data Sets (TRDS).

Verification Submittal: Test Report

4.3.5.1.2 ITCS FLUID EXPANSION

A. Verification that the payload has the capability to account for thermal expansion of ITCS fluid over the specified temperature range when disconnected from ITCS **shall** be by inspection and analysis. The verification **shall** be considered successful when the inspection and analysis shows that the payload is capable of compensating for thermal expansion of the payload's cooling fluid over the specified temperature.

Verification Submittal: Analysis Report that includes the total expansion volume of the thermal expansion method or device, and whether it is permanently installed or removed when the payload is connected to the ITCS on-orbit.

B. Verification that the thermal expansion device connected to the payload ITCS fluid system **shall** not actuate at less than the specified pressure **shall** be by test. The verification **shall** be considered successful when the test shows the device will not expand its fluid volume at less than 100 psia (690 kPa).

Verification Submittal: Test Report that includes the actuation pressure of the permanently installed thermal expansion device.

4.3.5.1.3 ITCS FLUID RETURN TEMPERATURES

A. Verification that the return temperature of the payload MTL fluid does not exceed the maximum specified temperature **shall** be verified by test or analysis. The test **shall** utilize a PRCU (or equivalent) to measure the outlet temperature for the maximum and nominal power modes of the payload. Analysis **shall** assume the maximum payload power used, and assume the highest fluid supply temperature to determine the fluid return temperature from the payload. The verification **shall** be considered successful when the test or analysis shows that the MTL fluid temperature returned does not exceed the specified limit.

Verification Submittal: Data Certification

B. Verification that the return temperature of the payload LTL fluid does not exceed the maximum specified temperature **shall** be verified by test or analysis. The test **shall** utilize a PRCU (or equivalent) to measure the outlet temperature for the maximum and nominal power modes of the payload. Analysis **shall** assume the maximum payload power used, and assume the highest fluid supply temperature to determine the fluid return temperature from the payload. The verification **shall** be considered successful when the test or analysis shows that the LTL fluid temperature returned does not exceed the specified limit.

Verification Submittal: Data Certification

4.3.5.1.4 ITCS MAXIMUM DESIGN PRESSURE (MDP)

The pressure integrity of payload volumes connected to the TCS moderate or low temperature loops **shall** be verified by performing a leak-check of the pressure system. The verification **shall** be considered successful if the test results show the payload passes the leak-check performed at a minimum of 1.0 × MDP.

Verification Submittal: Test Report

4.3.5.1.5 ITCS DESIGN DATA

Data Deliverable

4.3.5.1.6 ITCS COOLANT FLOW RATE DATA

Data Deliverable

4.3.5.2 CABIN AIR HEAT LOAD LIMITS

Verification that the cabin air sensible and latent heat loads do not exceed the limits specified in Table 3.5.2-1 *should* be by analysis. The verification analysis *should* use the thermal boundary conditions for thermal analysis in Table 3.9.3-3. Include the payload's sensible heat load from electronics, specimen metabolic heat load due to air exchange with the cabin aisle, and all associated ancillary equipment in the cabin aisle for each operational mode. The ISS Portable Computer System (PCS) loads are not to be included. Also include the latent heat load which is the heat load on the condensing heat exchanger needed to remove the payload water vapor, including humidity from specimen air exchange, from the cabin air. Assume the lower temperature limit for this calculation to be 43 °F (6.1 °C). The verification *should* be considered successful if the analysis results show the payload does not exceed the specified heat load limits.

Verification Submittal: Analysis Report

4.3.5.2.1 CABIN AIR HEAT LOAD DATA

Data Deliverable

4.3.6 VACUUM SYSTEM REQUIREMENTS

4.3.6.1 VACUUM EXHAUST SYSTEM (VES)/WASTE GAS SYSTEM (WGS) REQUIREMENTS

See section N.4.3.6.1.

4.3.6.2 VACUUM RESOURCE SYSTEM (VRS)/VACUUM VENT SYSTEM (VVS) REQUIREMENTS

See section N.4.3.6.2.

4.3.6.3 VACUUM OUTGASSING REQUIREMENTS

See section N.4.3.6.3.

4.3.7 PRESSURIZED GASES INTERFACE REQUIREMENTS

4.3.7.1 NITROGEN INTERFACE REQUIREMENTS

See section N.4.3.7.

4.3.7.2 ARGON INTERFACE REQUIREMENTS

See section N.4.3.8.1

4.3.7.3 CARBON DIOXIDE INTERFACE REQUIREMENTS

See section N.4.3.8.2

4.3.7.4 HELIUM INTERFACE REQUIREMENTS

See section N.4.3.8.3

4.3.7.5 PRESSURIZED GAS SYSTEMS

Verification of the expanded volume and flow rate for the payload with pressurized gas systems **shall** be by analysis. The verification **shall** be considered successful when the analysis of the drawings shows that the expanded volume of the gas in the pressurized system is below the limiting volume specified in the requirement. If the volume exceeds the limiting specified volume, then an analysis must be performed verifying that the flow rate after a single failure does not exceed the maximum allowable amount after release of the limiting expanded volume.

Verification Submittal: Analysis Report

4.3.8 POTABLE WATER INTERFACE VERIFICATION REQUIREMENTS

4.3.8.1 POTABLE WATER INTERFACE COMPATIBILITY

The verification **shall** be by inspection of drawings. The verification **shall** be considered successful when the inspection shows that the bag used to obtain water from the PWD is a standard Drink Bag (part number SED48101685-622, or equivalent) or standard Sample Bag (part numbers SEG46119988-611, or equivalent, or 1053-M-1051-00, or equivalent) or custom bag that utilizes a Luer Lock interface for connection to PWD.

Verification Submittal: Data Cert identifying the bag part number used, and if other than standard bag, the bag drawing.

4.3.8.2 POTABLE WATER DATA

<u>Data Deliverable</u>

4.3.8.3 SYSTEM BACKGROUND INFORMATION

NVR

4.3.8.4 WATER CONTAINERS

NVR

4.3.8.4.1 DRINK BAGS

NVR

4.3.8.4.2 SAMPLE BAGS

NVR

4.3.8.4.2.1 ONE LITER SAMPLE BAGS

NVR

4.3.8.4.2.2 THREE LITER SAMPLE BAG

NVR

4.3.8.4.2.3 IV BAGS

NVR

4.3.9 ENVIRONMENT INTERFACE REQUIREMENTS

4.3.9.1 CONDENSATION PREVENTION

Verification that the payload is designed to preclude condensation when exposed to the specified dewpoint and relative humidity **shall** be by analysis. All verification analysis **shall** use the thermal boundary conditions for condensation analysis in Table 3.9.3-4. The verification **shall** be considered successful when analysis shows that no internal or external surfaces in contact with the cabin air allow condensation when humidity and dewpoint are within the ISS atmosphere envelope defined by Figure 3.9.1-1. Surfaces **shall** be considered to be in contact with the cabin air unless a volume is hermetically sealed or environmentally conditioned to control humidity.

Verification Submittal: Analysis Report

4.3.9.2 WATER-SOLUBLE VOLATILE ORGANIC COMPOUND RELEASES

Verification of this requirement **shall** be by analysis. There can be no planned release of these compounds, with the exception of normal materials offgassing. An analysis of the hardware drawings must be performed to show that at least one level of containment is provided for each identified source of the restricted compounds and that release of the water-soluble volatile organic compound to the habitable environment can only occur as the result of a single barrier failure. Verification **shall** be considered successful if the analysis shows that at least one level of containment is provided for all restricted compounds present and there is no planned release of the contained compounds.

Verification Submittal: CoC

4.3.9.3 ADDITIONAL ENVIRONMENTAL CONDITIONS

NVR

4.3.9.4 ACTIVE AIR EXCHANGE

Data Deliverable

4.3.10 FIRE PROTECTION INTERFACE REQUIREMENTS

Fire protection verification requirements for racks and EXPRESS subracks are addressed in Sections N.4.3.10 and F.4.3.10.

4.3.11 MATERIALS AND PROCESSES INTERFACE VERIFICATION REQUIREMENTS

4.3.11.1 MATERIALS AND PROCESSES USE AND SELECTION

This requirement is verified through the Safety process.

4.3.11.2 FLUIDS

4.3.11.2.1 FLUID CHEMICAL COMPOSITION

Verification of LTL and MTL fluid physical and chemical characteristics **shall** be by test or inspection. A PD may satisfy this requirement by obtaining ITCS fluid from a NASA approved source. In this case an inspection of the certification for NASA provided ITCS fluid **shall** be performed to confirm the fluid meets SSP 30573, Table 4.1-2.8 A test **shall** be conducted for payload provided ITCS fluid according to the verification test requirements specified in SSP 30573, Table 4.1-2.8, to determine whether or not the fluid contained in the payload satisfies the fluid physical and chemical characteristics specified in SSP 30573, Table 4.1-2.8. The verification of NASA provided ITCS fluid **shall** be considered successful when the inspection shows that the fluid is provided by a NASA approved source. The verification of payload provided ITCS fluid composition **shall** be considered successful when the test results show the payload fluid physical and chemical characteristics meets the fluid chemistry requirements in SSP 30573, Table 4.1-2.8.

Verification Submittal: Test Report

4.3.11.2.2 FLUID SYSTEM CLEANLINESS

Verification that the payload LTL and MTL (and subrack equipment fluid systems, if any) meet the fluid system cleanliness levels of 300 per MIL-STD-1246, and have a 2-micron filter **shall** be by inspection. The inspection will consist of a review of the LTL and MTL fluid systems as-built drawings and/or manufacturing documentation to insure that appropriate precision cleaning and hardware control requirements are in place. The verification **shall** be considered successful when the inspection shows that the appropriate precision cleaning and hardware control requirements are in place to insure that MIL-STD-1246 fluid system cleanliness levels of 300, and a 2-micron filter at the flight hardware interface to the non-flight fill system are established and maintained.

Verification Submittal: CoC

The payload developer must test any ITCS fluid that is planned to fill the payload in accordance with SSP 30573. All records of sampling and testing must be supplied to KSC when the payload is turned over into KSC's custodial care.

Within 45 days prior to connecting to KSC GSE (such as the PRCU for off-line post-shipment health tests), the payload developer must sample and test the ITCS fluid in accordance with SSP

30573 or provide a sample to KSC for testing. If the payload developer is performing their own test, the results of the sample test must be provided to KSC prior to connection to prove that the hardware meets the requirements of SSP 30573.

Note 1: Per SSP 30573, de-ionized water or ISS ITCS fluid may be used as an ITCS fluid during testing prior to delivery to KSC. If de-ionized water is used during testing, the payload developer must refill with ISS ITCS fluid or provide a support requirement to KSC to fill with ISS ITCS fluid prior to integration with KSC GSE or flight systems.

Note 2: The payload developer is not required to establish a stable Total Organic Carbon (TOC). KSC will establish a stable TOC once it is in their custodial care.

Note 3: The payload developer must enter post-turnover requirements into the OMRSD via the PDL KSC TRDS to insure that MIL-STD-1246 fluid system cleanliness levels are established and maintained (or restored) while in KSC custodial care (“Online”).

Note 4: Once a payload is turned over to KSC, the payload is under KSC OMRS control even if the payload is returned temporarily to the custody of the payload developer.

Note 5: Final fluid system cleanliness is verified by closure of requirement 3.11.2.1.

4.3.11.2.3 THERMAL COOLING SYSTEM WETTED MATERIALS

A. Verification of the payload fluid system internal materials usage **shall** be by analysis. The analysis **shall** compare the as-built drawings and parts list with the materials listed in requirement 3.11.2.3.A. Verification **shall** be considered successful when the analysis of the as-built drawings and parts list show the internal materials used in the payload aqueous fluid systems match the materials listed in requirement 3.11.2.3.A.

Verification Submittal: Analysis Report

B. Verification that the payload connected to the LTL or MTL is composed of wetted materials that do not include aluminum alloys or alloys with greater than 5% copper **shall** be by analysis. An analysis of the as-built drawings and parts lists **shall** determine whether or not the wetted materials in the payload systems connected to the LTL or MTL contain aluminum alloys or alloys with greater than 5% copper. Verification **shall** be considered successful when the analysis shows the payload systems connected to the LTL or MTL wetted materials do not contain aluminum alloys or alloys with greater than 5% copper.

Verification Submittal: Analysis Report

C. Verification that the payload system’s non-metallic wetted surfaces are composed of materials that are non-nutrient to fungal growth inside the LTL and MTL systems **shall** be by analysis or test. An analysis **shall** review MIL-HDBK-454, to determine whether or not the non-metal materials used in the payload systems connected to the LTL or MTL support fungal growth. Or, a test **shall** be conducted in accordance with MIL-STD-810, Method 508.6, to determine whether or not the non-metallic materials support fungal growth. Verification **shall** be considered successful when the analysis or test shows the non-metallic wetted materials used in the payload systems connected to the LTL or MTL are non-nutrient to fungal growth.

Verification Submittal: Analysis Report

4.3.11.3 CLEANLINESS

Verification that the payload conforms to the Visibly Clean-Sensitive (VC-S) cleanliness level (See Glossary of Terms) **shall** be by inspection. An inspection of the cleanliness documentation required by precision cleaning **shall** be performed to show that each part, component, subsystem and system of the end product meets the VC-S requirement. Verification **shall** be considered successful when the inspection shows that each part, component, subsystem and system of the end product meets the VC-S requirement.

Verification Submittal: CoC

4.3.12 HUMAN FACTORS INTERFACE REQUIREMENTS

NVR

4.3.12.1 STRENGTH REQUIREMENTS

A. Grip strength *should* be verified by analysis or demonstration. The verification *should* be considered successful when the analysis or demonstration of the flight hardware shows that the grip strength required to remove, replace and operate the payload equipment is as specified.

Verification Submittal: CoC

B. Linear forces *should* be verified by analysis or demonstration. The verification *should* be considered successful when the analysis or demonstration of the flight hardware shows that the linear forces required to remove, replace and operate the payload equipment is as specified.

Verification Submittal: CoC

C. Torsional forces *should* be verified by analysis or demonstration. The verification *should* be considered successful when the analysis or demonstration of the flight hardware shows that the torsional forces required to remove, replace and operate the payload equipment is as specified.

Verification Submittal: CoC

D. Maintenance Operations forces *should* be verified by analysis or demonstration. The verification *should* be considered successful when the analysis or demonstration of the flight hardware shows that the strength values required to perform maintenance operations on the payload equipment is as specified.

Verification Submittal: CoC

4.3.12.2 BODY ENVELOPE AND REACH ACCESSIBILITY

4.3.12.2.1 ADEQUATE CLEARANCE

The payload clearance *should* be verified by analysis or demonstration. The analysis *should* be based on an evaluation of the drawing(s) with the clearance requirements to perform the tasks using the tools and equipment utilized in payload installation, operations, and maintenance. The demonstration *should* be performed on the flight hardware or hardware which replicates the flight hardware configuration with the tools and equipment utilized in payload installation, operations, and maintenance. The verification *should* be considered successful when the analysis or demonstration shows that the clearance accommodates crew performance of tasks, including tool utilization, and is sufficient to install/de-install, replace, operate and maintain the payload equipment.

Verification Submittal: CoC

4.3.12.2.2 ACCESSIBILITY

A. Payload hardware accessibility *should* be verified by analysis or demonstration. The verification *should* be considered successful when the analysis or demonstration shows that the specified accessibility is sufficient to remove, replace, operate and maintain the payload equipment.

Verification Submittal: CoC

B. IVA clearances *should* be verified by analysis or demonstration.The verification *should* be considered successful when the analysis or demonstration of the flight hardware shows the specified IVA clearances.

Verification Submittal: CoC

4.3.12.2.3 FULL SIZE RANGE ACCOMMODATION

Analyses of end item drawings that contain on-orbit crew interfaces or demonstration of the flight hardware *should* be performed to verify that Payload hardware accommodates the 5th percentile Japanese female to the 95th percentile American male size measurements, estimated for the year 2000, as specified in SSP 50005, Section 3.3, General Anthropometric and Biomechanics Related Design Data. Drawings of workstations and hardware having crew nominal operations and planned maintenance *should* be analyzed to verify that they are sized to meet the functional reach limits for the 5th percentile Japanese female. Drawings of workstations and hardware having crew nominal operations and planned maintenance *should* be analyzed to verify that they are sized to not confine the body envelope of the 95th percentile American male. The verification *should* be considered successful when the analyses or demonstration shows the flight hardware accommodates the 5^{th} percentile Japanese female to the 95^{th} percentile Amercian male size measurements.

Verification Submittal: CoC

4.3.12.3 HABITABILITY

4.3.12.3.1 HOUSEKEEPING

4.3.12.3.1.1 CLOSURES OR COVERS

Design of closures or covers **shall** be verified by inspection of the payload drawings or flight hardware. Verification **shall** be considered successful when inspection of the payload drawings or flight hardware confirms compliance with the requirement.

Verification Submittal: CoC

4.3.12.3.1.2 BUILT-IN CONTROL

A. Design of built-in controls **shall** be verified by inspection of the payload drawings or flight hardware. Verification **shall** be considered successful when inspection of the payload drawings or flight hardware confirms compliance with the requirement.

Verification Submittal: CoC

B. Crew access to capture elements **shall** be verified by inspection or demonstration. The verification **shall** be considered successful when the inspection or demonstration shows that the crew can access the flight hardware capture elements for cleaning or replacement without dispersion of trapped material.

Verification Submittal: CoC

4.3.12.3.2 INTERMITTENT NOISE LIMITS

Verification of payload Intermittent Noise Sources (See Glossary of Terms) **shall** be performed by test.

SPL test measurements **shall** be obtained for the payload. The test configuration **shall** include any adjunct equipment, such as integrated rack-provided external computers, fans, etc., added in support of the rack system. The SPL test **shall** use a Type 1 SLM in accordance with IEC 61672-1. The preferred instrument for acoustic verification is the Type 1 integrating-averaging sound level meter. This meter can either be of the handheld or component system variety.

The SPL test **shall** quantify the intermittent noise characteristics in terms of:

(1) When the intermittent sound occurs (a description of what payload activities/operations produce intermittent sound), i.e. a compressor turning on

(2) Duration and SPL (maximum A-weighted Overall SPL measured at 0.6 meter distance from the loudest part of the equipment)

(3) A projected mission timeline(s) (a typical payload scenario that would produce intermittent sound)

SPL test measurements **shall** be made for each serialized payload flight hardware (or ancillary flight equipment operated outside the rack) until repeatability and acoustic level are demonstrated to produce acceptably low risk of exceeding the composite acoustic environment requirement with minimal operational constraints. The JSC Acoustics Office, with consultation of the Acoustics Working Group (AWG), **shall** determine, on a case-by-case basis, if serial number unit testing can be suspended for a particular payload design based on the following factors: 1) Repeatability of serial number unit test results of first flight units, 2) impact of exceedances (if any), 3) A-weighted Overall SPLs compared to requirement, 4) operational durations and nominal mission timelines, and 5) projected impacts on composite acoustic environment.

The verification **shall** be considered successful when the test shows the Intermittent Noise Source's A-weighted Overall SPL (dBA) is at or below the levels specified in Table 3.12.3.2-1.

Verification Submittal: Test Report

4.3.12.3.3 LIGHTING DESIGN

A. Verification of the specularity of the total work surface reflection *should* be by testing or inspection. The testing *should* be considered successful when the specularity of the total work surface reflection does not exceed 20 percent. The inspection *should* be considered successful if the work space surface uses paint(s) selected from Table 3.12.3.3-1.

Verification Submittal: CoC

B. The task illumination level identified in Table 3.12.3.3-2 *should* be verified by test. The test *should* be considered successful when illumination level as identified in Table 3.12.3.3-2 measured at the task site(s) is met. The illumination level in a glovebox payload *should* be determined by taking the average of a minimum of nine measurements (3-by-3 matrix) equally spaced encompassing the base of the work area surface.

Verification Submittal: CoC

C. Verification of lighting for fine glovebox operations **shall** be by test. The test **shall** be considered successful when illumination level measured at the task site(s) meets the level specified. The illumination level in a glovebox payload **shall** be determined by taking the average of a minimum of nine measurements (3-by-3 matrix) equally spaced encompassing the base of the work area surface.

Verification Submittal: Test Report

D. Verification of a dimmable light source *should* be by demonstration. The demonstration *should* be considered successful when the light source is demonstrated to be continuously adjustable between 0 (off) and 100 percent (on) output.

Verification Submittal: CoC

4.3.12.3.4 STATUS INDICATOR LIGHTS

Payload status indicator lights *should* be verified by inspection or demonstration. The inspection *should* be of payload drawings or the flight hardware. The demonstration *should* be of the flight hardware. The verification *should* be considered successful when the inspection or demonstration shows that the status indicator lights adhere to the characteristics listed in 3.12.3.4.

Verification Submittal: CoC

4.3.12.4 STRUCTURAL/MECHANICAL INTERFACES

4.3.12.4.1 PAYLOAD HARDWARE MOUNTING

4.3.12.4.1.1 EQUIPMENT MOUNTING

Equipment mounting used during nominal operations and planned maintenance **shall** be verified by analysis or demonstration. The verification **shall** be considered successful when the analysis of design or demonstration of the flight hardware shows that the payload hardware used during nominal operations and planned maintenance is designed, labeled, or marked to protect against improper installation.

Verification Submittal: CoC

4.3.12.4.1.2 DRAWERS AND HINGED PANELS

Drawers and hinged panels *should* be verified by analysis. Verification *should* be considered successful when an analysis of the equipment flight drawings or demonstration with the flight hardware shows that any payload ORU that has to be removed is mounted on equipment drawers or hinged panels, and remains in the open position without being supported by the hand.

Verification Submittal: CoC

4.3.12.4.1.3 ALIGNMENT

Alignment **shall** be verified by inspection or demonstration. Verification **shall** be considered successful when an inspection of the payload drawings or demonstration of the flight hardware shows that guide pins or their equivalent are provided to assist in alignment during installation of hardware with blind mate connectors.

Verification Submittal: CoC

4.3.12.4.1.4 SLIDE-OUT STOPS

Slide-out stops *should* be verified by inspection, analysis or demonstration. Verification *should* be considered successful when an inspection or analysis of the drawings or demonstration of the payload flight hardware shows that limit stops are provided on slide or pivot mounted subrack hardware which is required to be pulled out of its installed positions.

Verification Submittal: CoC

4.3.12.4.1.5 PUSH-PULL FORCES

Push-Pull forces *should* be verified by analysis or demonstration. Verification *should* be considered successful when an analysis of design or demonstration of the payload flight hardware shows that hardware mounted into a capture-type receptacle that requires push-pull action requires a force less than 156 N to install and remove.

Verification Submittal: CoC

4.3.12.4.1.6 ACCESS

Access to inspect or replace a hardware item which is planned to be accessed on a daily or weekly basis *should* be verified by analysis or demonstration. Verification *should* be considered successful when an analysis of the payload flight hardware drawings or a demonstration of the payload flight hardware shows that hardware items which are planned to be accessed on a daily or weekly basis can be inspected and replaced without requiring the removal of an ORU or more than one access cover.

Verification Submittal: CoC

4.3.12.4.1.6.1 SELF-SUPPORTING COVERS

Self-supporting covers *should* be verified by analysis or demonstration. Verification *should* be considered successful when an analysis of the payload flight hardware drawings or demonstration of the payload flight hardware shows that all access covers that are not completely removable are self-supporting in the open position.

Verification Submittal: CoC

4.3.12.4.1.6.2 PAYLOAD IN-FLIGHT MAINTENANCE AND OPERATIONAL TOOLS

Payload In-Flight Maintenance and Operational Tools *should* be verified by analysis or demonstration. The verification *should* be considered successful when it is shown the analysis of payload hardware and flight drawings, or demonstration of flight hardware shows the payload is maintainable using Space Station provided on-orbit tools and/or when it is shown any unique tools meet the requirements of 50005, paragraph 11.2.3.

Verification Submittal: CoC

4.3.12.4.2 CONNECTORS

4.3.12.4.2.1 ONE-HANDED OPERATION

One-handed operation *should* be verified by analysis or demonstration. The analysis or demonstration *should* be performed on the drawings or flight hardware which replicates the flight configuration. Verification *should* be considered successful when the analysis or demonstration shows the connectors, latches, handles, fasteners, operating mechanisms or cleaning equipment can be operated or used with only one hand, and that either hand may be used.

Verification Submittal: CoC

4.3.12.4.2.2 ACCESSIBILITY

A. For nominal and maintenance operations, accessibility *should* be verified by analysis or demonstration. Verification *should* be considered successful when an analysis of the payload flight hardware drawings or demonstration of the payload flight hardware shows that it is possible to mate/demate individual connectors without having to remove or mate/demate connectors on other ORUs.

Verification Submittal: CoC

B. Accessibility of cable, hose, and umbilical connectors **shall** be verified by demonstration. Verification **shall** be considered successful when a demonstration on the payload hardware shows that it is possible to disconnect and reconnect cable, hose, and umbilical connectors and cable installations without damage to the connectors.

Verification Submittal: CoC

4.3.12.4.2.3 EASE OF DISCONNECT

A. Ease of disconnect *should* be verified by analysis or demonstration. Verification *should* be considered successful when the analysis of design or demonstration of the flight hardware shows that electrical connectors which are mated/demated during nominal operations, require no more than two turns to disconnect.

Verification Submittal: CoC

B. Ease of disconnect *should* be verified by analysis or demonstration. Verification *should* be considered successful when the analysis of design or demonstration of flight hardware shows that electrical connectors which are mated/demated during ORU replacement operations require no more than six turns to disconnect.

Verification Submittal: CoC

4.3.12.4.2.4 INDICATION OF PRESSURE/FLOW

Indication of pressure flow **shall** be verified by inspection. Verification **shall** be considered successful when inspection of payload flight hardware drawings or flight hardware shows that payload liquid or gas lines that are not equipped with quick disconnect connectors, which are designed to be connected/disconnected under pressure, are fitted with pressure/flow indicators.

Verification Submittal: CoC

4.3.12.4.2.5 SELF-LOCKING

Self-locking *should* be verified by inspection. Verification *should* be considered successful when an inspection of payload flight hardware drawings or flight hardware shows payload electrical connectors are provided with a self-locking feature.

Verification Submittal: CoC

4.3.12.4.2.6 CONNECTOR ARRANGEMENT

A. Connector arrangement *should* be verified by inspection. Verification *should* be considered successful when an inspection of payload flight hardware drawings or flight hardware shows the space between connectors and adjacent obstructions comply with the requirement.

Verification Submittal: CoC

B. Connector arrangement *should* be verified by inspection. Verification *should* be considered successful when an inspection of payload flight hardware drawings or flight hardware shows connectors in a single row or staggered rows comply with the requirements.

Verification Submittal: CoC

4.3.12.4.2.7 CONNECTOR PROTECTION

Connector protection *should* be verified by inspection. Verification *should* be considered successful when the inspection of payload flight hardware drawings or flight hardware shows that protection is provided for all demated connectors against physical damage and contamination.

Verification Submittal: CoC

4.3.12.4.2.8 CONNECTOR SHAPE

Connector shape **shall** be verified by inspection. Verification **shall** be considered successful when an inspection of payload flight hardware drawings or flight hardware shows that connectors which differ in content are of different shape or are physically incompatible.

Verification Submittal: CoC

4.3.12.4.2.9 FLUID AND GAS LINE CONNECTORS

The location of fluid and gas line connectors that are mated and demated on-orbit **shall** be verified by inspection. Verification **shall** be considered successful when an inspection of payload flight hardware drawings or flight hardware shows that fluid and gas connectors that are mated and demated on-orbit are located and configured so that they can be fully inspected for leakage.

Verification Submittal: CoC

4.3.12.4.2.10 ALIGNMENT MARKS OR GUIDE PINS

Alignment marks or guide pins on mating parts *should* be verified by inspection. Verification *should* be considered successful when an inspection of the payload flight hardware drawings or flight hardware shows that mating parts have alignment marks in a visible location during mating or guide pins (or their equivalent).

Verification Submittal: CoC

4.3.12.4.2.11 PIN IDENTIFICATION

Pin identification *should* be verified by inspection. Verification *should* be considered successful when an inspection of payload flight hardware drawings or flight hardware shows that each electrical pin in each electrical plug and each socket in each electrical receptacle is uniquely identifiable.

Verification Submittal: CoC

4.3.12.4.2.12 ORIENTATION

Orientation *should* be verified by inspection. Verification *should* be considered successful when an inspection of the payload flight hardware drawings or flight hardware shows that grouped plugs and receptacles are oriented so that the aligning pins or equivalent devices are in the same relative position.

Verification Submittal: CoC

4.3.12.4.2.13 HOSE/CABLE RESTRAINTS

A. Hose/Cable restraints **shall** be verified by inspection. Verification **shall** be considered successful when an inspection shows that hoses, bundles, or cables are secured by a means of clamps unless they are contained in wiring ducts or cable retractors.

Verification Submittal: CoC

B. Hose/Cable restraints *should* be verified by inspection. Verification *should* be considered successful when an inspection shows that loose cables are restrained as specified.

Verification Submittal: CoC

4.3.12.4.3 FASTENERS

4.3.12.4.3.1 ENGAGEMENT STATUS

Non-threaded fasteners and stowage/equipment drawer/tray latches status indication *should* be verified by demonstration or inspection. Verification *should* be considered successful when the demonstration or inspection of the flight hardware shows that an indication of correct engagement (hooking, latch fastening, or proper positioning of interfacing parts) of non-threaded fasteners and stowage/equipment drawer/tray latches is provided.

Verification Submittal: CoC

4.3.12.4.3.2 MOUNTING BOLT/FASTENER SPACING

Mounting bolt/fastener spacing *should* be verified by inspection. Verification *should* be considered successful when an inspection of the payload flight hardware drawings or flight hardware shows that mounting bolts and fasteners are spaced as specified.

Verification Submittal: CoC

4.3.12.4.3.3 MULTIPLE FASTENERS

Multiple fasteners *should* be verified by inspection. Verification *should* be considered successful when an inspection of the payload flight hardware drawings or flight hardware shows that when several fasteners are used on one item they are all of identical type.

Verification Submittal: CoC

4.3.12.4.3.4 QUICK RELEASE FASTENERS

A. Quick release fasteners *should* be verified by inspection. Verification *should* be considered successful when the inspection of the payload flight hardware drawings or flight hardware shows that fasteners require a maximum of one complete turn to operate.

Verification Submittal: CoC

B. Quick release fasteners *should* be verified by inspection. Verification *should* be considered successful when inspection of the payload flight hardware drawings or flight hardware shows that fasteners are positive locking in open and closed positions.

Verification Submittal: CoC

4.3.12.4.3.5 THREADED FASTENERS

Threaded fasteners *should* be verified by inspection. The inspection *should* be a review of the payload flight hardware drawings or flight hardware. Verification *should* be considered successful when the inspection of the payload flight hardware drawings or flight hardware shows that all threaded fasteners are right-handed.

Verification Submittal: CoC

4.3.12.4.3.6 OVER CENTER LATCHES

A. Non-self-latching over center latches *should* be verified by inspection. Verification *should* be considered successful when an inspection of payload flight hardware drawings or flight hardware shows that latches include a provision to prevent undesired latch element realignment, interface, or reengagement.

Verification Submittal: CoC

B. Over center latches *should* be verified by inspection. Verification *should* be considered successful when an inspection of payload flight hardware drawings or flight hardware shows that latch catches have locking features.

Verification Submittal: CoC

4.3.12.4.3.7 FASTENER HEAD TYPE

The hex type external or internal grip or combination head fastener type *should* be verified by inspection. The inspection *should* be of the hardware or the drawings and parts list. Verification *should* be considered successful when an inspection of payload flight hardware drawings or flight hardware shows that the hex type external or internal grip or combination head fasteners are used for all on-orbit crew actuated equipment.

Verification Submittal: CoC

4.3.12.5 CONTROLS AND DISPLAYS

4.3.12.5.1 CONTROLS SPACING DESIGN REQUIREMENTS

Controls spacing design *should* be verified by inspection. Verification *should* be considered successful when an inspection of the payload flight hardware drawings or flight hardware shows the spacing between controls and adjacent obstructions is as specified.

Verification Submittal: CoC

4.3.12.5.2 ACCIDENTAL ACTUATION

4.3.12.5.2.1 PROTECTIVE METHODS

Protective methods to reduce accidental actuation of controls *should* be verified by inspection. Verification *should* be considered successful when an inspection of payload flight hardware drawings or flight hardware shows one or more of the conditions called out in sub-paragraphs 1 through 10 of paragraph 3.12.5.2.1 are met.

Verification Submittal: CoC

4.3.12.5.2.2 NONINTERFERENCE

Noninterference *should* be verified by inspection. Verification *should* be considered successful when an inspection of payload flight hardware drawings or flight hardware shows that protection devices do not cover or obscure other displays and controls.

Verification Submittal: CoC

4.3.12.5.2.3 BARRIER GUARD AND RECESSED SWITCH PROTECTION

Barrier guard and recessed switch protection *should* be verified by inspection. Verification *should* be considered successful when an inspection of payload flight hardware drawings or flight hardware shows that a barrier guard or recessed switch is used around all toggle switches, rotary switches, and thumbwheels.

Verification Submittal: CoC

4.3.12.5.2.4 POSITION INDICATION

Position indication *should* be verified by inspection. Verification *should* be considered successful when an inspection of payload flight hardware drawings or flight hardware shows that control position is evident without requiring cover removal.

Verification Submittal: CoC

4.3.12.6 RESTRAINTS AND MOBILITY AIDS

4.3.12.6.1 CONTENTS RESTRAINTS

Payload restraints **shall** be verified by inspection. Verification **shall** be considered successful when the inspection of payload flight hardware drawings or flight hardware shows that all payload items are restrained in a manner to prevent floating or jamming of payload mechanisms when the drawer/tray is opened or closed.

Verification Submittal: CoC

4.3.12.6.2 CAPTIVE PARTS

Captive parts **shall** be verified by inspection. Verification **shall** be considered successful when an inspection shows that all parts that are temporarily removed on-orbit are held captive.

Verification Submittal: CoC

4.3.12.6.3 HANDLES AND RESTRAINTS

Verification of portable equipment grasp capability *should* be by demonstration or inspection. The demonstration of flight hardware or inspection of payload flight hardware drawings *should* be considered successful when it is shown that the portable equipment has handles or other suitable means of grasping, tethering, carrying and restraining, and the item is larger than 1 ft^3.

Verification Submittal: CoC

4.3.12.7 IDENTIFICATION LABELING

Labels on payloads **shall** be verified by inspection. The inspection **shall** be of the IPLAT approval documentation. The verification **shall** be considered successful when all payload crew interface labels have been shown to have been approved by IPLAT using the instructions in Appendix O.

Verification Submittal: CoC

4.3.12.8 CREW SAFETY

4.3.12.8.1 ELECTRICAL PROTECTION

4.3.12.8.1.1 MISMATCHED

A. Verification **shall** be by inspection. An inspection of the design drawings or flight hardware **shall** be conducted to determine the connectors which could produce a hazardous condition if mated incorrectly. The verification **shall** be considered successful when an inspection of payload flight hardware drawings or flight hardware shows that the connectors provide mechanisms to prevent inadvertent reversing or mating of the wrong connectors. Non-compliance with this requirement requires an NCR.

Verification Submittal: CoC

B. Verification **shall** be by inspection. An inspection of the design drawings or flight hardware **shall** be conducted to determine the blind mate connectors during payload installation, operation, removal, or maintenance on-orbit. The verification **shall** be considered successful when an inspection of payload flight hardware drawings or flight hardware shows that the blind mate connector design includes scoop proof connectors or other protective features. Non-compliance with this requirement requires an NCR.

Verification Submittal: CoC

4.3.12.8.1.2 OVERLOAD PROTECTION

4.3.12.8.1.2.1 DEVICE ACCESSIBILITY

Verification that an overload protective device is inaccessible without opening a door or cover (except operating handles or buttons of a circuit breaker, the cap of an extractor-type fuse holder, and similar parts may project outside the enclosure) **shall** be by inspection. Verification **shall** be considered successful when an inspection of payload flight hardware drawings or flight hardware shows a door or cover must be opened to access the overload protective device.

Verification Submittal: CoC

4.3.12.8.1.2.2 EXTRACTOR - TYPE FUSE HOLDER

Verification that the extractor-type fuse holder operates such that the fuse is extracted when the cap is removed **shall** be by inspection or demonstration. Verification **shall** be considered successful when an inspection of payload flight hardware drawings or demonstration of the flight hardware shows the fuse is extracted when the removable cap assembly is removed.

Verification Submittal: CoC

4.3.12.8.1.2.3 OVERLOAD PROTECTION LOCATION

Verification that overload protection (fuses and circuit breakers) intended to be manually replaced or physically reset on-orbit are located where they can be seen and replaced or reset without removing other components *should* be by inspection. Verification *should* be considered successful when inspection of the payload flight hardware drawings or flight hardware show that overload protection devices are directly visible and accessible without removal of other components.

Verification Submittal: CoC

4.3.12.8.1.2.4 OVERLOAD PROTECTION IDENTIFICATION

Verification that each overload protector (fuse or circuit breaker), intended to be manually replaced or physically reset on-orbit, is readily identified or keyed (mechanically or color coded) for its rated value **shall** be by inspection. Verification **shall** be considered successful when inspection of the payload flight hardware drawings or flight hardware show the rated identification for each overload protection is in place.

Verification Submittal: CoC

4.3.12.8.1.2.5 AUTOMATIC RESTART PROTECTION

Verification **shall** be by inspection. The inspection **shall** confirm that an overload protection device exists and is designed to prevent automatic restart when power is reapplied to the payload. The verification of Automatic Restart Protection **shall** be considered successful when it shows that automatic restart cannot occur following an overload-initiated shutdown, without explicit operation of the protection switch/control to enable restarting.

Verification Submittal: CoC

4.3.12.8.2 SHARP EDGES AND CORNERS PROTECTION

Verification that the payload meets the sharp edges and corners requirements specified in paragraph 3.12.8.2 **shall** be by inspection of design drawings or flight hardware. Verification **shall** be considered successful when all payload edges and corners are shown to have at least the minimum edge radii per 3.12.8.2 and all threaded screws protruding more than 0.12 inch (3.0 mm) are covered or guarded. Non-compliance with this requirement requires an NCR. This requirement is not verified by HFIT.

Verification Submittal: CoC

4.3.12.8.3 HOLES

Verification **shall** be by analysis or inspection. Verification **shall** be considered successful when analysis of payload flight hardware drawings, integration documentation, and operational procedures, or inspection of flight hardware shows that all round or slotted holes in the range of 0.4 to 1.0 inch (10 to 25 mm) are covered.

Verification Submittal: CoC

4.3.12.8.4 LATCHES

Verification **shall** be by inspection. The verification **shall** be considered successful when the inspection of drawings or flight hardware shows that all latches and similar devices have been properly covered, or guarded and designed to prevent entrapment of crew member appendages.

Verification Submittal: CoC

4.3.12.8.5 LEVERS, CRANKS, HOOKS, AND CONTROLS

Verification **shall** be by inspection. The verification **shall** be considered successful when the inspection of drawings or flight hardware shows that all levers, cranks, hooks, and controls have been properly covered, or guarded and cannot pinch, snag, or cut, the crewmembers or their clothing.

Verification Submittal: CoC

4.3.12.8.6 BURRS

Verification **shall** be by inspection. The verification **shall** be considered successful when the inspection of flight hardware shows that all edges have been properly de-burred. This must be completed before the hardware is shipped.

Verification Submittal: CoC

4.3.12.8.7 LOCKING WIRES

Verification **shall** be by inspection. The verification **shall** be considered successful when the inspection of payload flight hardware drawings or flight hardware shows the hardware does not have any safety wire on fasteners which must be unfastened for on-orbit removal or replacement.

Verification Submittal: CoC

5.0 DOCUMENTATION

The following documents include specifications, models, standards, guidelines, handbooks, and other special publications. Specific date and revision number of documents under control of the Space Station Control Board can be found in SSP 50257, Program Controlled Document Index.

The documents in this paragraph form a part of this document to the extent specified herein. In the event of a conflict between the documents referenced herein and the contents of this document, the contents of this document must be considered a superseding requirement.

5.1 APPLICABLE DOCUMENTS

Document No.	Title
ANSI/TIA/EIA-422	Electrical Characteristics of Balanced Voltage Digital Interface Circuits
BB-C-101	Federal Specification, Carbon Dioxide
CCSDS 301.0-B-2	Time Code Formats
IEC 60060-3	High-Voltage test techniques, Part 3: Definitions and requirements for on-site testing
IEC 60950-1	Information technology equipment- Safety- Part 1 General requirements
IEC 61260-1	Electroacoustics – Octave-band and fractional-octave-band filters
IEC 61672-1	Electroacoustics-Sound level meters-Part 1: Specifications
IEEE 802.3 (Revision of IEEE Std 802.3-2008) (ISO/IEC 8802-3)	IEEE Standard for Ethernet
IETF RFC 791	Internet Protocol
IETF RFC 1122	Requirements for Internet Hosts—Communication Layers
IETF RFC 1350	The TFTP Protocol (Revision 2)
IETF RFC 2817	Upgrading to TLS within HTTP/1.1
IETF RFC 3411	An Architecture for Describing Simple Network Management Protocol (SNMP) Management Frameworks
IETF RFC 3412	Message Processing and Dispatching for the Simple Network Management Protocol (SNMP)
IETF RFC 3413	Simple Network Management Protocol (SNMP) Applications
IETF RFC 3414	User-based Security Model (USM) for Version 3 of the Simple Network Management Protocol (SNMPv3)
IETF RFC 3415	View-Based Access Control Model (VACM) for the Simple Network Management Protocol (SNMP)

Document No.	Title
IETF RFC 3416	Version 2 of the Protocol Operations for the Simple Network Management Protocol (SNMP)
IETF RFC 3417	Transport Mappings for the Simple Network Management Protocol (SNMP)
IETF RFC 3418	Management Information Base (MIB) for the Simple Network Management Protocol (SNMP)
IETF RFC 4217	Securing FTP with TLS
IETF RFC 4251	The Secure Shell (SSH) Protocol Architecture
IETF RFC 4789	Simple Network Management Protocol (SNMP) over IEEE 802 Networks
IETF RFC 5246	The Transport Layer Security (TLS) Protocol Version 1.2
IETF RFC 5343	Simple Network Management Protocol (SNMP) Context EngineID Discovery
IETF RFC 5590	Transport Subsystem for the Simple Network Management Protocol (SNMP)
IETF RFC 5746	Transport Layer Security (TLS) Renegotiation Indication Extension
IETF RFC 5878	Transport Layer Security (TLS) Authorization Extensions
IETF RFC 6176	Prohibiting Secure Sockets Layer (SSL) Version 2.0
IETF RFC 6298	Computing TCP's Retransmission Timer
IETF RFC 6633	Deprecation of ICMP Source Quench Messages
IETF RFC 6864	Updated Specification of the IPv4 ID Field
JSC 27260	Decal Process Document and Catalog
MIL-A-18455	Military Specification, Argon, Technical
MIL-HDBK-454	General Guidelines for Electronic Equipment
MIL-HDBK-1553	Multiplex Application Handbook
MIL-PRF-27401	Performance Specification, Propellant Pressurizing Agent, Nitrogen
MIL-PRF-27407	Performance Specification, Propellant Pressurizing Agent, Helium
MIL-STD-461	Interface Standard Requirements for the Control of Electromagnetic Interference Characteristics of Subsystems and Equipment
MIL-STD-810	Test Method Standard, Environmental Engineering Considerations and Laboratory Tests
MIL-STD-1246	Military Standard, Product Cleanliness Levels and Contamination Control Program
MIL-STD-1553B	Digital Time Division Command/Response Multiplex Data Bus

Document No.	Title
SDD32100397	Decal, Fire Hole
SKG33120762	T61p Firmware/BIOS Configuration Drawing
SMPTE 170M	Television – Composite Analog Video Signal – NTSC for Studio Applications
SSP 30233	Space Station Requirements for Materials and Processes
SSP 30237	Space Station Electromagnetic Emission and Susceptibility Requirements
SSP 30238	Space Station Electromagnetic Techniques
SSP 30573	Space Station Program Fluid Procurement and Use Control Specification
SSP 50313	Display and Graphics Commonality Standard
SSP 50342	MIL-STD 1553 Remote Terminal Test Exceptions Report
SSP 50892	Ethernet Requirements for Interoperability with the Joint Station LAN (JSL)
SSP 51700	Payload Safety Policy and Requirements for the International Space Station
SSP 52005	Payload Flight Equipment Requirements and Guidelines for Safety-Critical Structures
SSP 52050	International Standard Payload Rack to International Space Station, Software Interface Control Document Part 1
SSQ 21635	Connectors and Accessories, Electrical, Circular, Miniature, IVA/EVA Compatible, Space Quality, General Specification for
SSQ 21655	Cable, Electrical, MIL-STD-1553 DataBus, Space Quality, General Specification for

5.2 REFERENCE DOCUMENTS

Document No.	Title
683-16348 (Boeing Drawing)	Coupling, Quick Disconnect, Fluid, Self-Sealing, Internal
683-50243-4 (Boeing Drawing)	Rack, Equipment, U.S. Standard-Assy
ANSI X3.255	Fibre Distributed Data Interface (FDDI) - Abstract Test Suite for FDDI Physical Medium Dependent Conformance Testing (PMD ATS)
ASTM E1316	Standard Terminology for Nondestructive Examinations

Document No.	Title
CCSDS 701.0-B-3	Advanced Orbiting Systems, Networks and Data Links: Architectural Specification
CCSDS 727.0-B-4	CCSDS File Delivery Protocol (CFDP)
CCSDS 734.1-R-2	Licklider Transmission Protocol (LTP) for CCSDS
CCSDS 734.2-B-1	CCSDS Bundle Protocol Specification
CMC2-00025	Cargo Mission Contract (CMC) Stowage Provisions List and Assessment
COL-ESA-RQ-014	Columbus EMC & Power Quality Requirements
COL-RIBRE-SPE-0164	Columbus Pressurized Payloads Interface Requirements Document
COL-RIBRE-SPE-0165	Columbus External Payloads Interface Requirements Document
D684-11300-01	Unique Ancillary Data Sets Interface Definition Document
D684-13066-01	Payload Microgravity Verification Guidelines
EIA-RS-170	Electrical Performance Standards - Monochrome Television Studio Facilities
EIA/TIA 568-B.2	Commercial Building Telecommunications Cabling Standard Part 2: Balanced Twisted-Pair Cabling Components
FED-STD-595B	Colors Used in Government Procurement
IEC 61000-4-2	Electromagnetic compatibility (EMC) - Part 4-2: Testing and measurement techniques - Electrostatic discharge immunity test
IEEE 802.11	Part 11: Wireless LAN Medium Access Control (MAC) and Physical Layer (PHY) Specification
IETF RFC 768	User Datagram Protocol
IETF RFC 792	Internet Control Message Protocol
IETF RFC 793	Transmission Control Protocol
IETF RFC 826	An Ethernet Address Resolution Protocol
IETF RFC 950	Internet Standard Subnetting Procedure
IETF RFC 1812	Requirements for IP Version 4 Routers, Section 7.4
IETF RFC 2644	Changing the Default for Directed Broadcasts in Routers
IETF RFC 3550	RTP: A Transport Protocol for Real-Time Applications
IETF RFC 5227	IPv4 Address Conflict Detection
IETF RFC 5325	Licklider Transmission Protocol - Motivation
IETF RFC 5326	Licklider Transmission Protocol - Specification
IETF RFC 5327	Licklider Transmission Protocol - Security Extensions

Document No.	Title
IETF RFC 5506	Support for Reduced-Size Real-Time Transport Control Protocol (RTCP): Opportunities and Consequences
IETF RFC 5761	Multiplexing RTP Data and Control Packets on a Single Port
IETF RFC 5771	IANA Guidelines for IPv4 Multicast Address Assignments
IETF RFC 5905	Network Time Protocol Version 4: Protocol and Algorithms Specification
IETF RFC 6051	Rapid Synchronization of RTP Flows
JSC 10506	Mission Operations Directorate Drafting Standards
JSC 26557	International Space Station On-Orbit Assembly, Modeling, and Mass Properties Data book
JSC 27472	Requirements for Submission of Data Needed for Toxicological Assessment of Chemicals to be Flown on Manned Spacecraft
JSC 28533	International Space Station Catalogue of IVA Government Furnished Equipment (GFE) Flight Crew Equipment (FCE)
JSC-63414	Spacecraft Water Exposure Guidelines (SWEGS)
JSC 64267	ISS ThinkPad T61p™ Laptop Hardware Interface Requirements Document
MA2-99-142 (JSC Letter located in NSTS 18798)	On-Orbit Bonding and Grounding
MIL-C-26074D	Coatings, Electroless Nickel Requirements for
MIL-DTL-5541F 11 July 2006 Superseding MIL-C-5541E 30 November 1990	Chemical Conversion Coatings on Aluminum and Aluminum Alloys
MIL-STD-130	Identification Marking of U.S. Military Property
MIL-STD-MS33540	Safety Wiring and Cotter Pinning, General Practices for
MSFC-STD-531	High Voltage Design Criteria
MSFC-STD-1274 Volume 2	MSFC HOSC Telemetry Format Standard
NASDA-ESPC-2898, JPAH Vol. 1	JEM Payload Accommodation Handbook Vol. 1 JEM PM ELM PS / Experiment Rack Standard Interface Control Specifications
NASDA-ESPC-2900A, JPAH Vol. 3	JEM Payload Accommodation Handbook Vol. 3 Exposed Facility/Payload Standard Interface Control Document

Document No.	Title
NCR-IPVR-001	120V and 28V AC Power Inverter with AC loads non-compliance to inadvertent disconnect of powered connectors and grounding/bonding resulting in potential for crew exposure to exposed electrical conductors.
NTC Report No. 7	Video Facility Testing Technical Performance Objectives
SAE AS 50881	Wiring Aerospace Vehicle
SDD39119020 (Drawing)	Knob, Latch, Door Mid-Deck Stowage Locker Assy.
SDD39119021 (Drawing)	Base, Latch, Door Mid-Deck Stowage Locker Assy.
SDD39119023 (Drawing)	Stud, Latch, Door Mid-Deck Stowage Locker Assy.
SDD39119025 (Drawing)	Handle, Latch, Door Mid-Deck Stowage Locker Assy.
SDG32108582	IMS Stowage Kit Contents Label
SDG32112200	Stowage Contents Labels
SED33102474 (JSC Drawing)	Adapter Assembly Multiuse Bracket
SL-E-0002 Book 1	Specification Electromagnetic Interference Characteristics, Requirements for Equipment Book 1
SSP 30219	Space Station Reference Coordinate Systems
SSP 30243	Space Station Requirements for Electromagnetic Compatibility
SSP 30245	Space Station Electrical Bonding Requirements
SSP 30512	Space Station Ionizing Radiation Design Environment
SSP 41002	International Standard Payload Rack to NASA/ESA/JAXA Modules Interface Control Document
SSP 41017 Part 1 and Part 2	Rack to Mini-Pressurized Logistics Module Interface Control Document (ICD)
SSP 41172	Qualification and Acceptance Environmental Test Requirements
SSP 41175-02	Software Interface Control Document Station Management and Control to International Space Station Book 2, General Software Interface Requirements
SSP 50005	International Space Station Flight Crew Integration Standard (NASA-STD-3000/T)

Document No.	Title
SSP 50007	Space Station Inventory Management System Bar Code Label Requirements and Specification
SSP 50036	Microgravity Control Plan
SSP 50184	Physical Media, Physical Signaling & Link Level Protocol Specifications for Ensuring Interoperability of High Rate Data Link Stations on the International Space Station
SSP 50253	Operations Data File Standards
SSP 50254	Operations Nomenclature
SSP 50257	Program Controlled Document Index
SSP 50261-01	Generic Groundrules, Requirements, and Constraints Part 1: Strategic and Tactical Planning
SSP 50482	ISS Program Software Management Plan
SSP 50540	Software Interface Definition Document Broadcast Ancillary Data
SSP 50986	Commercial-Off-The-Shelf (COTS) Interface Certification Requirements and Guidelines for System and Payload End Items
SSQ 21654	Cable, Single Fiber, Multimode, Space Quality, General Specification for
TIA/EIA-250-C	Electrical Performance for Television Transmission Systems

APPENDIX A

ABBREVIATIONS AND ACRONYMS

APPENDIX A - ABBREVIATIONS AND ACRONYMS

μA	Microampere
μF	Microfarad
μg	Microgravity
μPa	MicroPascal
μs	Microsecond
A	Amp/Ampere, Analysis
AAA	Avionics Air Assembly
AC	Alternating Current
A/m	Amperes per Meter
amu	Atomic Mass Unit
ANSI	American National Standards Institute
APID	Application Process Identifier
APM	Attached Pressurized Module
APS	Automated Payload Switch
Ar	Argon
ARIS	Active Rack Isolation System
ASCII	American Standard Code for Information Exchange
Assy	Assembly
ASTM	American Society for Testing and Materials
Async	Asynchronous
ATV	Automated Transfer Vehicle
Aux	Auxiliary
AWG	American Wire Gauge
BAD	Broadcast Ancillary Data
BCD	Binary Coded Decimal
BIOS	Basic Input Output System
BIT	Built-In-Test
Btu	British Thermal Unit
°C	Degrees Celsius
C&C	Command and Control

C&DH	Command and Data Handling
C&W	Caution and Warning
CAM	Centrifuge Accommodations Module
cc	cubic centimeters
CCIR	International Radio Communication/Consulate Committee
CCSDS	Consultative Committee for Space Data Systems
CCT	Cold Cathode Transducer
CDR	Critical Design Review
CE	Conducted Emissions
Cfm	Cubic Feet per Minute
CFU	Colony Forming Units
cg	Center of Gravity
CHeCS	Crew Health Care System
cm	Centimeter
CMD	Command
CO_2	Carbon Dioxide
CoC	Certificate of Compliance
CoFR	Certification of Flight Readiness
COL	Columbus Module
COTS	Commercial-Off-The-Shelf
CR	Change Request
CRC	Cyclic Redundancy Check
CRCP	Computer Resources Control Panel
CRES	Corrosion Resistant Steel
CS	Conducted Susceptibility
CSCI	Computer Software Configuration Item
CSMA/CD	Carrier Sense Multiple Access with Collision Detection
CUC	CCSDS Unsegmented time Code
CVIU	Common Video Interface Unit
dB	Decibel
dBA	A-Weighted Decibel

dBm	deciBels Referenced to One Milliwatt
dBpT	Decibels relative to One picoTesla
DC	Direct Current
DCB	Double Cold Bag
DDCU	Direct Current to Direct Current Converter Unit
DDPF	Decal Design & Production Facility
Deg	Degree
DET	Detector
DGCS	Display and Graphics Commonality Standard
DOF	Degrees of Freedom
DQA	Document Quality Assurance
DVD	Digital Versatile/Video Disk
EarthKAM	Earth Knowledge Acquired by Middle School Students
ECR	Engineering Change Request
ECW	Emergency, Caution, and Warning
EF	Exposed Facility
EHS	Enhanced Huntsville Operations Support Center
EI	Engineering Integration
EIA	EXPRESS Interface Agreement
ELC	EXPRESS Laptop Computer
EMC	Electromagnetic Compatibility
EME	Electromagnetic Effects
EMEEC	Electromagnetic Environment Effects Control
EMF	Electromagnetic Force
EMI	Electromagnetic Interference
EMU	EXPRESS Memory Unit
EPCE	Electrical Power Consuming Equipment
EPF	Exposed Payload Facility
EPS	Electrical Power System
ERO	EXPRESS Project Office
ESA	European Space Agency

ESD	Electrostatic Discharge
ESTA	Energy Systems Test Area
ETS	Ethernet Test Suite
EUT	Equipment Under Test
EWACS	Emergency, Warning, Advisory, Caution System
EXPRESS	EXpedite the PRocessing of Experiments to Space Station
°F	Degrees Fahrenheit
Fc	Foot-Candles
FCC	Federal Communications Commission
FCS	Frame Check Sequence
FDDI	Fiber Optics Distribution Data Interface
FDS	Fire Detection and Suppression
FEM	Finite Element Model
FM	Frequency Modulation
FMT	File and Memory Transfer
FSM	Frequency Spectrum Manager
Ft	Foot/Feet
Ft^2	Square Feet
Ft^3	Cubic Feet
FTP	File Transfer Protocol
Ft/s	Feet per second
G	Giga, Gravity
GByte	Gigabyte
GCAR	Government Certification Approval Request
GFCI	Ground Fault Circuit Interrupter
GFI	Ground Fault Interrupt
GFE	Government Furnished Equipment
GHz	Gigahertz
GLACIER	General Laboratory Active Cryogenic ISS Experiment Refrigerator
GN&C	Guidance, Navigation, and Control

GN_2	Gaseous Nitrogen
g_{rms}	Gravity, Root Mean Square
GS	Ground Station
GSE	Ground Support Equipment
GUI	Graphical User Interface
H	Hex
H_2O	Water
HDBK	Handbook
HDR	Header
He	Helium
HFIT	Human Factors Implementation Team
Hg	Mercury
HOSC	Huntsville Operations Support Center
hr	hour
HRDL	High Rate Data Link
HRF	Human Research Facility
H&S	Health & Status
HTV	H-IIB Transfer Vehicle
Hz	Hertz
i	Current
ICD	Interface Control Document
ICDE	ICD Engineer
ICU	Integrated Communications Unit
ID	Identifier
IDAGS	Integrated Display and Graphics Standards
IEC	International Electro Technical Commission
IEEE	Institute of Electrical and Electronic Engineers
I/F	Interface
IHI	Ishikawajima Harima Industries
IMS	Inventory Management System

in	Inch
in^2	Square Inch
in-lb	Inch-Pound
I/O	Input/Output
IP	International Partner / Internet Protocol (in Appendix I)
i_{pk}	Peak Current
IPLAT	ISS Payload Label Approval Team
IRD	Interface Requirements Document
IRE	Institute of Radio Engineers
ISIS	International Subrack Interface Standard
ISL	Integrated Station LAN
ISO/IEC	International Standards Organization/International Electrotechnical Commission
ISPR	International Standard Payload Rack
ISRP	ISSP (International Space Station Program) Safety Review Panel
ISS	International Space Station
ISSAC	International Space Station Agricultural Camera
ITCS	Internal Thermal Control System
ITU	International Telecommunications Union
IVA	Intravehicular Activity
IVCWG	Internal Volume Configuration Working Group
JAXA	Japan Aerospace Exploration Agency
JCCT	Joint Cargo Certification Team
JEM	Japanese Experiment Module
JSC	Johnson Space Center
JSL	Joint Station LAN
K	kilo
KBAR	Kneebrace Bolt Action Replacement
kg	kilograms
kg/cm^2	Kilograms per square centimeter
kg/hr	Kilograms per hour

kHz	kiloHertz
km	kilometer
KNPR	Kennedy NASA Procedural Requirements
KOZ	Keep Out Zone
kPa	kiloPascal
KSC	Kennedy Space Center
KuIP	Ku-band IP Services
kW	kiloWatt
L	Liter
L-	Launch Minus
LAB	Laboratory
LAN	Local Area Network
LAP	Laptop
Lbf	Pounds force
lb/hr or lb/h	Pounds Per Hour
lbm	pounds mass
Lbs	Pounds
LCD	Liquid Crystal Display
LED	Light Emitting Diode
LEHX	Layer 2 Ethernet Hub Multiplexer
LISN	Line Impedance Simulation Network
LRDL	Low Rate Data Link
LRODS	Launch, Return, On-Orbit, Data Set
LSB	Least Significant Bit
LTL	Low Temperature Loop
m	meter
mA	milliAmperes
MAC	Media Access Control
MALR	Maximum Allowable Leakage Rate
MAPTIS	Materials and Processes Technical Information System

MASCB	Multilateral Avionics and Software Control Board
Max	Maximum
MB	Megabit
mbps	megabits per second
Mbyte	Megabyte
MCB	Mini Cold Bag
MCC	Mission Control Center
MCC-H	Mission Control Center - Houston
MCRWG	Multilateral Computer Resources Working Group
MDM	Multiplexer-Demultiplexer
MDP	Maximum Design Pressure
MELFI	Minus Eighty-degree Laboratory Freezer for ISS
MEOP	Maximum Expected Operating Pressure
mg	Milligram
MHI	Mitsubishi Heavy Industries
MHz	Megahertz
MIL	Military
MIL-SPEC	Military Specification
MIL-STD	Military Standard
Min.	Minimum
Ml	Milliliter
MLE	Middeck Locker Equivalent
Mm	millimeter
Mohm	Milliohm
M&P	Materials and Processes
MRDL	Medium Rate Data Link (Ethernet)
ms	Millisecond
MSB	Most Significant Bit
msec	Millisecond
MSFC	Marshall Space Flight Center
MTL	Moderate Temperature Loop
M_{tot}	Mass Total

mV	Millivolt
MVCB	Multilateral Vehicle Control Board
M/W	Mates with
N	Newton
N/A	Not Applicable
N-M	Newton-Meter
N-s	Newtons per second
N_2	Nitrogen
NASA	National Aeronautics and Space Administration
NC	Noise Criteria
NCR	Non-Compliance Report
NEMA	National Electrical Manufacturers Association
nf	nanoFarad
NHB	NASA Handbook
nm	nanometer
Nom	Nominal
NRZI	Non-Return to Zero Invert on Ones
ns	nanosecond
NSTS	National Space Transportation System
NTIA	National Telecommunication and Information Administration
NTSC	National Television System Committee
NVR	No Verification Required
O_2	Oxygen
OB	Vehicle Office
OCA	Orbital Communications Adaptor
Oct	Octave
ODF	Operations Data File
ODFCB	Operations Data File Control Board
OMRS	Operations and Maintenance Requirements and Specifications
OMRSD	Operations and Maintenance Requirements and Specification Document
OpNom	Operations Nomenclature

Ops	Operations
ORU	Orbital Replacement Unit
OTO	On Third Octave
oz	Ounce
P	Pressure, Pressure Differential
Pa	Pascal
PA	Payload Application
PAH	Payload Accommodations Handbook
PaRIS	Passive Rack Isolation System
Pa/s	Pascal per second
PAS	Payload Application Software
PCS	Portable Computer System
PD	Payload Developer
PDL	Payload Data Library
PDR	Preliminary Design Review
PDRT	Payload Display Review Team
PEHB	Payload Ethernet Hub Bridge
PEHG	Payload Ethernet Hub Gateway
PEP	Payload Executive Processor
pF	picoFarad
PFE	Portable Fire Extinguisher
PFM	Pulse Frequency Modulation
PGT	Pirani Gauge Transducer
PI	Payload Integrator
PIA	Payload Integration Agreement
PIM	Payload Integration Manager
PIRN	Preliminary Interface Revision Notice
PL or P/L	Payload
PLD	Payload
PL MDM	Payload Multiplexer/Demultiplexer
PMP	Payload Mounting Panel

PN or P/N	Part Number
POIC	Payload Operations Integration Center
PPCB	Point-to-Point Communications Bus
PPT	Positive Pressure Transducer
PRCU	Payload Rack Checkout Unit
PSCP	Payload Software Control Panel
PSE&I	Payload Software Engineering and Integration
PSI	Payload Software Integration
psi	Pounds per square inch
psia	pounds per square inch absolute
psid	Pounds per square inch differential
psi/min	Pounds per square inch per minute
PSIV	Payload Software Integration and Verification
PSIVF	Payload Software Integration and Verification Facility
PU	Panel Unit
PVP	Payload Verification Plan
PWD	Potable Water Dispenser
PWR	Power, Potable Water Reservoir
QD	Quick Disconnect
RAD	Radiation Absorbed Dose
RAM	Random Access Memory
RAPTR	Remote Advanced Payload Test Rig
RE	Radiated Emissions
REF	Reference
Rev	Revision
RF	Radio Frequency
RFA	Radio Frequency Authorization
RFCA	Rack Flow Control Assembly
RFI	Radio Frequency Interference
RFS	Request For Service

RIC	Rack Interface Controller
RIV	Rack Isolation Valve
RMA	Restraint and Mobility Aid
RMS	Root Mean Square
RPC	Remote Power Controller
RPCM	Remote Power Controller Module
RS	Radiated Susceptibility
RSS	Root Sum Squared
RT	Remote Terminal
RTD	Resistive Temperature Device
RTN	Return
RTP	Real-Time Transport Protocol
RV	Random Vibration
RVCP	Requirements and Verification Control Panel
RWS	Robotic Workstation
RX	Reception, Receive, Receiver
s	second
scc	Standard Cubic Centimeter
SCC	Stress Corrosion Cracking
SCH	SubCarrier to Horizontal
ScS	Suitcase Simulator
SEA	Statistical Energy Analysis
sec	second
SE&I	Systems Engineering and Integration
SI	Standard International
SIR	Standard Interface Rack
SLM	Sound Level Meter
SLPM	Standard Liters Per Minute
SMAC	Spacecraft Maximum Allowable Concentrations
SMPTE	Society of Motion Pictures and Television Engineers
S/N	Serial Number

SpaceX / SpX	Space Exploration Technologies
SPHERES	Synchronized Position Hold, Engage, Re-orient, Experimental Satellites
SPL	Sound Pressure Level
SRF	Science Research Facility
SSC	Station Support Computer
SSCN	Space Station Change Notice
SSH	Secure Shell
SSID	Service Set Identifier
SSPC	Solid State Power Controller
SSPCM	Solid State Power Controller Module
SSQ	Space Station Qualified
STELLA	Software Toolkit for Ethernet Lab-Like Architecture
STP	Shielded Twisted Pair
SUP	Standard Utility Panel
SYNC	Synchronous, Synchronize
SWL	Software Load
t	Time
T	Transducer, Test
TAXI	Transparent Asynchronous Transmitter/Receiver Interface
TBD	To Be Determined
TBR	To Be Resolved
TBS	To Be Supplied
TCP/IP	Transmission Control Protocol/Internet Protocol
TCS	Thermal Control System
TIA	Tailoring Interpretation Agreement
TM	Technical Memorandum
TOC	Total Organic Carbon
Torr	Unit of pressure
TPS	Test Performance Sheet
TRDS	Technical Requirements Data Set
Tx	Transmitter, Transmit

TX	Transfer
Typ	Type
UAD	Unique Ancillary Data
UDP	User Datagram Protocol
UI	User Interface
UIP	Utility Interface Panel
UOP	Utility Outlet Panel
US or U.S.	United States
USL or US Lab	United States Laboratory
USOS	United States On-orbit Segment
USPODFCB	United States Payload Operations Data File Control Board
UTP	Unshielded Twisted Pair
V	Volt
VA	Volt amperes
VCB	Vehicle Control Board
VC-S	Visibly Clean - Sensitive
VCU	Video Control Unit
Vdc	Volts direct current
VDPU	Video and Data Processing Unit
VDS	Video Distribution System
VERITAS	Verification of Engineering Requirements – Interface for Tracking, Approval and Submission
VES	Vacuum Exhaust System
V/m	Volts per Meter
Vrms	Volts root-mean-square
VRS	Vacuum Resource System
VSU	Video Switch Unit
VUA	Volatile Organic Compound Usage Agreement
VV	Vent Valve
VVS	Vacuum Vent System

W	Watt
WAP	Wireless Access Point
WFSV	Water Flow Selection Valve
WG	Waste Gas
WGS	Waste Gas System
WORF	Window Observational Research Facility
WPA	Water Processing Assembly

APPENDIX B

GLOSSARY OF TERMS

APPENDIX B - GLOSSARY OF TERMS

Access Port: Hole that allows penetration of the Portable Fire Extinguisher nozzle.

Acoustic Reference: All Sound Pressure Levels in decibels are referenced to 20 micropascals.

Active Air Exchange: Forced convection between two volumes. For example, forced convection between a subrack payload the internal volume of an integrated rack, or forced convection between a subrack payload and the cabin air.

Adjunct Active Portable Equipment: Equipment operated outside the rack required to support nominal payload operations (including any required GFE).

Aisle Mounted Equipment: Payloads and GFE that cannot be packaged into an ISPR due to the nature of the equipment intended operations (i.e., laptop computers, crew exercise equipment, etc.). Aisle mounted equipment also includes non-ISPR payloads mounted in "open" rack locations (i.e., rack locations in which there is no rack installed) ventilated by the module ventilation system.

Alignment Marks: Are straight or curved lines of sufficient length and width to allow alignment, are applied to both mating parts, align when the parts are in the installation position, and are visible during alignment and attachment.

Analysis: A technical evaluation process using techniques and tools such as mathematical models and computer simulation, historical/design/test data, and other quantitative assessments to calculate characteristics and verify specification compliance. Analysis is used to verify requirements compliance in cases where established techniques are adequate to yield confidence or where testing is impractical.

amu: One Atomic Mass Unit, equal to one-twelfth the mass of a carbon-12 atom, the average atomic mass is called the atomic weight.

Boss: Protruding hard-points for GSE attachment.

Brightness ratio: Defined as the ratio of the maximum light level on the work surface area to the minimum light level on the work surface area.

Catastrophic Hazard: Any hazard which causes loss of on-orbit life sustaining system function.

Cold Stowage Facility: Active or passive facility used to transport or store samples at controlled temperatures.

Common Mode Noise: Interference that appears on both signal leads (signal and circuit return), or the terminals of a measuring circuit, and ground.

Continuous Noise Source: A significant noise source which exists for a cumulative total of more than eight hours in any 24-hour period is considered a continuous noise source.

Continuously-Powered Payload: Payload requires power 24 hours per day, 7 days a week, from the time the payload is deployed in the ISS until the time it is removed from the ISS.

Note: All payloads must be able to withstand a no-power condition for short periods to allow physical transfer from the transport vehicle to ISS (when required). Many of these payloads are expected to also require power during ascent and descent (rides up/down) in the transport vehicle.

Critical Hazard: Any hazard which may cause a non-disabling injury, severe occupational illness, loss of emergency procedures, or involves major damage to one of the following: the launch or servicing vehicle, manned base, an on-orbit life-sustaining function, a ground facility or any critical support facility.

Current Limiting: The current is limited to a specific level plus or minus a percentage for tolerance.

Demonstration: The qualitative determination of compliance with requirements by observation during actual operation or simulation under preplanned conditions and guidelines.

Designated Cold Stowage: A volume that is normally sealed from the cabin air whose sole purpose is to maintain payloads or samples at temperatures below 15.6 °C (60°F) and is designated Cold Stowage in its Payload Tactical Plan.

Electromagnetic Compatibility (EMC): The capability of systems and all associated subsystems/equipment to perform within design limits without degradation due to the Electromagnetic Effect encountered during accomplishment of the assigned mission. The deliverable end item compatibility test is as described in paragraph 3.6.2 of SSP 30243.

Electromagnetic Interference (EMI): Any electromagnetic disturbance, phenomenon, signal, or emission (man-made or natural) which causes equipment performance outside of the equipment’s design limits. Testing is as described in SSP 30237 and SSP 30238 as referenced by paragraph 3.2.4.4 of this IRD.

Emergency Condition: Toxic atmosphere, rapid cabin depressurization or fire.

EPCE: Equipment that consumes electrical power including battery powered equipment.

Exception: A general term for any payload-proposed departure from requirements or interfaces.

Fire Event: Localized or propagating combustion, pyrolysis, smoldering or other thermal degradation process characterized by the potentially hazardous release of energy, particulates, or gases.

GSE Plane: A reference plane that is defined by the front surface of the four rack GSE bosses.

Hazard: The presence of a potential risk situation caused by an unsafe act or condition.

Health and Status Data: Information originating at the payload and passed to the respective payload MDM that provides the crew and the ground confirmation of payload performance, operational state, resource consumption, and assurance that the payload is operating within the safety guidelines as defined by the Payload Safety Review Panel and the ISS Flight Rules. Some examples of payload health and status data are subsystem status (power, voltages, currents, temperatures, pressures, fluid flow velocities, warning indicators, error messages/codes, etc.), digital communications system statistics (1553, Ethernet, and high rate system status, etc.), and video system status (camera and video recorder on/off indications, Synchronization indicators, etc.).

HRDL Gateway: The PEHG HRDL gateway provides a data downlink path by converting incoming MRDL packets to HRDL optical fiber for transmission to the APS and ICU.

Inspection: A physical measurement or visual evaluation of equipment and associated documentation. Inspection is used to verify construction features, drawing compliance, workmanship, and physical condition.

Integrated Rack: The ISPR and all other subrack equipment which operates within a rack.

Integrator: A group that assembles multiple subcomponents to make one larger component.

Intermittent Noise Source: A significant noise source which exceeds its continuous noise requirement for a cumulative total of eight hours or less in a 24-hour period is considered an intermittent noise source.

International Space Station: The first space station to be comprised of major elements from many nations, including the United States, Russia, Europe, Japan, Canada, and Italy. The ISS is a place for humans to perform scientific and commercial research to improve the lives of others on Earth and in space.

Keep-Alive Power: Payload which will potentially have loss of science in the event of power interruptions greater than 45 minutes.

ISS Program: A cooperative international program involving the following partners: ESA, NASA, and JAXA.

Line Impedance Simulation Network: An electrical circuit, including resistance, capacitance, and inductance, used to simulate a specific electrical power bus.

Non-Normal: Pertaining to performance of the Electrical Power System outside the nominal design due to ISS system equipment failure, fault clearing, or overload conditions.

Non-Permanent Protrusion: A payload item which is typically located in the aisle for experiment purposes only. These items must be returned to their stowed configuration when not being used.

Example: Front panel mounted equipment

Non-Rack Payload: A payload which does not utilize an ISPR and has discrete physical interfaces to ISS services (i.e. power, data, video, vacuum, etc.) This may apply to both pressurized and unpressurized (attached) payloads.

Operate: Perform intended design functions given specified conditions.

ORU: A Part of the subsystem of a facility payload that is intended to be replaced on-orbit if required.

Payload Cold Stowage Sample: A payload science specimen or sample to be transported or stowed in a cold stowage facility at controlled temperatures.

Payload Developer: The organization or individual who has been chosen by the Payload Sponsor to design, fabricate, verify, and deliver the payload hardware, software, and supporting equipment (instruments or facilities) to the ISS program for integration into the ISS. A Payload Sponsor may also be the PD. The organization responsible for overall design, fabrication, integration, and operation of the payload.

Permanent Protrusion: A payload hardware item which is not ever intended to be removed.

Potential Fire Event: A fire event that is detected by other means (e.g., temperature sensors, current sensors, etc.) than a certified Space Station smoke detector. Since, this alternate method cannot confirm the presence of smoke with a confirmed redundant method like the certified Space Station smoke detector there is only a potential that a fire is occurring.

Potential Fire Source: Any electrical, chemical, or other energy source capable of creating a fire event (e.g., electrically powered equipment).

Pressurized Payload: A pressurized payload consists of any experiment operated in the pressurized environment of ISS, including experiments integrated into a rack and non-rack payload items, (i.e., hardware requiring access to and resources from a UOP, or any EPCE configuration residing in a module).

Protrusion: A payload hardware item which extends beyond the GSE plane.

Quasi-Steady Acceleration: ISS accelerations in the frequency range below 0.01 Hz. This limit is defined to be consistent with SSP 50036, Microgravity Control Plan, so that the maximum average acceleration contribution from no integrated rack exceeds 0.02 micro-g continuously nor exceeds 10 micro-g seconds over any period of time not protected by the continuous limit.

Rack Integrator: Organization (typically the rack owner) responsible for determining compatibility of subracks/investigations with each other and the rack facility. The rack integrator collects and processes verification submitted by the subrack PDs. The rack integrator also submits verification to the module integrators to demonstrate compatibility with the ISS.

Restraints and Mobility Aids: Long and short duration foot restraints, handrails, seat track equipment anchors, bungees, etc.

Safety-Critical: Having the potential to be hazardous to the safety of hardware, software, and personnel.

Safety-Critical Structure: All structural elements (including interfaces, fasteners, and welds) in the primary load path including pressure systems, uncontained glass, composites, structural bonds/adhesives, beryllium, rotating/articulating machinery, and containment devices are safety critical.

Significant Noise Source: A significant noise source is any individual item of equipment or group of equipment items which collectively functions as an operating system that generates an A-weighted overall SPL equal to or in excess of 37 dBA (A weighted decibels), measured at a 0.6-m distance from the noisiest part of the equipment.

Soft-good Payload Item: Any payload item composed solely of mesh, fabric, or soft plastic. Items made of metal, glass, or any other material hard/sharp/stiff enough to puncture or slice human skin are not considered a soft-good payload item.

Specularity: Defined as the ratio of the flux leaving a surface or medium by regular (specular) reflection to the incident flux.

Standard Conditions: Measured volumes of gases are generally recalculated to 0 °C temperature and 760 mm Hg pressure, which have been arbitrarily chosen as standard conditions.

Subrack Level Payload: A payload that is installed into a facility rack, which becomes part of the integrated rack.

Systems Engineering & Integration: The organization responsible for analytical integration of a payload rack/non-rack payload/integrated external payload adapter/pallet or payload hardware to comply with ISS/SSP imposed design–to specification, accommodations and constraints, and interface requirements. This payload organization will establish applicable payload verification requirements and perform all required analytical verification tasks associated with an ISS program–approved Payload Verification Program Plan.

Test: The actual operation of normally-instrumented equipment under simulated or flight-equivalent conditions, or the subjection of parts or equipment to specified environments to measure and record responses in a quantitative manner.

Vented conditions: Condition (Temperature and Pressure) of the gas in the experiment chamber as the chamber is opened to the ISS VES/WGS.

Verification: The process of verifying a design/product is compliant with its given design requirements, accounting for the operational/environmental design envelope. The verification methods for determining if the design/product is compliant with the design requirements include inspection, analysis, demonstration, and test.

VES/WGS: Vacuum Exhaust System and/or Waste Gas System. The USL, JEM and Columbus each have similar systems to vent gases to space from an experiment chamber. The System in the USL is the Vacuum Exhaust System and the Systems in the JEM and Columbus are the Waste Gas Systems.

Visibly Clean-Sensitive Cleanliness Level: Hardware meeting the Visibly Clean-Sensitive level is cleaned and afterwards, the exposed/accessible surfaces of the hardware are qualitatively verified to be free of all particulate and non-particulate material visible to the normal unaided eye. The required incident light level for inspection is at least 50 foot-candles (500 lumens/square meter) and the required inspection distance is 2 to 4 feet (0.6 to 1.2 meters). Areas of suspected contamination may be examined at distances closer than specified for final verification.

Wire derating: Wire is derated based on the current flow, environment, electrical circuitry that operates within an integrated rack or within electrical power consuming equipment individual boxes.

APPENDIX C

OPEN ITEMS

APPENDIX C - OPEN ITEMS

C.1 TO BE DETERMINED ITEMS

TABLE C-1 TO BE DETERMINED ITEMS

TBD No.	Description	Document Section	Responsible	Due Date	Resolution and Closure Date

C.2 TO BE RESOLVED ITEMS

TABLE C-2 TO BE RESOLVED ITEMS

TBR No.	Description	Document Section	Responsible	Due Date	Resolution and Closure Date

APPENDIX D

COMMON TRANSPORT REQUIREMENTS FOR SOFT STOWED PAYLOADS

APPENDIX D – COMMON TRANSPORT REQUIREMENTS FOR SOFT STOWED PAYLOADS

D.1.0 INTRODUCTION

D.1.1 PURPOSE

This appendix provides requirements, guidelines and data deliverables for soft stowed payloads in transportation vehicles.

D.1.2 SCOPE

This appendix addresses soft stowed unpowered or battery powered payloads in transportation vehicles including Soyuz, Progress, Dragon, Cygnus and HTV. Soft stowed payloads are those that are not hard mounted to vehicle structure.

D.1.3 USE

These requirements, guidelines and data deliverables are applied to soft stowed payloads in addition to the general requirements, guidelines and data deliverables in Section 3.0 and are allocated to a payload through the payload unique ICD. The PD and the ISS Program must jointly agree on the interfaces and identify requirements as applicable if the interface exists, and not applicable if the interface does not exist for the payload configuration documented in the ICD. See Section D.5.0 for the optional process to eliminate verification of launch requirements and descent requirements.

D.2.0 DOCUMENTATION

See Section 5.0.

D.3.0 COMMON TRANSPORT FOR SOFT STOWED PAYLOADS INTERFACE REQUIREMENTS

D.3.1 STRUCTURAL/MECHANICAL INTERFACE REQUIREMENTS

D.3.1.1 ACCELERATION LOADS

Payload safety-critical structures **shall** (and other payload structures *should*) provide positive margins of safety when exposed to the accelerations documented in Table D.3.1.1-1 at the CG of the item, with all six degrees of freedom acting simultaneously. The acceleration values are applicable to both soft stowed and hard mounted hardware.

TABLE D.3.1.1-1 LAUNCH AND LANDING LOAD FACTORS ENVELOPE

	Nx (g)	Ny (g)	Nz (g)	Rx (rad/sec^2)	Ry (rad/sec^2)	Rz (rad/sec^2)
Launch	± 9.0	± 9.0	± 9.0	± 13.5	± 13.5	± 13.5
Landing	± 10.0	± 10.0	± 10.0	± N/A	± N/A	± N/A

D.3.1.2 RANDOM VIBRATION ENVIRONMENTS FOR PAYLOADS PACKED IN FOAM OR BUBBLE WRAP INSIDE HARD CONTAINERS OR SOFT CONTAINERS

Payload safety-critical structures packed in foam or bubble wrap and enclosed in hard containers such as lockers, boxes, or similar structures, and payload safety-critical structures packed in foam or bubble wrap and soft stowed in bags **shall** (and other payload structures *should*) meet the specified performance requirements when exposed to the maximum flight random vibration (RV) environments defined in Figures D.3.1.2-1, D.3.1.2-2, and D.3.1.2-3 and Tables D.3.1.2-1 and D.3.1.2-2 These figures show the vibration environments that the payload experiences when isolated using the given packaging configurations compared with the un-isolated environment defined in Table D.3.1.2-3. The isolated environments are functions of payload weight (W) and the foam contact area (A) in each axis. To obtain the pounds per square inch (psi) loading for a particular payload, divide the payload weight by the foam contact area. It is recommended this value be between 0.2 to 0.7 psi to lie within the data range of the Figures. The value of W/A is in pounds-per-square inch units, psi units.

Example environments are shown for W/A values of 0.2 and 0.7 psi. These values cover the range for the typical payload launched in hard containers and the user is expected to apply the curve closest to the actual W/A loading. It is recommended that the payload’s isolated W/A value be calculated in each of the three axes.

Isolation performances and thicknesses are shown for Minicel, Pyrell, and Bubble Wrap which are three common packaging materials. Note that the use of Nomex overwrap for flammability protection does not significantly change the isolation performance of the foam.

Successful verification of this requirement does not conclude the foam packing process. Payload developers must also evaluate foam compression and KOZ protection for their payload. Packing guidelines and requirements are processed through the Joint Cargo Certification Team (JCCT), supervised by the NASA Management Integration Office.

Note: Payload developers are not required to evaluate foam deflection and keep-out zone protection for their hardware. The JCCT performs this analysis only for Vehicle hardware.

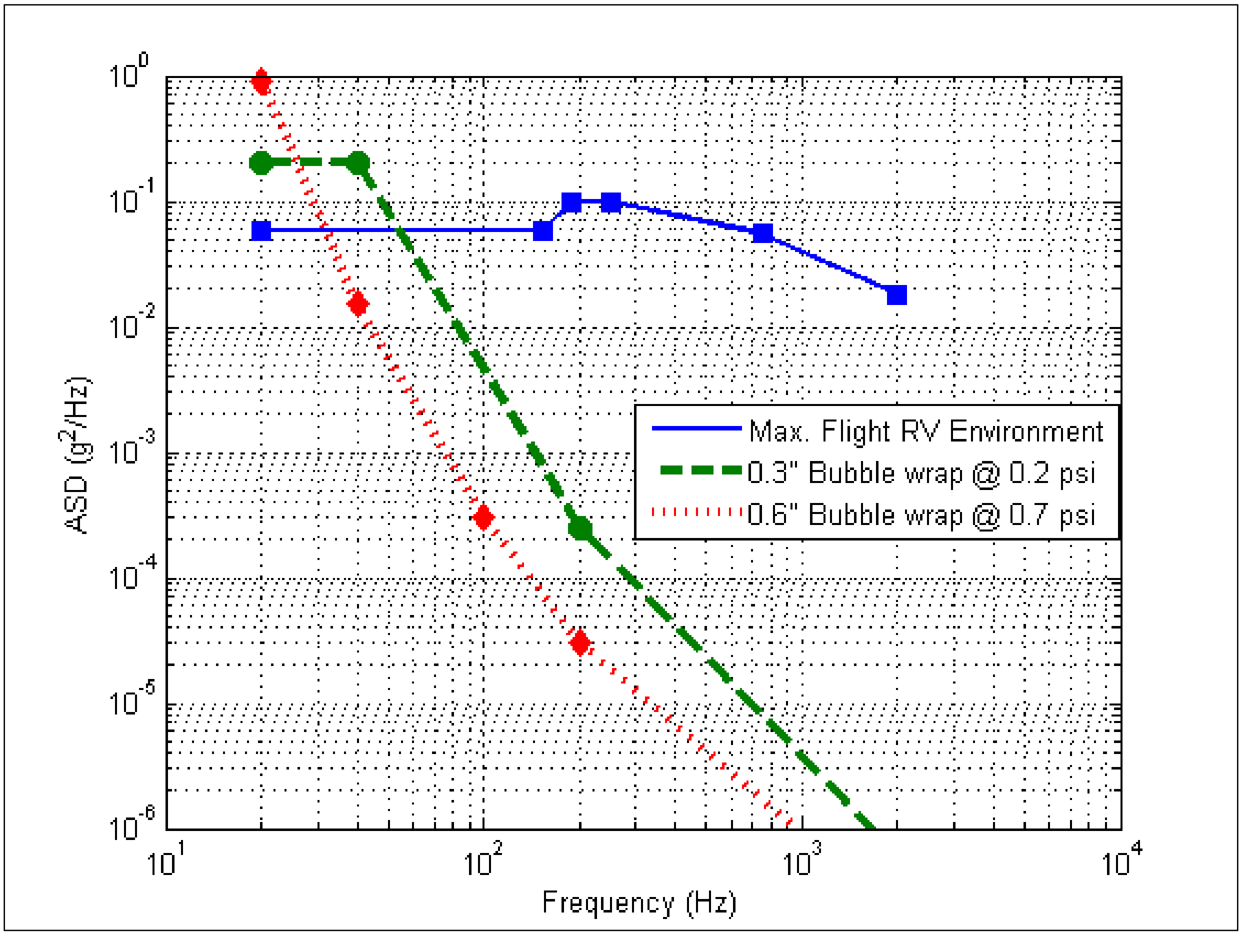


FIGURE D.3.1.2-1 ATTENUATED RANDOM VIBRATION ENVIRONMENTS FOR 0.3-INCH AND 0.6-INCH BUBBLE WRAP

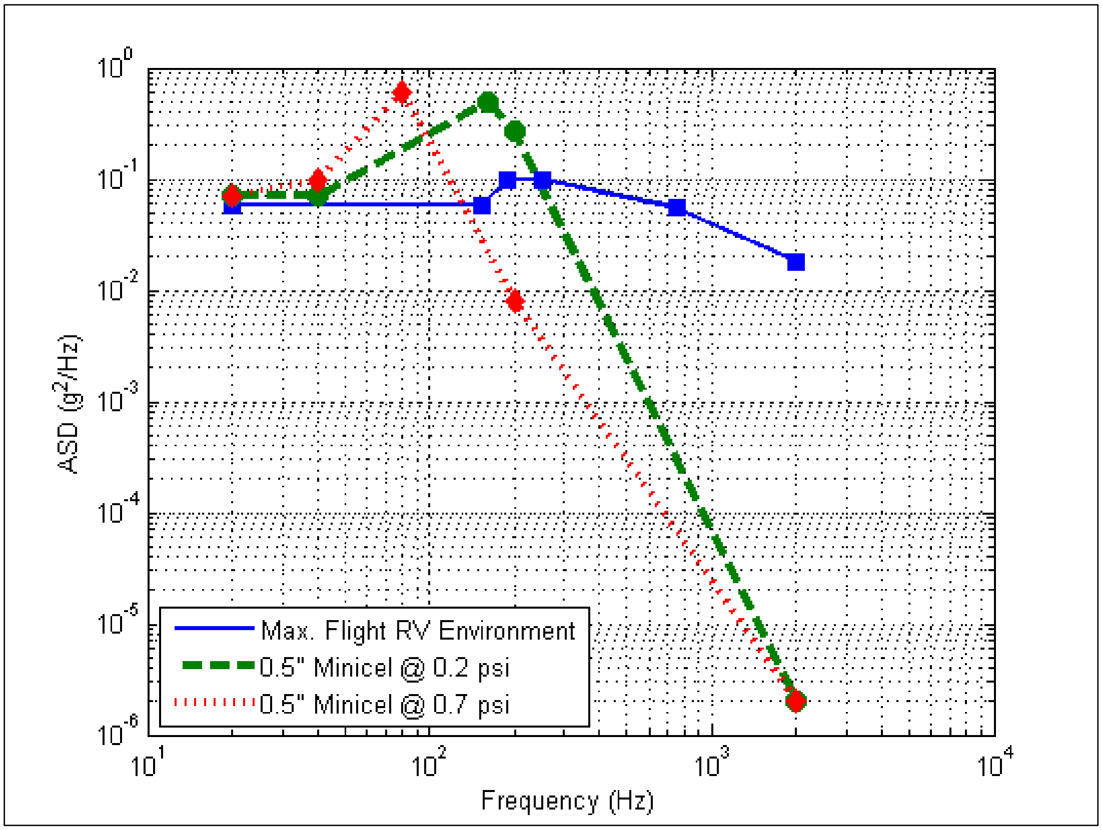


FIGURE D.3.1.2-2 ATTENUATED RANDOM VIBRATION ENVIRONMENTS FOR 0.5-INCH MINICEL

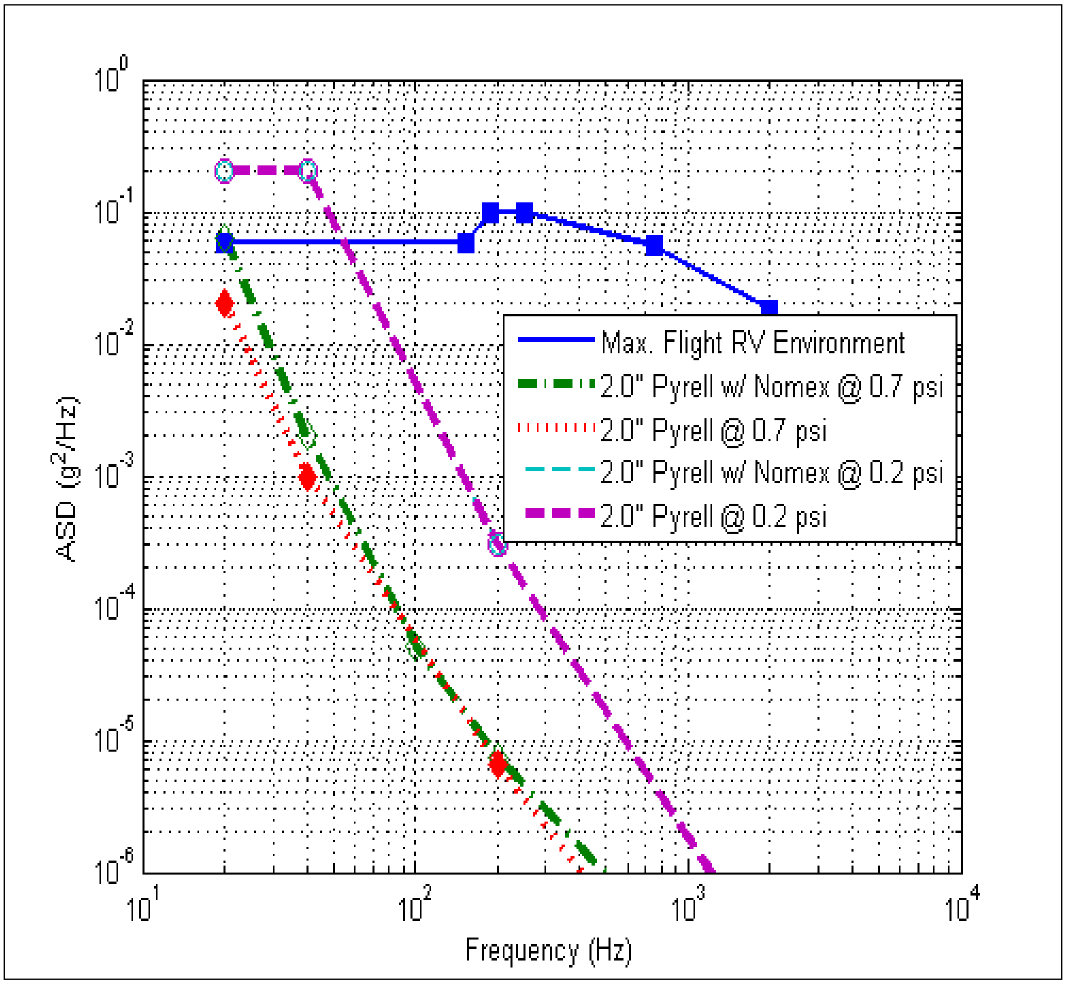


FIGURE D.3.1.2-3 ATTENUATED RANDOM VIBRATION ENVIRONMENTS FOR 2.0-INCH PYRELL AND 2.0-INCH PYRELL WITH NOMEX WRAPPING

TABLE D.3.1.2-1 UNATTENUATED AND ATTENUATED RANDOM VIBRATION ENVIRONMENTS FOR W/A = 0.2 PSI

Frequency (Hz)	Max. Flight RV Env[1]	0.3" Bubble Wrap[2]	0.5" Minicel[3, 4]	2.0" Pyrell[5]	2.0" Pyrell w/Nomex[6]
20	0.057 (g^2/Hz)	0.2 (g^2/Hz)	0.07 (g^2/Hz)	0.2 (g^2/Hz)	0.2 (g^2/Hz)
20-40	0 (dB/oct)	0 (dB/oct)	0 (dB/oct)	0 (dB/oct)	0 (dB/oct)
40	0.057 (g^2/Hz)	0.2 (g^2/Hz)	0.07 (g^2/Hz)	0.2 (g^2/Hz)	0.2 (g^2/Hz)
40-80	0 (dB/oct)	-12.5 (dB/oct)	+4.27 (dB/oct)	-12.16 (dB/oct)	-12.16 (dB/oct)
80	0.057 (g^2/Hz)	0.011 (g^2/Hz)	0.187 (g^2/Hz)	0.012 (g^2/Hz)	0.012 (g^2/Hz)
80-100	0 (dB/oct)	-12.5 (dB/oct)	+4.27 (dB/oct)	-12.16 (dB/oct)	-12.16 (dB/oct)
100	0.057 (g^2/Hz)	4.45×10^{-3} (g^2/Hz)	0.257 (g^2/Hz)	4.93×10^{-3} (g^2/Hz)	4.93×10^{-3} (g^2/Hz)
100-153	0 (dB/oct)	-12.5 (dB/oct)	+4.27 (dB/oct)	-12.16 (dB/oct)	-12.16 (dB/oct)
153	0.057 (g^2/Hz)	7.61×10^{-4} (g^2/Hz)	0.469 (g^2/Hz)	8.85×10^{-4} (g^2/Hz)	8.85×10^{-4} (g^2/Hz)
153-160	+7.67 (dB/oct)	-12.5 (dB/oct)	+4.27 (dB/oct)	-12.16 (dB/oct)	-12.16 (dB/oct)
160	0.064 (g^2/Hz)	6.32×10^{-4} (g^2/Hz)	0.5 (g^2/Hz)	7.39×10^{-4} (g^2/Hz)	7.39×10^{-4} (g^2/Hz)
160-190	+7.67 (dB/oct)	-12.5 (dB/oct)	-8.31 (dB/oct)	-12.16 (dB/oct)	-12.16 (dB/oct)
190	0.099 (g^2/Hz)	3.09×10^{-4} (g^2/Hz)	0.311 (g^2/Hz)	3.69×10^{-4} (g^2/Hz)	3.69×10^{-4} (g^2/Hz)
190-200	0 (dB/oct)	-12.5 (dB/oct)	-8.31 (dB/oct)	-12.16 (dB/oct)	-12.16 (dB/oct)
200	0.099 (g^2/Hz)	2.5×10^{-4} (g^2/Hz)	0.27 (g^2/Hz)	3.0×10^{-4} (g^2/Hz)	3.0×10^{-4} (g^2/Hz)
200-250	0 (dB/oct)	-7.83 (dB/oct)	-15.44 (dB/oct)	-9.56 (dB/oct)	-9.56 (dB/oct)
250	0.099 (g^2/Hz)	1.4×10^{-4} (g^2/Hz)	0.086 (g^2/Hz)	1.48×10^{-4} (g^2/Hz)	1.48×10^{-4} (g^2/Hz)
250-750	-1.61 (dB/oct)	-7.83 (dB/oct)	-15.44 (dB/oct)	-9.56 (dB/oct)	-9.56 (dB/oct)
750	0.055 (g^2/Hz)	8.02×10^{-6} (g^2/Hz)	3.06×10^{-4} (g^2/Hz)	4.5×10^{-6} (g^2/Hz)	4.5×10^{-6} (g^2/Hz)
750-2000	-3.43 (dB/oct)	-7.83 (dB/oct)	-15.44 (dB/oct)	-9.56 (dB/oct)	-9.56 (dB/oct)
2000	0.018 (g^2/Hz)	6.25×10^{-7} (g^2/Hz)	2.0×10^{-6} (g^2/Hz)	2.0×10^{-7} (g^2/Hz)	2.0×10^{-7} (g^2/Hz)
OA (grms)	**9.47**	**2.56**	**7.82**	**2.58**	**2.58**

Notes:

1) Unattenuated RV levels are from Table D.3.1.2-3.
2) Bubble wrap refers to SECO 88 manufactured by Seco Industries, 6909 East Washington Blvd. Montebello, CA 90640.
3) Minicel refers to Minicel L200 manufactured by Voltek, 73 Shepard St. Lawrence, MA 01843.
4) Zotek refers to Zotek F30 distributed by Zotefoams, 55 Precision Dr. Walton, KY 41094, Ref. Tables I.3-2 & I.3-3.
5) Pyrell refers to Pyrell#2 manufactured by Foamex, 1500 E. 2nd St. Eddystone, PA 19022.
6) Nomex refers to HT90-40 manufactured by Stern & Stern Industries, 188 Thacher St., Hornell, NY 14843.

TABLE D.3.1.2-2 UNATTENUATED AND ATTENUATED RANDOM VIBRATION ENVIRONMENTS FOR W/A = 0.7 PSI

Frequency (Hz)	Max. Flight RV Env[1]	0.6" Bubble Wrap[2]	0.5" Minicel[3, 4]	2.0" Pyrell[5]	2.0" Pyrell w/Nomex[6]
20	0.057 (g^2/Hz)	0.9 (g^2/Hz)	0.07 (g^2/Hz)	0.02 (g^2/Hz)	0.064 (g^2/Hz)
20-40	0 (dB/oct)	-17.78 (dB/oct)	+1.55 (dB/oct)	-13.01 (dB/oct)	-15.05 (dB/oct)
40	0.057 (g^2/Hz)	0.015 (g^2/Hz)	0.1 (g^2/Hz)	0.001 (g^2/Hz)	0.002 (g^2/Hz)
40-80	0 (dB/oct)	-12.85 (dB/oct)	+7.78 (dB/oct)	-9.42 (dB/oct)	-11.99 (dB/oct)
80	0.057 (g^2/Hz)	7.78×10^{-4} (g^2/Hz)	0.6 (g^2/Hz)	1.14×10^{-4} (g^2/Hz)	1.26×10^{-4} (g^2/Hz)
80-100	0 (dB/oct)	-12.85 (dB/oct)	-14.18 (dB/oct)	-9.42 (dB/oct)	-11.99 (dB/oct)
100	0.057 (g^2/Hz)	3.0×10^{-4} (g^2/Hz)	0.21 (g^2/Hz)	5.69×10^{-5} (g^2/Hz)	5.2×10^{-5} (g^2/Hz)
100-153	0 (dB/oct)	-10.0 (dB/oct)	-14.18 (dB/oct)	-9.42 (dB/oct)	-8.41 (dB/oct)
153	0.057 (g^2/Hz)	7.30×10^{-5} (g^2/Hz)	0.028 (g^2/Hz)	1.50×10^{-5} (g^2/Hz)	1.59×10^{-5} (g^2/Hz)
153-160	+7.67 (dB/oct)	-10.0 (dB/oct)	-14.18 (dB/oct)	-9.42 (dB/oct)	-8.41 (dB/oct)
160	0.064 (g^2/Hz)	6.30×10^{-5} (g^2/Hz)	0.023 (g^2/Hz)	1.30×10^{-5} (g^2/Hz)	1.40×10^{-5} (g^2/Hz)
160-190	+7.67 (dB/oct)	-10.0 (dB/oct)	-14.18 (dB/oct)	-9.42 (dB/oct)	-8.41 (dB/oct)
190	0.099 (g^2/Hz)	3.56×10^{-5} (g^2/Hz)	0.01 (g^2/Hz)	7.63×10^{-6} (g^2/Hz)	8.66×10^{-6} (g^2/Hz)
190-200	0 (dB/oct)	-10.0 (dB/oct)	-14.18 (dB/oct)	-9.42 (dB/oct)	-8.41 (dB/oct)
200	0.099 (g^2/Hz)	3.0×10^{-5} (g^2/Hz)	0.008 (g^2/Hz)	6.5×10^{-6} (g^2/Hz)	7.5×10^{-6} (g^2/Hz)
200-250	0 (dB/oct)	-6.55 (dB/oct)	-10.84 (dB/oct)	-7.94 (dB/oct)	-6.84 (dB/oct)
250	0.099 (g^2/Hz)	1.85×10^{-5} (g^2/Hz)	3.58×10^{-3} (g^2/Hz)	3.61×10^{-6} (g^2/Hz)	4.52×10^{-6} (g^2/Hz)
250-750	-1.61 (dB/oct)	-6.55 (dB/oct)	-10.84 (dB/oct)	-7.94 (dB/oct)	-6.84 (dB/oct)
750	0.055 (g^2/Hz)	1.69×10^{-6} (g^2/Hz)	6.85×10^{-5} (g^2/Hz)	1.99×10^{-7} (g^2/Hz)	3.72×10^{-7} (g^2/Hz)
750-2000	-3.43 (dB/oct)	-6.55 (dB/oct)	-10.84 (dB/oct)	-7.94 (dB/oct)	-6.84 (dB/oct)
2000	0.018 (g^2/Hz)	2.0×10^{-7} (g^2/Hz)	2.0×10^{-6} (g^2/Hz)	1.5×10^{-8} (g^2/Hz)	4.0×10^{-8} (g^2/Hz)
OA (grms)	**9.47**	**1.93**	**5.21**	**0.36**	**0.57**

Notes:
1) Unattenuated RV levels are from Table D.3.1.2-3.
2) Bubble wrap refers to SECO 88 manufactured by Seco Industries, 6909 East Washington Blvd. Montebello, CA 90640.
3) Minicel refers to Minicel L200 manufactured by Voltek, 73 Shepard St. Lawrence, MA 01843.
4) Zotek refers to Zotek F30 distributed by Zotefoams, 55 Precision Dr. Walton, KY 41094, Ref. Tables I.3-2 & I.3-3.
5) Pyrell refers to Pyrell#2 manufactured by Foamex, 1500 E. 2nd St. Eddystone, PA 19022.
6) Nomex refers to HT90-40 manufactured by Stern & Stern Industries, 188 Thacher St., Hornell, NY 14843.

TABLE D.3.1.2-3 RANDOM VIBRATION ENVIRONMENT FOR LAUNCH FOR PAYLOADS NOT PACKED IN FOAM

FREQUENCY	FATIGUE LEVEL[1]	STRENGTH LEVEL
20 Hz	0.057 g^2/Hz	0.020 g^2/Hz
50 Hz	0.057 g^2/Hz	0.020 g^2/Hz
100 Hz	0.057 g^2/Hz	0.029 g^2/Hz
120 Hz	0.061 g^2/Hz	0.031 g^2/Hz
200 Hz	0.071 g^2/Hz	0.050 g^2/Hz
500 Hz	0.071 g^2/Hz	0.050 g^2/Hz
1000 Hz	0.035 g^2/Hz	0.025 g^2/Hz
2000 Hz	0.018 g^2/Hz	0.013 g^2/Hz
Composite	9.02 g root mean square (rms)	7.46 grms
Duration	60 seconds	Not Applicable

Notes:
1) A fatigue exponent of 4 was used in all equivalent fatigue level computations.
2) Criteria are the same for all directions (X, Y, Z).

D.3.2 ELECTRICAL INTERFACE REQUIREMENTS

D.3.2.1 ELECTROMAGNETIC INTERFERENCE FOR TRANSPORT VEHICLES

The payload with battery-powered EPCE which is planned to be energized when stowed on transport vehicles **shall** meet the EMI RE02 limits shown in Figure D.3.2.1-1 and Table D.3.2.1-1. EPCE that launch in an energized state for the purpose of retaining memory only are considered to be compliant with this requirement.

Note: This limit is a composite of Russian and non-Russian launch vehicle limits. Showing compliance to this limit will afford the payload the latitude to fly on any of the current launch vehicles. However, the payload is still required to comply with the launch vehicle specific IDD requirements and any non-compliances must be reviewed against the applicable IDD.

Note: The payload launching with batteries installed can still claim this requirement is not applicable as long as it has an open circuit preventing the hardware from becoming energized during any phase of launch.

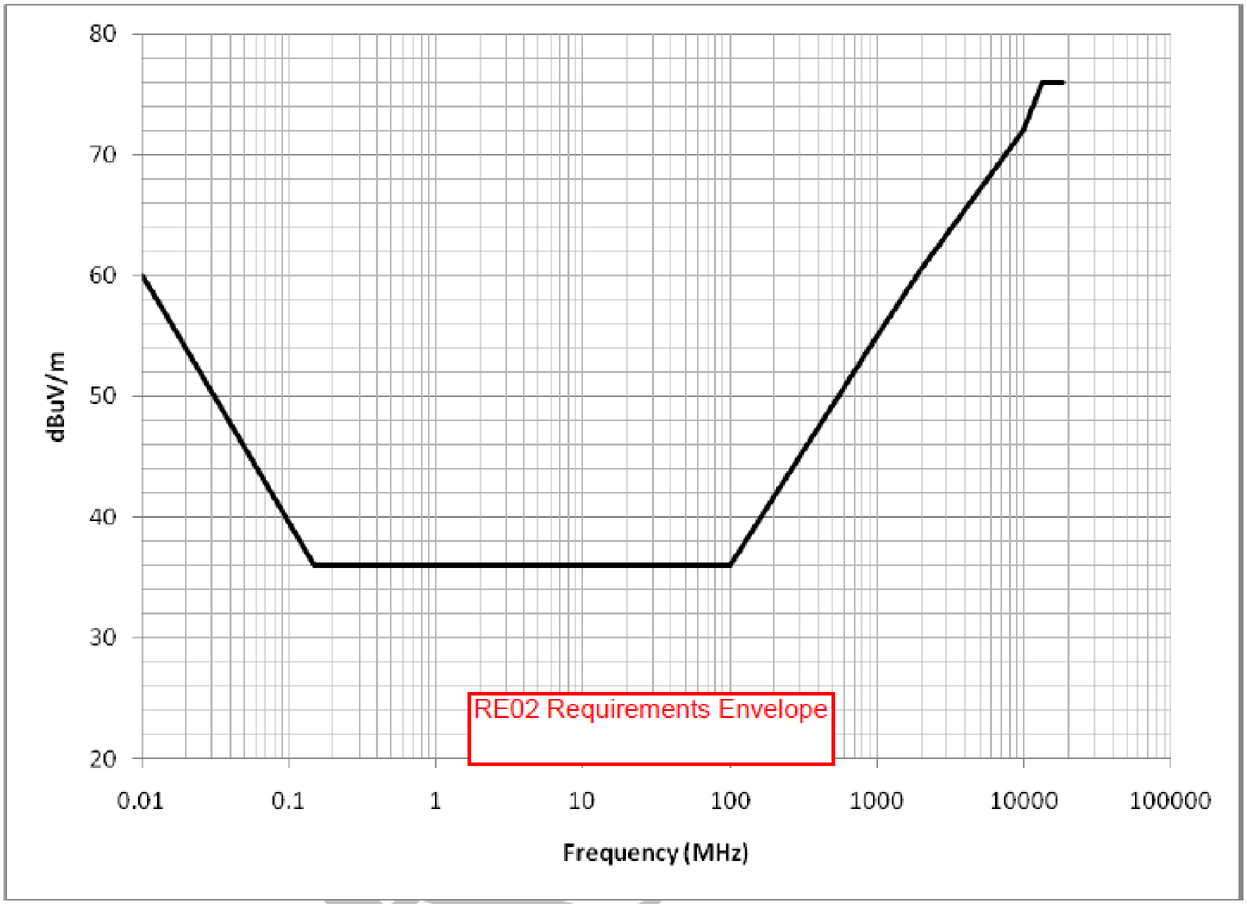


FIGURE D.3.2.1-1 LAUNCH RADIATED EMISSIONS ENVELOPE

TABLE D.3.2.1-1 LAUNCH RADIATED EMISSIONS ENVELOPE

Frequency	Emissions
0.01 MHz – 0.150 MHz	Decreasing log linearly with increasing frequency from 60 dBuV/m to 36 dBuV/m (20.4 dB per decade)[= 60-20.4·log(f/0.01) dBuV/m ;where f is frequency in MHz]
0.150 MHz - 100 MHz	36 dBµV/m
100 MHz - 2000 MHz	Increasing log linearly with increasing frequency from 36 dBuV/m to 61 dBuV/m (19 dB per decade)[= 36 + 19·log(f/100) dBuV/m ;where f is frequency in MHz]
2000 MHz - 10 GHz	Increasing log linearly with increasing frequency from 61 dBuV/m to 72 dBuV/m (16.4 dB per decade)[= 46 + 16.4·log(f/259) dBuV/m ;where f is frequency in MHz]
10 GHz - 13.5 GHz	Increasing log linearly with increasing frequency from 72 dBuV/m to 76 dBuV/m (30.7 dB per decade)[=72 + 30.7·log(f/10) dBuV/m ;where f is frequency in GHz]
13.5 GHz - 18.2 GHz	76 dBµV/m

D.3.2.2 DC MAGNETIC FIELDS FOR RUSSIAN TRANSPORT VEHICLES

Data Deliverable: Provide data showing the maximum distance at which the DC magnetic field is equal to 1 oersted (79.58 A/m) for payloads launching or returning (including destructive re-entry flights) on a Russian vehicle and containing devices that intentionally generate magnetic fields (electromagnets and permanent magnets). This must be performed for each magnetic field source in the payload. The distance must be measured on all six sides, from a point on the enclosure of the equipment case nearest to source of the field.

Note 1: The term “intentionally generate” is intended to exclude devices that have very low magnetic fields as part of their natural material properties (i.e. any object made of iron) or as an unintended by-product of their operations (i.e. EMI filter inductor core).

Note 2: The data is needed in order to allow the vehicle integrator to stow hardware away from GN&C systems and other sensitive equipment.

D.3.3 COMMAND AND DATA HANDLING INTERFACE REQUIREMENTS

N/A

D.3.4 PAYLOAD NTSC VIDEO INTERFACE REQUIREMENTS

N/A

D.3.5 THERMAL CONTROL INTERFACE REQUIREMENTS

Thermal expansion of ITCS fluid in the payload cooling systems during transport is addressed in 3.5.1.2.A.

D.3.6 VACUUM SYSTEM REQUIREMENTS

N/A

D.3.7 PRESSURIZED GASES INTERFACE REQUIREMENTS

The pressurized gas systems requirement is addressed in paragraph 3.7.5.

D.4.0 VERIFICATION

D.4.1 RESPONSIBILITIES

The PD is responsible for providing verification for all applicable requirements in this appendix, as allocated to the payload through the payload unique ICD. The ISS Program is responsible for review and approval of the submitted verification.

D.4.2 VERIFICATION METHODS

Compliance with the requirements stated in Section D.3 are proven using one or more of the methods described in paragraph 4.2.

D.4.3 COMMON TRANSPORT FOR SOFT STOWED PAYLOADS INTERFACE VERIFICATION REQUIREMENTS

D.4.3.1 STRUCTURAL/MECHANICAL INTERFACE REQUIREMENTS

D.4.3.1.1 ACCELERATION LOADS

An analysis **shall**/*should* be performed to show that the payload maintains positive margins of safety after exposure to the launch and landing acceleration loads as defined in paragraph D.3.1.1. This analysis **shall**/*should* follow the guidelines provided in SSP 52005 for ISS payload hardware. The verification **shall**/*should* be considered successful when the analysis report shows that the payload maintains positive margins of safety.

Verification Submittal: Analysis Report

D.4.3.1.2 RANDOM VIBRATION ENVIRONMENTS FOR PAYLOADS PACKED IN FOAM OR BUBBLE WRAP INSIDE HARD CONTAINERS OR SOFT CONTAINERS

A test or analysis **shall**/*should* be performed to show that the payload meets the specified performance requirements after exposure to the design random vibration environment for launch as defined in paragraph D.3.1.2. The payload **shall**/*should* be qualification and acceptance tested as described in SSP 52005. The verification **shall**/*should* be considered successful when the payload is shown to be fully functional after the random vibration testing is completed.

Verification Submittal: Test Report or Analysis Report

D.4.3.2 ELECTRICAL INTERFACE REQUIREMENTS

D.4.3.2.1 ELECTROMAGNETIC INTERFERENCE FOR TRANSPORT VEHICLES

Verification that the Electromagnetic Interference of the payload with battery-powered EPCE which draws power when stowed on transport vehicles **shall** be verified by test and analysis. Tests **shall** be performed and data submitted for radiated emissions (RE02).This data **shall** be evaluated against the limits in paragraph D.3.2.1. The test results **shall** be documented in the EMI test plan/report. The verification **shall** be considered successful when the results show requirements of paragraph D.3.2.1 are met.

The EMI test methods **shall** be as specified in SSP 30238.

Note 1: EPCE that launch in an energized state for the purpose of retaining memory only are considered to be compliant with this requirement and are not required to submit verification.

Note 2: EPCE that has intentional transmitters/receivers is considered to be energized and must submit verification, even when launched in a “standby” or “off’ state.

Verification Submittal: Test Report

D.4.3.2.2 DC MAGNETIC FIELDS FOR RUSSIAN TRANSPORT VEHICLES

<u>Data Deliverable</u>

D.4.3.3 COMMAND AND DATA HANDLING INTERFACE REQUIREMENTS

N/A

D.4.3.4 PAYLOAD NTSC VIDEO INTERFACE REQUIREMENTS

N/A

D.4.3.5 THERMAL CONTROL INTERFACE REQUIREMENTS

Verification of thermal expansion of ITCS fluid in the payload cooling systems during transport is addressed in 4.3.5.1.2.A.

D.4.3.6 VACUUM SYSTEM REQUIREMENTS

N/A

D.4.3.7 PRESSURIZED GASES INTERFACE REQUIREMENTS

The pressurized gas systems verification requirement is addressed in paragraph 4.3.7.5.

D.5.0 OPTIONAL PROCESS TO ELIMINATE VERIFICATION OF LAUNCH REQUIREMENTS AND DESCENT REQUIREMENTS

If the payload is willing to accept the risk to mission success and it meets the criteria below, then it can choose to forego verification to launch and descent vehicle requirements in Appendix D and does not have to document those requirements in a NASA ICD. If the payload does not meet any one of the criteria below, additional launch and descent vehicle requirements must be addressed. If the payload meets the criteria only for launch, the launch vehicle requirements may be eliminated. If the payload meets the criteria only for descent, the descent vehicle requirements may be eliminated. The payload must still go through the payload safety process and show that the payload is safe. This process does not apply for sortie payloads.

- The PD agrees that the payload does not have any safety-critical structures per SSP 52005 (e.g., hard mounted, containers storing pressurized gasses or liquids over 100 psi, high energy rotating/articulating machinery, lines, fittings and components of pressurized systems, uncontained glass, mechanisms used to control a hazard, or any reason to be considered a Safety-Critical Structure), for the transportation and on-orbit phases.
- The PD agrees that the payload item is unpowered (including battery powered) during launch or descent. (Does not apply to small batteries that are only used to retain memory.)
- The PD agrees that the payload does not have any items (including magnets) that produce magnetic fields during launch or descent.
- The PD agrees that the payload does not go into cold stowage during the launch phase or the descent phase. (Does not apply to cold stowage hardware items at ambient temperature during launch or descent.)

- The PD agrees that the payload is not being transported charged with ITCS fluid.

Items that meet all of these criteria will be listed in the payload hardware identification table of the payload unique NASA ICD as “meets launch requirement and descent requirement elimination criteria per SSP 57000 Section D.5.0”. The PD accepts the risk to mission success of not providing verification.

APPENDIX E

COMMON TRANSPORT REQUIREMENTS FOR HARD MOUNTED MIDDECK LOCKER EQUIVALENT PAYLOADS

APPENDIX E - COMMON TRANSPORT REQUIREMENTS FOR HARD MOUNTED MIDDECK LOCKER EQUIVALENT PAYLOADS

E.1.0 INTRODUCTION

E.1.1 PURPOSE

This section provides requirements, guidelines and data deliverables for hard mounted middeck locker equivalent payloads in transportation vehicles

E.1.2 SCOPE

This appendix addresses hard mounted middeck locker equivalent payloads, powered or unpowered, in transportation vehicles including Dragon and Cygnus.

E.1.3 USE

These requirements, guidelines and data deliverables are applied to hard mounted payloads in addition to the general requirements, guidelines and data deliverables in Section 3.0 and are allocated to a payload through the payload unique ICD. The PD and the ISS Program must jointly agree on the interfaces and identify requirements as applicable if the interface exists, and not applicable if the interface does not exist for the payload configuration documented in the ICD.

Because the transport vehicle interfaces for powered MLE payloads were required to provide the same interfaces as the EXPRESS Rack, there are several instances in this Appendix E where there are pointers to the interface requirements in the EXPRESS Rack Appendix F which the payload will need to meet to be compatible with the transport vehicle interface. The intent of this is to provide the PD common requirements, and allow one verification to satisfy both the transport vehicle interface and the EXPRESS Rack interface.

E.2.0 DOCUMENTATION

See Section 5.0.

E.3.0 COMMON TRANSPORT HARD MOUNTED MIDDECK LOCKER EQUIVALENT PAYLOADS INTERFACE REQUIREMENTS

E.3.1 STRUCTURAL/MECHANICAL INTERFACES

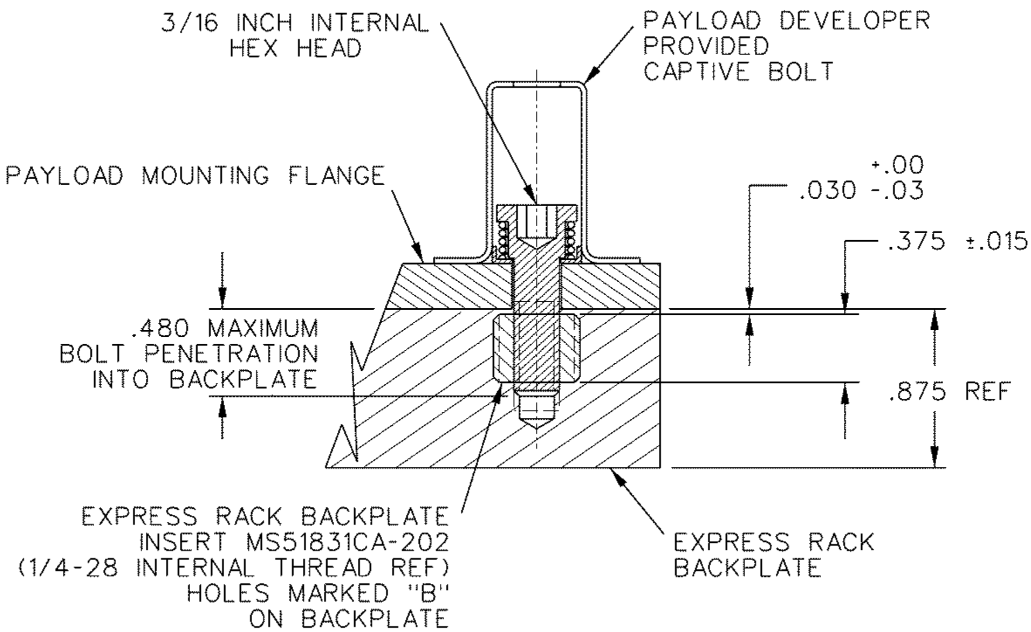
E.3.1.1 MOUNTING PLATE

The middeck locker equivalent (MLE) payload **shall** be compatible with the mechanical interfaces defined in Figure F.3.1.2.1-1.

E.3.1.2 PAYLOAD ATTACHMENT POINTS

The attachment points on the payload mounting structure for securing to the transport vehicle **shall** be designed per Figure E.3.1.2-1.

Note: It is recommended that the (1/4-28) threaded inserts be utilized in lieu of the sleeve bolt receptacle attachment points (reference Figure F.3.1.2.1-1) when the additional load carrying capability is required.



DIMENSIONS ARE IN INCHES

FIGURE E.3.1.2-1 PAYLOAD ATTACHMENT POINT DETAILS (PART 1 OF 2)

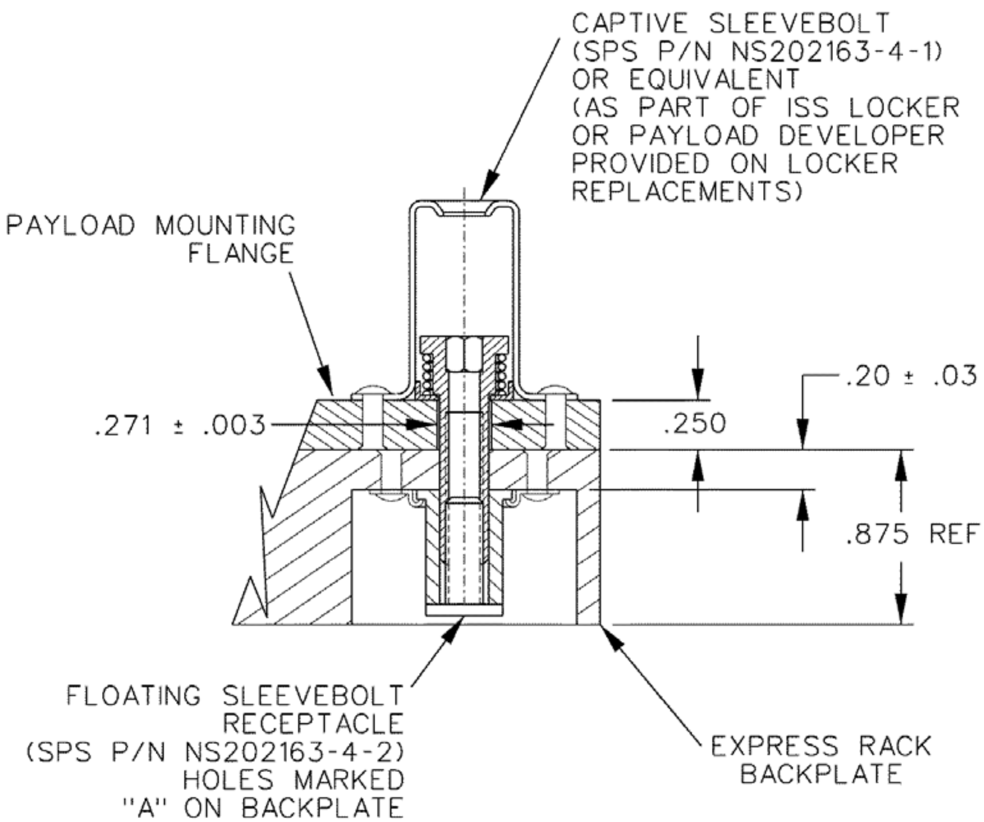


FIGURE E.3.1.2-1 PAYLOAD ATTACHMENT POINT DETAILS (PART 2 OF 2)

E.3.1.3 SINGLE MIDDECK LOCKER EQUIVALENTS

A. The dimensions of the single MLE **shall** be within the following limits:

Length: 24.6 inches (Reference Figure F.3.1.2.1-1), including Dragon connector length defined in Figure E.3.1.3-1

Width: 18.125 inches (Reference Appendix F, Figures F.3.1.2.4-1, F.3.1.2.4-2 and F.3.1.2.4-3)

Height: 10.757 inches (Reference Appendix F, Figures F.3.1.2.4-1, F.3.1.2.4-2 and F.3.1.2.4-3)

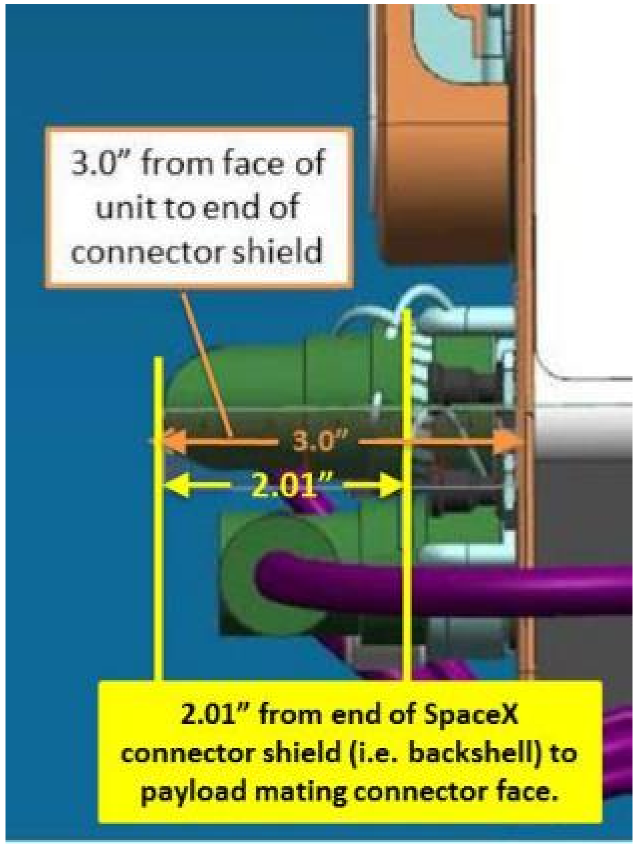


FIGURE E.3.1.3-1 DRAGON MATING CONNECTORS TO POWERED MLE

B. The single MLE payload **shall** meet the mass-to-CG relationship listed in Table E.3.1.3-1.

TABLE E.3.1.3-1 SINGLE MLE MAXIMUM MASS AND CENTER OF GRAVITY LIMITS

X_{CG} (Inches from Base Attach Plate)	Allowable Mass (lbm/kg, with Y_{CG} and Z_{CG} within 3 inches of center axis)
14	51/23
13	55/25
12	60/27
11	65/29
0 to 10	72/32.66

Notes:
1. X_{CG} is measured from the backplate mounting surface. The Y_{CG} and Z_{CG} location is measured from the geometric center of the payload interface envelope.
2. Radius applies to Y_{CG} and Z_{CG} locations.
3. The 14 inch X_{CG} is the maximum.
4. These limits are for launch and landing (i.e., transportation). Once on-orbit, these restrictions do not apply.
5. Allowable mass includes mounting hardware and adapter plate mass, but does not include power and data cable mass.
6. Mass of the empty ISS-supplied single locker is 11.40 lbs (± 0.40 lbs). This does not include door panels or internal close-out cover. (Component mass information is shown in Table F.3.1.2.4-1).The CG of the empty ISS-supplied single locker (internal close-out cover and door panels not installed) is X=10.32 inches (± 0.15 inches), Y= 9.05 inches (± 0.15 inches), Z= 5.36 inches (± 0.15 inches). The origin of the coordinate system is located at the lower left corner of the rear plate. The X-axis is positive toward the front of the locker. The Y-axis is positive toward the right panel of the locker. The Z-axis is positive toward the top panel of the locker.
7. 72 lbs (32.66 kg) is the maximum allowable mass.

C. Single MLE payload components hard mounted during launch and return flight events **shall** have a first natural frequency equal to or exceeding 30 Hz with respect to the vehicle attachment interface.

E.3.1.4 DOUBLE MIDDECK LOCKER EQUIVALENTS

A. The dimensions of the double MLE **shall** be within the following limits:

Length: 24.6 inches, including Dragon connector length defined in Figure E.3.1.3-1

Width: 18.125 inches (Reference Appendix F, Figures F.3.1.2.4-1, F.3.1.2.4-2 and F.3.1.2.4-3)

Height: 21.882 inches (Figure E.3.1.1-1)

B. The double MLE payload **shall** meet the mass-to-CG relationship listed in Table E.3.1.4-1.

TABLE E.3.1.4-1 DOUBLE MLE MAXIMUM MASS AND CENTER OF GRAVITY LIMITS

X_{CG} (Inches from Base Attach Plate)	Allowable Mass (lbm/kg, with Y_{CG} and Z_{CG} within 3 inches of center axis)
14	100/45
13	107/49
12	116/53
11	127/58
0 to 10	140/64

Notes:

1. X_{CG} is measured from the backplate mounting surface. The Y_{CG} and Z_{CG} location is measured from the geometric center of the payload interface envelope.
2. Radius applies to Y_{CG} and Z_{CG} locations.
3. The 14 inch X_{CG} is the maximum.
4. These limits are for launch and landing (i.e., transportation). Once on-orbit, these restrictions do not apply.
5. Allowable mass includes mounting hardware and adapter plate mass, but does not include power and data cable mass.
6. 140 lbs (64 kg) is the maximum Allowable Mass.

C. Double MLE payload components hard mounted during launch and return flight events **shall** have a first natural frequency equal to or exceeding 30 Hz with respect to the vehicle attachment interface.

E.3.1.5 LAUNCH ACCELERATION LOADS

The payload launching on visiting vehicles **shall** maintain positive margins of safety when exposed to the launch acceleration load factors documented in Table E.3.1.5-1 at the CG of the item, with all six degrees of freedom acting simultaneously. Refer to SSP 52005 for guidelines.

TABLE E.3.1.5-1 ACCELERATION LOADS FOR LAUNCH ON VISITING VEHICLES

Nx (g)	Ny (g)	Nz (g)	Rx (rad/sec^2)	Ry (rad/sec^2)	Rz (rad/sec^2)
±7.0	± 4.0	± 4.0	N/A	N/A	N/A

Notes:
Load factors assume that the payload has 85% of its modal effective mass below 100 Hz. If this is not the case, the payload must combine these load factors with loads induced from random vibration to determine worst-case design loads.
The reference frame for the load factors with respect to the directions of motion is as follows:

1. X: The longitudinal axis of the visiting vehicle. Positive x-axis extends from the base or bottom of the vehicle to the nose of the vehicle
2. Y: Y-axis completes the right-handed coordinate system
3. Z: Positive z-axis completes the right-handed coordination system

E.3.1.6 RETURN ACCELERATION LOADS

The payload returning on visiting vehicles **shall** maintain positive margins of safety when exposed to the return acceleration load factors documented in Table E.3.1.6-1 at the CG of the item, with all six degrees of freedom acting simultaneously.

TABLE E.3.1.6-1 ACCELERATION LOADS FOR RETURN ON VISITING VEHICLES

Axial Bias			Lateral Bias		
Axial	**Lateral**	**Ax/Lat RSS**	**Axial**	**Lateral**	**Ax/Lat RSS**
± 9.2	± 1.8	± 9.4	± 1.4	± 9.3	± 9.4

Notes:
1. The load factors shown are limit loads which include a Model Uncertainty Factor (MUF) of 1.25.
2. Lateral loads must be applied in all or worst-case lateral directions.
3. The reference frame for the load factors with respect to the direction of motion is as follows:
   X: The longitudinal axis of the visiting vehicle. Positive x-axis extends from the base or bottom of the vehicle to the nose of the vehicle.
   Y: Y-axis completes the right-handed coordinate system
   Z: Positive Z-axis completes the right-handed coordinate system.
4. Recovery boat limit loads are ±2.5 in all directions.
5. All return loads do not need to be combined with random vibration environments to determine the worst-case design load because the random vibration environment is minimal during return.

E.3.1.7 LAUNCH RANDOM VIBRATION ENVIRONMENTS

The payload launching on visiting vehicles **shall** maintain positive margins of safety after exposure to the maximum predicted random vibration environment for launch as defined in Table E.3.1.7-1 and Figure E.3.1.7-1.

TABLE E.3.1.7-1 LAUNCH RANDOM VIBRATION ENVIRONMENT FOR THE MLE PAYLOAD

FREQUENCY (Hz)	MPE (g^2/Hz)
20	0.0250
30	0.0250
40	0.0150
66	0.0150
70	0.0181
500	0.0181
700	0.0059
800	0.0055
1200	0.0055
2000	0.0025
GRMS	4.07
Duration	60 seconds/axis

Notes:
1. Criteria are the same for all directions (X, Y, Z).
2. Environment presented is a Maximum Predicted Environment (MPE) which includes 4.9 dB margin for variability.

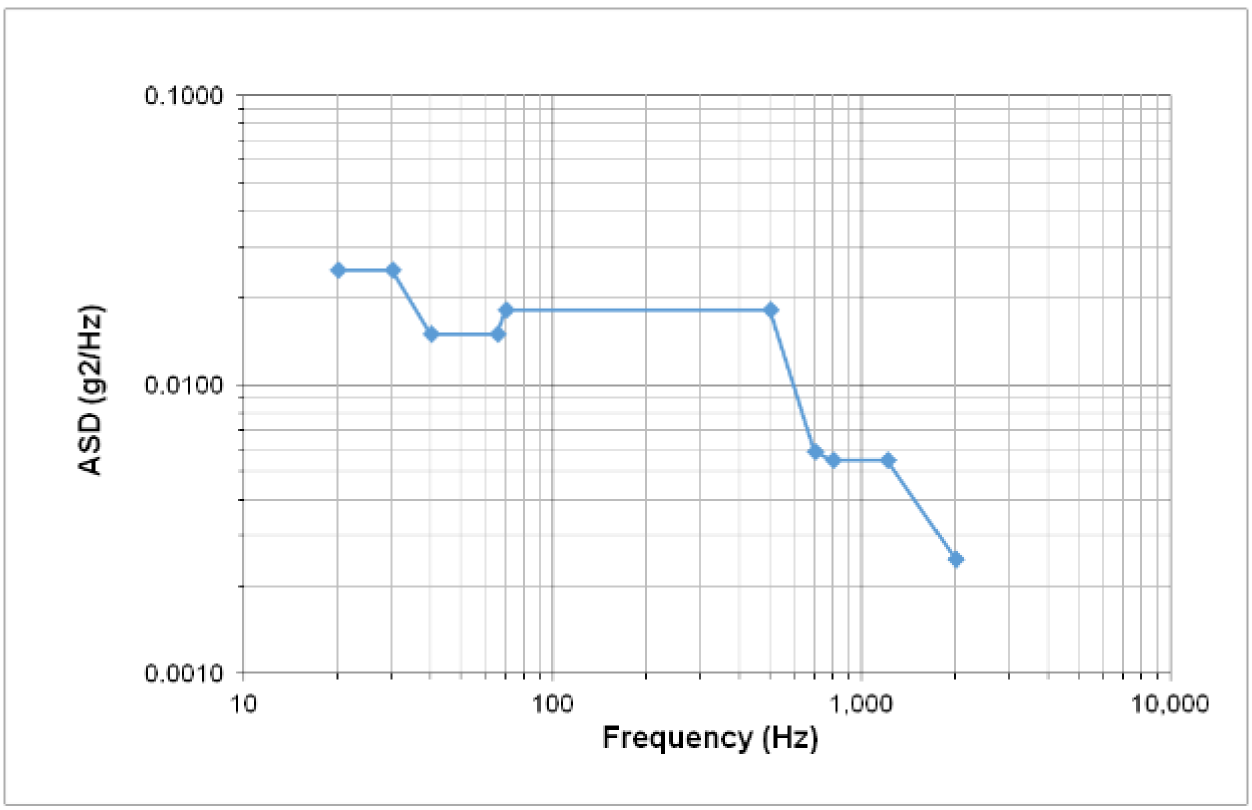


FIGURE E.3.1.7-1 LAUNCH RANDOM VIBRATION ENVIRONMENT FOR THE MLE PAYLOAD

E.3.1.8 RETURN RANDOM VIBRATION ENVIRONMENTS

The payload returning on visiting vehicles **shall** maintain positive margins of safety after exposure to the maximum predicted random vibration environment for return as defined in Table E.3.1.8-1 and Figure E.3.1.8-1.

TABLE E.3.1.8-1 RETURN RANDOM VIBRATION ENVIRONMENT FOR THE MLE PAYLOAD

FREQUENCY (Hz)	MPE (g^2/Hz)
20	0.0055
1200	0.0055
2000	0.001
Grms	2.9
Duration	60 seconds/axis

Notes:

1. Criteria are the same for all directions (X, Y, Z).
2. Environment presented is a MPE which includes 4.9 dB margin for variability.
3. Return environments include all re-entry and descent events except for transient events such as drogue deploy and splashdown. Those environments are not considered random vibration events and are covered in the loads and/or shock sections.
4. Random vibration environments during recovery (boat) operations, ground handling and shipment to the cargo processing facility (truck) are expected to be low and are enveloped by return environments in Table E.3.1.8-1.

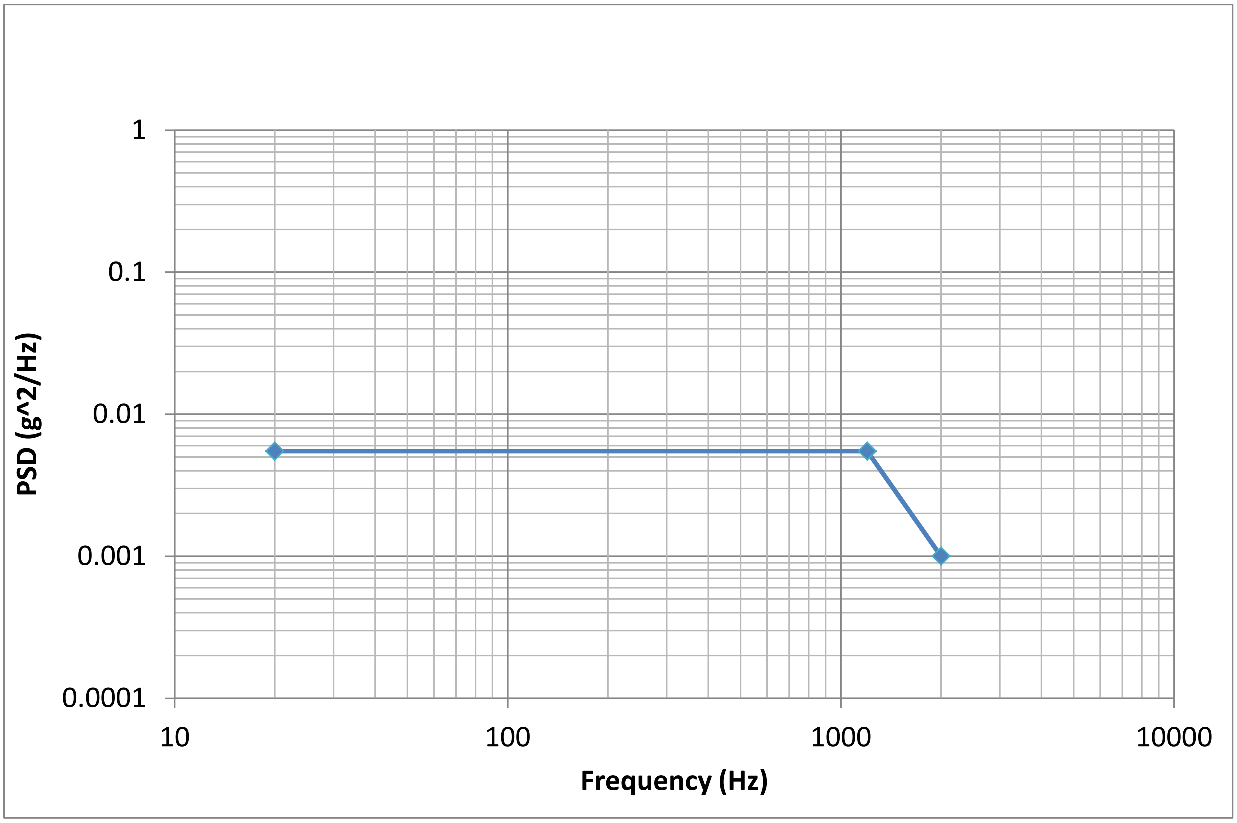


FIGURE E.3.1.8-1 RETURN RANDOM VIBRATION ENVIRONMENT FOR POWERED MLE

E.3.1.9 LAUNCH LOAD SPECTRUM

The payload **shall** retain sufficient life after being subjected to the launch load spectrum documented in Table E.3.1.9-1. Loads do not apply to a payload in a foam insert in a locker.

TABLE E.3.1.9-1 LAUNCH LOAD SPECTRUM

Load Step Number	Cycles/Flight	Cyclic Stress (% Limit value)	
		Minimum	Maximum
1	13	-100	100
2	13	-90	90
3	24	-80	80
4	59	-70	70
5	115	-60	60
6	321	-50	50
7	641	-40	40
8	3120	-30	30
9	3405	-20	20
10	125,537	-10	10

E.3.1.10 PAYLOAD LAUNCH AND LANDING CONFIGURATION

Data Deliverable: Provide a launch and landing configuration of the payload hardware, including the following:

- Clear depiction of the Display and Control Panel, identifying payload interfaces and control features with proper nomenclature.
- Unique customer-defined torque sequences or patterns.

E.3.1.11 DEPRESSURIZATION/REPRESSURIZATION RATES

Payloads with safety-critical structures **shall** maintain positive margins of safety and not create a hazard during or after exposure to a depressurization rate of 0.890 kPa/second (7.75 psi/minute) and a repressurization rate of 0.800 kPa/second (6.96 psi/min).

E.3.2 ELECTRICAL INTERFACE REQUIREMENTS

E.3.2.1 ELECTRICAL POWER CHARACTERISTICS AND INTERFACES

E.3.2.1.1 INTERFACE VOLTAGE LEVELS

The MLE powered payload **shall** operate properly with the interface voltage levels at +28 Vdc +1.5 to -2.5 Vdc, as shown in Figure F.3.2.1.1-1.

E.3.2.1.2 28 VDC POWER

A. The single MLE powered payload **shall** be operable on 75 W or less at +28 Vdc.

B. The double MLE powered payload **shall** consume 150 W or less at +28 Vdc.

E.3.2.1.3 REVERSE CURRENT

Powered MLE payloads **shall** meet the reverse current requirement per paragraph F.3.2.1.3.

E.3.2.1.4 REVERSE ENERGY

Powered MLE payloads **shall** meet the reverse energy requirement per paragraph F.3.2.1.4.

E.3.2.1.5 CURRENT LIMITING

Powered MLE payloads **shall** meet the current limiting requirement per paragraph F.3.2.1.7.B.

E.3.2.1.6 ON-ORBIT TRANSFER

The payload requiring on-orbit transfer *should* be designed to withstand up to 30 minutes without vehicle supplied power.

E.3.2.1.7 VEHICLE SUPPLIED POWER

Permanent or temporary loss of launch vehicle supplied power to the payload during on-orbit operation **shall** not result in the payload producing an unsafe or hazardous condition.

E.3.2.1.8 CONNECTOR/PIN INTERFACES

The payload **shall** meet the connector/pin interfaces requirements listed in Table E.3.2.1.8-1.

TABLE E.3.2.1.8-1 CONNECTOR/PIN INTERFACES REQUIREMENTS

SSP 57000 Requirement	Title/Subject
F.3.2.1.10.A	CONNECTOR/PIN INTERFACES
F.3.2.1.10.B	CONNECTOR/PIN INTERFACES

E.3.2.2 ELECTROMAGNETIC COMPATIBILITY (EMC)

Electromagnetic compatibility for powered MLE payloads is addressed with general requirements 3.2.1.4, Electrical Grounding, 3.2.2.8, Electrical Bonding, and 3.2.2, Electromagnetic Compatibility requirements applicable to the payload.

E.3.2.3 DRAGON VEHICLE SPECIFIC REQUIREMENTS

For Dragon powered MLE payloads, both the power connector on the MLE payload and the data connector on the MLE payload **shall** be clocked at 12 o’clock relative to the MLE payload. This means that the master key on both connectors is pointed towards the top of the MLE. Note that the mating power and data connectors from Dragon are orientated at 12 o’clock and 6 o’clock, respectively, so that the cables do not interfere with each other. Figure E.3.2.3-1 shows the orientation of the Dragon connectors for the maximum number of powered MLEs.

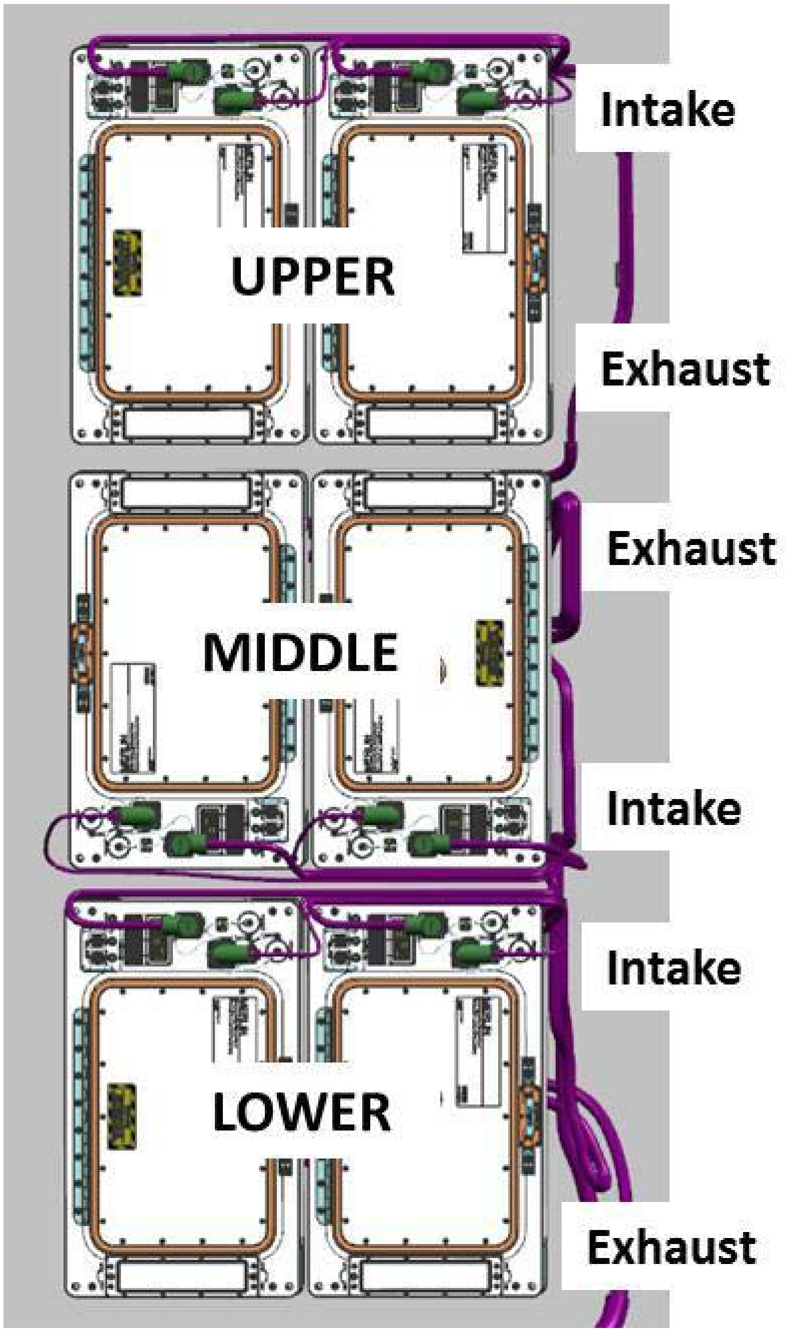


FIGURE E.3.2.3-1 DRAGON LAUNCH AND LANDING ORIENTATION OF POWERED MLE WITH DUCTING INTERFACES

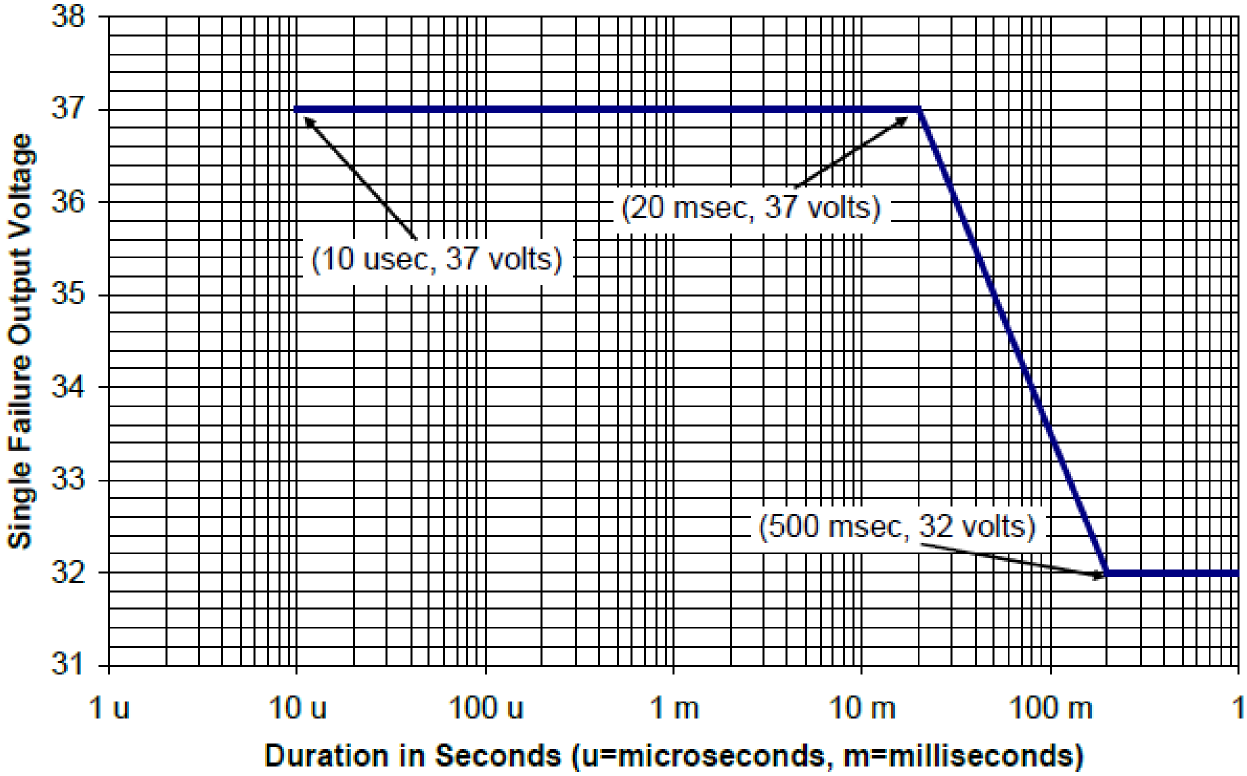
E.3.2.4 CYGNUS VEHICLE SPECIFIC REQUIREMENTS

A. Once activated, Cygnus MLE payload power can be commanded off and on as required, either from the Cygnus GSE, Launch Control Center, or Mission Control Center at Dulles. This power is provided through a European standard connector (SCC Component Number 3401007BDFE5714-4SN with SCC Component Number 340100912B sockets) as shown in Figure E.3.2.4-1, Cygnus MLE Power Connector. This connector interfaces to NASA standard payload connector NB0E14-4PNT.

Note: Power to payloads will be removed in the event that smoke is detected in the cabin atmosphere.

FIGURE E.3.2.4-1 CYGNUS MLE POWER CONNECTOR

B. Cygnus MLE 28 V loads **shall** be compatible with exposure to abnormal voltages within the envelope shown in Figure E.3.2.4-2, Cygnus Abnormal Input Voltage Envelope.



Note: Duration is the amount of time that the input voltage is above the cross-indexed value. There is no power quality requirement for the duration less than 10 microseconds. For purposes of this document, compatibility is defined as operating without producing an unsafe condition or one that could result in damage to the vehicle equipment or payload hardware.

FIGURE E.3.2.4-2 CYGNUS ABNORMAL INPUT VOLTAGE ENVELOPE

C. Cygnus MLE 28 V loads **shall**, at each frequency between 200 Hz and 20 kHz, have either input impedance magnitude greater than the limit indicated or input impedance phase within the limits indicated in Figure E.3.2.4-3.

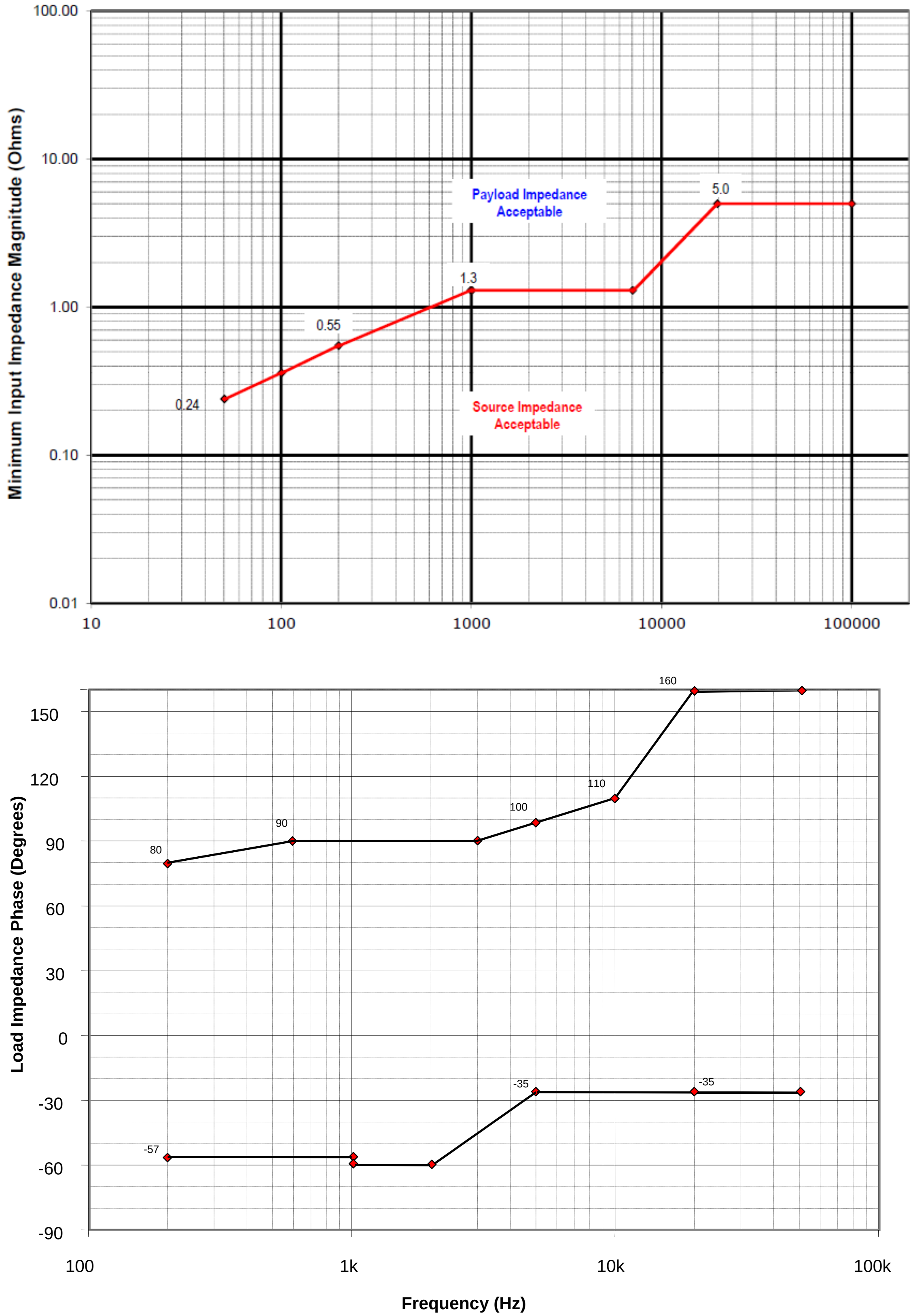


FIGURE E.3.2.4-3 CYGNUS INPUT IMPEDANCE ENVELOPE FOR 28 V MLE LOADS

D. Cygnus MLE 28 V loads **shall** limit the load transient input current such that the integral of the input current in excess of the load rating is less than 0.02 ampere-seconds (A·s). This requirement can be expressed by the following equation:

$$\int [(\text{Load Input Current}) - (\text{Load Current Rating})]dt <= 0.02 \text{ A}\cdot\text{s}$$

evaluated over the time interval that Load Input Current > Load Current Rating

E. Cygnus MLE 28 V loads **shall** power on as expected when the input voltage rate of rise is 5,000 volts per second (V/s) and faster.

F. Cygnus MLE 28 V loads **shall** limit the reverse EMF generated by the load and imposed on the upstream power system so that the voltage rise at the load input does not exceed 2 V for more than 10 μs.

E.3.3 COMMAND AND DATA HANDLING INTERFACE REQUIREMENTS

A. The payload **shall** meet the C&DH requirements listed in Table E.3.3-1.

TABLE E.3.3-1 C&DH REQUIREMENTS

SSP 57000 Requirement	Title/Subject
I.3.8.3.1	SIGNAL CHARACTERISTICS
I.3.8.7.3.6.1.C	PAYLOAD HEALTH AND STATUS DATA – ECW (1ST WORD)
I.3.8.7.3.6.2.A	PAYLOAD HEALTH AND STATUS DATA – H&S CYCLE COUNTER (2ND WORD)
I.3.8.7.3.6.2.B	PAYLOAD HEALTH AND STATUS DATA – H&S CYCLE COUNTER (2ND WORD)
I.3.8.7.3.6.2.C	PAYLOAD HEALTH AND STATUS DATA – H&S CYCLE COUNTER (2ND WORD)
I.3.8.7.3.6.2.D	PAYLOAD HEALTH AND STATUS DATA – H&S CYCLE COUNTER (2ND WORD)

B. The payload *should* meet the C&DH requirements listed in Table E.3.3-2.

TABLE E.3.3-2 C&DH REQUIREMENTS

SSP 57000 Requirement	Title/Subject
I.3.8.1.1	MLE/MLE REPLACEMENT PAYLOAD
I.3.8.3.2	COMMUNICATIONS PROTOCOL
I.3.8.7.3.6.1.A	PAYLOAD HEALTH AND STATUS DATA – ECW (1ST WORD)
I.3.8.7.3.6.1.B	PAYLOAD HEALTH AND STATUS DATA – ECW (1ST WORD)
I.3.8.7.3.6.3	PAYLOAD HEALTH AND STATUS DATA – PAYLOAD MESSAGE (3RD TO 92ND WORD)
I.3.8.7.3.6.3.1.A	PAYLOAD MESSAGE COUNTER (FIRST BYTE OF PAYLOAD MESSAGE)
I.3.8.7.3.6.3.1.B	PAYLOAD MESSAGE COUNTER (FIRST BYTE OF PAYLOAD MESSAGE)
I.3.8.7.3.6.3.1.C	PAYLOAD MESSAGE COUNTER (FIRST BYTE OF PAYLOAD MESSAGE)
I.3.8.7.3.6.3.1.D	PAYLOAD MESSAGE COUNTER (FIRST BYTE OF PAYLOAD MESSAGE)
I.3.8.7.3.6.3.2	PAYLOAD MESSAGE IDENTIFIER

E.3.4 PAYLOAD NTSC VIDEO INTERFACE REQUIREMENTS

N/A

E.3.5 THERMAL CONTROL INTERFACE REQUIREMENTS

E.3.5.1 INLET AND OUTLET LOCATION INTERFACES

Inlet and outlet locations for the air cooled payload **shall** meet the interfaces per Figure F.3.1.2.1-1.

E.3.5.2 HEAT LOAD

The powered MLE payload heat load at the payload air outlet **shall** not exceed 75 W for single MLE or 150 W for double MLE.

Note: The design value for the convective heat transfer coefficient from the payload enclosure to the cabin environment is 0.20 Btu/ hr °F ft^2 for 14.7 psia.

E.3.5.3 AIR EXCHANGE

The powered MLE payload **shall** only exchange air with the cabin for metabolic purposes.

Note: All front breathers manifested in Dragon will be worked through task orders and the unique ICD process.

E.3.5.4 CABIN AND AAA AIR MIXING LIMITATIONS

Powered MLE payloads exchanging air with the cabin and using avionic air cooling *should* meet the cabin and AAA air mixing limitations per paragraph F.3.5.11.

E.3.5.5 PAYLOAD LIMITATIONS ON HEAT CONVECTED OR RADIATED TO CABIN AIR

Rejection of heat from the sides and front of a payload to the cabin air by convection and radiation *should* be limited to ten (10) percent of the payload’s total heat load.

E.3.5.5.1 FANS

Powered MLE payloads *should* provide their own fan for drawing air from the transport vehicle’s cooling system.

E.3.6 VACUUM SYSTEM REQUIREMENTS

N/A

E.3.7 PRESSURIZED GAS SYSTEMS REQUIREMENTS

The pressurized gas systems requirement is addressed in paragraph 3.7.5.

E.3.8 PAYLOAD SUPPORT SERVICES INTERFACE REQUIREMENTS

N/A

E.3.9 ENVIRONMENT INTERFACE REQUIREMENTS

E.3.9.1 PRESSURE

MLE powered payloads **shall** be compatible with all interface requirements when exposed to a pressure of 13.9 to 15.2 psia. It is possible (though unlikely) that the combination of local atmospheric and facility-induced pressure may exceed 15.2 psia for periods of less than 24 hours. Payloads needing special protection from these atypical excursions will require special accommodations. For purposes of pressure interface requirements, compatibility is defined as operating without producing an unsafe condition and/or resulting in damage to hardware items or the crew.

E.3.9.2 TEMPERATURE

A. The MLE powered payload **shall** be compatible with all interface requirements when exposed to temperatures ranging from 18.3 to 29.4 °C (65 to 85 °F). For purposes of thermal interface requirements, compatibility is defined as operating without producing an unsafe condition and/or resulting in damage to hardware items or the crew.

   For all mission phases, the nominal air temperature supplied to the MLE cooling inlet is + 18.3 to + 29.4 °C (+ 65 to + 85 °F).

B. Air is nominally supplied at 18 cubic feet per minute (CFM) for a single MLE and at 36 CFM for a double MLE. However, if the complement of payloads has any unpowered lockers in powered locations, the CFM of supplied air to a single MLE location will be increased proportionally.

   The MLE powered payload **shall** be compatible with all interface requirements when exposed to an air circulation range of 18 - 36 CFM for a single MLE and 36 CFM for a double MLE at the exhaust location.

E.3.10 FIRE PROTECTION INTERFACE REQUIREMENTS

There are no unique fire protection interface requirements for payloads on transport vehicles.

E.3.11 MATERIALS AND PROCESSES INTERFACE REQUIREMENTS

General materials and processes interface requirements are addressed in section 3.11.

E.3.12 HUMAN FACTORS INTERFACE REQUIREMENTS

E.3.12.1 CONTINUOUS NOISE LIMITS

A payload which generates continuous noise levels **shall** not exceed the limits provided in Table E.3.12.1-1 for all octave bands. These levels apply to sortie and crossover payloads operating in the noisiest configuration or operating mode in the visiting vehicle.

TABLE E.3.12.1-1 CONTINUOUS NOISE LIMITS IN THE VISITING VEHICLE

Rack Noise Limits At 0.6 Meters Distance	Maximum Design Levels For Active Hardware Items
Frequency Band Hz	**MLE Payload (dB)***
63	64
125	56
250	50
500	45
1000	41
2000	39
4000	38
8000	37

*dB, re 20 μPa

E.4.0 VERIFICATION

E.4.1 RESPONSIBILITIES

The PD is responsible for providing verification for all applicable requirements in this appendix, as allocated to the payload through the payload unique ICD. The ISS Program is responsible for review and approval of the submitted verification.

E.4.2 VERIFICATION METHODS

Compliance with the requirements stated in Section E.3.0 are proven using one or more of the methods described in paragraph 4.2.

E.4.3 COMMON TRANSPORT HARD MOUNTED MIDDECK LOCKER EQUIVALENT PAYLOADS INTERFACE VERIFICATION REQUIREMENTS

E.4.3.1 STRUCTURAL/MECHANICAL INTERFACES

E.4.3.1.1 MOUNTING PLATE

Verification of payload compatibility with mechanical interfaces **shall** be by inspection of the flight hardware to show compliance with the mechanical interfaces defined in paragraph E.3.1.1. The verification **shall** be considered successful when the inspection shows the flight hardware is in compliance with mechanical interfaces.

Verification Submittal: CoC

E.4.3.1.2 PAYLOAD ATTACHMENT POINTS

Verification of payload attachment points on the payload mounting structure **shall** be by inspection of the flight hardware to show compliance with the transport vehicle interface as defined in paragraph E.3.1.2. The verification **shall** be considered successful when the inspection shows the flight hardware is in compliance with the transport vehicle interface.

Verification Submittal: CoC

E.4.3.1.3 SINGLE MIDDECK LOCKER EQUIVALENTS

A. The dimensions of the single MLE **shall** be verified by an analysis of the payload design to verify that the payload, including Dragon connector length defined in Figure E.3.1.3-1, does not violate the static envelope dimensions as defined in Appendix F, Figures F.3.1.2.4-1, F.3.1.2.4-2 and F.3.1.2.4-3. The verification **shall** be considered successful when the analysis of the payload design shows that the payload conforms to the mechanical information shown in Appendix F, Figures F.3.1.2.4-1, F.3.1.2.4-2 and F.3.1.2.4-3.

Verification Submittal: Analysis Report

B. The single MLE mass-to-CG relationship **shall** be verified by test of the actual CG of each payload element in three orthogonal axes. The coordinate system used will be clearly defined in the weight and balance report. Verification **shall** be considered successful when the test results show that the mass-to-CG relationship meets the limits in Table E.3.1.3-1.

Verification Submittal: Certified weight and balance report for each payload element and mass properties compliance assessment.

C. The first primary natural frequency of single MLE payload components **shall** be verified by analysis or analysis and test. See SSP 52005, paragraph 7.2 for information on verification by test. If the lift-off and landing configurations of the design differ, verify the primary natural frequency of each configuration is equal to or greater than 30 Hz. Verification **shall** be considered successful when the analysis or analysis and test results show that the first primary natural frequency is equal to or greater than 30 Hz.

Verification Submittal: CoC

E.4.3.1.4 DOUBLE MIDDECK LOCKER EQUIVALENTS

A. The dimensions of the double MLE **shall** be verified by an analysis of the payload design to verify that the payload, including Dragon connector length defined in Figure E.3.1.3-1 does not violate the static envelope dimensions as defined in Figure F.3.1.2.1-1 and Appendix F, Figures F.3.1.2.4-1, F.3.1.2.4-2 and F.3.1.2.4-3. The verification **shall** be considered successful when the analysis of the payload design shows that the payload conforms with the mechanical information shown in Figure F.3.1.2.1-1 and Appendix F, Figures F.3.1.2.4-1, F.3.1.2.4-2 and F.3.1.2.4-3.

Verification Submittal: Analysis Report

B. The double MLE mass-to-CG relationship **shall** be verified by test of the actual CG of each payload element in three orthogonal axes. The coordinate system used will be clearly defined in the weight and balance report. Verification **shall** be considered successful when the test results show that the mass-to-CG relationship meets the limits in Table E.3.1.4-1.

Verification Submittal: Certified weight and balance report for each payload element and mass properties compliance assessment.

C. The first primary natural frequency of double MLE payload components **shall** be verified by analysis or analysis and test, following guidelines in SSP 52005, Table 7.1-1. If the lift-off and landing configurations of the design differ, verify the primary natural frequency of each configuration is equal to or greater than 30 Hz. Verification **shall** be considered successful when the analysis or analysis and test results show that the first primary natural frequency is equal to or greater than 30 Hz.

Verification Submittal: CoC

E.4.3.1.5 LAUNCH ACCELERATION LOADS

An analysis **shall** be performed to show that the payload maintains positive margins of safety after exposure to the launch acceleration loads as defined in paragraph E.3.1.5. This analysis **shall** follow the guidelines provided in SSP 52005. The verification **shall** be considered successful when the analysis shows that the payload maintains positive margins of safety.

Verification Submittal: Analysis Report

E.4.3.1.6 RETURN ACCELERATION LOADS

An analysis **shall** be performed to show that the payload maintains positive margins of safety after exposure to the return acceleration loads as defined in paragraph E.3.1.6. This analysis **shall** follow the guidelines provided in SSP 52005. The verification **shall** be considered successful when the analysis shows that the payload maintains positive margins of safety.

Verification Submittal: Analysis Report

E.4.3.1.7 LAUNCH RANDOM VIBRATION ENVIRONMENTS

A test and analysis **shall** be performed to show that the payload maintains positive margins of safety after exposure to the random vibration environment for launch as defined in paragraph E.3.1.7. The analysis **shall** follow the guidelines provided in SSP 52005 paragraphs 4.2.1 and 4.2.4. The verification **shall** be considered successful when the test and analysis show that the payload maintains positive margins of safety after exposure to the launch random vibration environments defined in paragraph E.3.1.7.

Verification Submittal: Analysis Report and Test Report

E.4.3.1.8 RETURN RANDOM VIBRATION ENVIRONMENTS

A test and analysis **shall** be performed to show that the payload maintains positive margins of safety after exposure to the random vibration environment for return as defined in paragraph E.3.1.8. The analysis **shall** follow the guidelines provided in SSP 52005 paragraphs 4.2.1 and 4.2.4. The verification **shall** be considered successful when the test and analysis show that the payload maintains positive margins of safety after exposure to the return random vibration environments defined in paragraph E.3.1.8.

Verification Submittal: Analysis Report and Test Report

E.4.3.1.9 LAUNCH LOAD SPECTRUM

An analysis **shall** be conducted to verify that the payload will retain sufficient life after being subjected to the launch load spectrum identified in Table E.3.1.9-1. Verification **shall** be considered successful when the analysis results show the payload retains sufficient life.

Verification Submittal: Analysis Report

E.4.3.1.10 PAYLOAD LAUNCH AND LANDING CONFIGURATION

Data Deliverable

E.4.3.1.11 DEPRESSURIZATION/REPRESSURIZATION RATES

Verification which shows that the payload with safety-critical structures maintains a positive margin of safety and does not create a hazard after exposure to depressurization rates and repressurization rates identified in E.3.1.11 **shall** be by analysis. Verification **shall** be considered successful when an analysis determines the payload maintains positive margins of safety and does not create a hazard during or after exposure to a depressurization rate of 0.890 kPa/second (7.75 psi/minute) and a repressurization rate of 0.800 kPa/second (6.96 psi/min).

Verification Submittal: Analysis Report

E.4.3.2 ELECTRICAL INTERFACE REQUIREMENTS

E.4.3.2.1 ELECTRICAL POWER CHARACTERISTICS AND INTERFACES

E.4.3.2.1.1 INTERFACE VOLTAGE LEVELS

Verification that the MLE powered payload operates properly with the interface voltage at +28 Vdc +1.5/-2.5 Vdc **shall** be by test. The test **shall** be conducted at the maximum and minimum voltage ranges. The verification **shall** be considered successful when the test results show the MLE powered payload is operable at +28 Vdc +1.5/-2.5 Vdc.

Verification Submittal: Test Report

E.4.3.2.1.2 28 VDC POWER

A. Verification that the single MLE powered payload is compatible with the interface voltage of 75 W or less at +28 Vdc **shall** be by test. The verification **shall** be considered successful when the test results show the single MLE powered payload is compatible with the interface voltage of 75 W or less at +28 Vdc.

Verification Submittal: Test Report

B. Verification that the double MLE powered payload consumes less than 150 W or less at +28 Vdc **shall** be by test. The verification **shall** be considered successful when the test results show the double MLE powered payload consumes less than 150 W or less at +28 Vdc.

Verification Submittal: Test Report

E.4.3.2.1.3 REVERSE CURRENT

Powered MLE payloads **shall** verify the reverse current requirement per paragraph F.4.3.2.1.3.

E.4.3.2.1.4 REVERSE ENERGY

Powered MLE payloads **shall** verify the reverse energy requirement per paragraph F.4.3.2.1.4.

E.4.3.2.1.5 CURRENT LIMITING

Powered MLE payloads **shall** verify the current limiting requirement per paragraph F.4.3.2.1.7.B.

E.4.3.2.1.6 ON-ORBIT TRANSFER

Verification that the payload can withstand up to 30 minutes without vehicle supplied power *should* be by analysis or demonstration. The verification *should* be considered successful when the analysis or demonstration of the payload hardware shows that the payload will properly function after a 30 minute loss of power.

Verification Submittal: CoC

E.4.3.2.1.7 VEHICLE SUPPLIED POWER

Verification that the loss or restoration of launch vehicle supplied power to the payload does not result in a hazardous condition **shall** be by analysis. Verification **shall** be considered successful when the loss or restoration of launch vehicle supplied power to the payload does not result in a hazardous condition.

Verification Submittal: Analysis Report

E.4.3.2.1.8 CONNECTOR/PIN INTERFACES

Connector/pin interfaces requirements **shall** be verified per the requirements listed in Table E.4.3.2.1.8-1.

TABLE E.4.3.2.1.8-1 CONNECTOR/PIN INTERFACES VERIFICATION REQUIREMENTS

SSP 57000 Requirement	Title/Subject
F.4.3.2.1.10.A	CONNECTOR/PIN INTERFACES
F.4.3.2.1.10.B	CONNECTOR/PIN INTERFACES

E.4.3.2.2 ELECTROMAGNETIC COMPATIBILITY (EMC)

Electromagnetic compatibility for powered MLE payloads is addressed with general verification requirements 4.3.2.1.4, Electrical Grounding, 4.3.2.2.8, Electrical Bonding, and 4.3.2.2, Electromagnetic Compatibility requirements applicable to the payload.

E.4.3.2.3 DRAGON VEHICLE SPECIFIC REQUIREMENTS

Verification that both the power connector on the Dragon MLE payload and the data connector on the Dragon MLE payload are clocked at 12 o'clock relative to the Dragon MLE payload **shall** be by inspection. The verification **shall** be considered successful when the inspection of flight hardware or drawings shows the master keys on both connectors are pointed towards the top of the Dragon MLE payload.

Verification Submittal: CoC

E.4.3.2.4 CYGNUS VEHICLE SPECIFIC REQUIREMENTS

A. NVR

B. Verification that Cygnus MLE 28 V loads are compatible with exposure to abnormal voltages as specified in paragraph E.3.2.4.B **shall** be by test or analysis. The verification **shall** be considered successful when the test or analysis shows the MLE payload is not damaged (e.g., all parts are within rating) by abnormal input voltage as defined in paragraph E.3.2.4.B.

Verification Submittal: Test Report or Analysis Report

C. Verification of the Cygnus MLE 28 V loads input impedance requirement **shall** be by test. The MLE payload input impedance **shall** be tested under conditions of high, 29.5 volts, and low, 25.5 volts, steady-state input voltage and with these conditions for the active converters directly downstream, **shall** be exercised through the complete range of their loading. Selected combinations of the payload's converters that can influence the measured input impedance **shall** be tested. The verification **shall** be considered successful when the test shows that all load impedance measured for high and low voltage conditions remain within specified limits as indicated in paragraph E.3.2.4.C.

Verification Submittal: Test Report

D. Verification that the Cygnus MLE 28 V loads load current transient requirement is met **shall** be by test. Verification test **shall** be performed to measure the load current transient at source power on, for an input voltage step from 0 to 29.5 Vdc. Verification test **shall** also be performed to measure the load current transients for all payload transitions from one operating mode to another with an input voltage at the low end of the steady-state voltage range (i.e., 25.5 V). The verification **shall** be considered successful when the test shows the integral of the payload input current in excess of the load rating is less than 0.02 A·s for source power on and for each tested load transition.

Verification Submittal: Test Report

E. Verification of the Cygnus MLE 28 V loads slow rate-of rise power on compatibility requirement **shall** be by test. Verification test **shall** be performed to demonstrate load initiation when the time for the input voltage to rise from 5 V to 25 V is less than 100 μs (fast), and when the time is at least 3.6 ms (slow). Less comprehensive testing, such as only that necessary to verify other requirements like power-on inrush current, is acceptable if supported by analysis showing that the design is inherently insensitive to variations in external power application (e.g., a purely resistive load (heater) or a load with an internal power switch). The verification **shall** be considered successful when the test shows the payload can power on as expected with both fast and slow voltage rise times for external power application.

Note: A payload that passes EMI CE07 testing meets the intent of the “input voltage to rise from 5 V to 25 V is less than 100 μs (fast)” requirement.

Verification Submittal: Test Report

F. Verification of the Cygnus MLE 28 V loads Reverse EMF requirement **shall** be by test and analysis. Verification test and analysis **shall** be performed to demonstrate that either the payload does not generate any reverse EMF or that the payload does not generate sufficient reverse EMF to raise the input voltage by more than two volts for more than 10 μs. The first test condition (no reverse EMF) is met if the measured input current of the load is always non-negative during the load current transient conditions in tests for payload operating mode transitions. If the negative input current exists during the load current transient conditions, test and analysis **shall** be performed to measure the input voltage increase caused by negative input current. If the test is performed, a diode **shall** be installed in the input power path to block reverse current. The voltage rise caused by the EMF generated by the payload is obtained by measuring the peak voltage across the diode (in the reverse direction from normal power flow), or by measuring the difference between the peak differential voltage and the steady state voltage. The verification **shall** be considered successful when the test and analysis shows the payload does not generate negative input current or the voltage generated by negative load input current generated is less than 2 V.

Verification Submittal: Test Report

E.4.3.3 COMMAND AND DATA HANDLING INTERFACE REQUIREMENTS

A. The payload **shall** meet the C&DH verification requirements listed in Table E.4.3.3-1.

TABLE E.4.3.3-1 C&DH REQUIREMENTS

SSP 57000 Requirement	Title/Subject
I.4.3.8.3.1	SIGNAL CHARACTERISTICS
I.4.3.8.7.3.6.1.C	PAYLOAD HEALTH AND STATUS DATA – ECW (1ST WORD)
I.4.3.8.7.3.6.2.A	PAYLOAD HEALTH AND STATUS DATA – H&S CYCLE COUNTER (2ND WORD)
I.4.3.8.7.3.6.2.B	PAYLOAD HEALTH AND STATUS DATA – H&S CYCLE COUNTER (2ND WORD)
I.4.3.8.7.3.6.2.C	PAYLOAD HEALTH AND STATUS DATA – H&S CYCLE COUNTER (2ND WORD)
I.4.3.8.7.3.6.2.D	PAYLOAD HEALTH AND STATUS DATA – H&S CYCLE COUNTER (2ND WORD)

B. The payload *should* meet the C&DH verification requirements listed in Table E.4.3.3-2.

TABLE E.4.3.3-2 C&DH REQUIREMENTS

SSP 57000 Requirement	Title/Subject
I.4.3.8.1.1	MLE/MLE REPLACEMENT PAYLOAD
I.4.3.8.2.2	COMMUNICATIONS PROTOCOL
I.4.3.8.7.3.6.1.A	PAYLOAD HEALTH AND STATUS DATA – ECW (1ST WORD)
I.4.3.8.7.3.6.1.B	PAYLOAD HEALTH AND STATUS DATA – ECW (1ST WORD)
I.4.3.8.7.3.6.3	PAYLOAD HEALTH AND STATUS DATA – PAYLOAD MESSAGE (3RD TO 92ND WORD)
I.4.3.8.7.3.6.3.1.A	PAYLOAD MESSAGE COUNTER (FIRST BYTE OF PAYLOAD MESSAGE)
I.4.3.8.7.3.6.3.1.B	PAYLOAD MESSAGE COUNTER (FIRST BYTE OF PAYLOAD MESSAGE)
I.4.3.8.7.3.6.3.1.C	PAYLOAD MESSAGE COUNTER (FIRST BYTE OF PAYLOAD MESSAGE)
I.4.3.8.7.3.6.3.1.D	PAYLOAD MESSAGE COUNTER (FIRST BYTE OF PAYLOAD MESSAGE)
I.4.3.8.7.3.6.3.2	PAYLOAD MESSAGE IDENTIFIER

E.4.3.4 PAYLOAD NTSC VIDEO INTERFACE REQUIREMENTS

N/A

E.4.3.5 THERMAL CONTROL INTERFACE REQUIREMENTS

E.4.3.5.1 INLET AND OUTLET LOCATION INTERFACES

Verification that inlet and outlet locations for the air cooled payload meets mechanical interfaces **shall** be by inspection. The verification **shall** be considered successful when an inspection of the flight hardware shows compliance with the mechanical interface per Figure F.3.1.2.1-1.

Verification Submittal: CoC

E.4.3.5.2 HEAT LOAD

Verification that the powered MLE payload heat load at the payload air outlet does not exceed 75 W for a single MLE or 150 W for a double MLE **shall** be by thermal analysis. The verification **shall** be considered successful if the thermal analysis results do not exceed the cabin air heat load limits.

Verification Submittal: CoC

E.4.3.5.3 AIR EXCHANGE

Verification that the payload only exchanges air with the cabin for metabolic purposes **shall** be by inspection of drawings. The verification **shall** be considered successful when the drawings show the payload only exchanges air with the cabin for metabolic purposes.

Verification Submittal: CoC

E.4.3.5.4 CABIN AND AAA AIR MIXING LIMITATIONS

Powered MLE payloads exchanging air with the cabin and using avionic air cooling *should* verify the cabin and AAA air mixing limitations per paragraph F.4.3.5.11.

E.4.3.5.5 PAYLOAD LIMITATIONS ON HEAT CONVECTED OR RADIATED TO CABIN AIR

Verification *should* be by thermal analysis of the payload hardware using “worst-case” payload and ambient boundary conditions to determine that the heat rejection from the sides and front of the payload hardware to the cabin air by convection and radiation is limited to 10 percent of the payload hardware total heat load. Verification *should* be considered successful when the analysis results show that the heat rejection from the sides and front of the payload hardware to the cabin air by convection and radiation is not more than 10 percent of the payload hardware total heat load.

Verification Submittal: CoC

E.4.3.5.5.1 FANS

Verification that the powered MLE payload drawing air from the transport vehicle’s cooling systems *should* be by inspection. The verification *should* be considered successful when inspection of drawings and/or design documentation show that the design includes a fan.

Verification Submittal: CoC

E.4.3.6 VACUUM SYSTEM REQUIREMENTS

N/A

E.4.3.7 PRESSURIZED GAS SYSTEMS REQUIREMENTS

The pressurized gas systems verification requirement is addressed in paragraph 4.3.7.5.

E.4.3.8 PAYLOAD SUPPORT SERVICES INTERFACE REQUIREMENTS

N/A

E.4.3.9 ENVIRONMENT INTERFACE REQUIREMENTS

E.4.3.9.1 PRESSURE

An analysis and/or test **shall** be conducted which shows that operation of the payload will not result in incompatibility when exposed to a pressure of 13.9 to 15.2 psia. Verification **shall** be considered successful when the analysis and/or test results show that the payload is compatible with all interface requirements when exposed to a pressure of 13.9 to 15.2 psia.

Verification Submittal: CoC

E.4.3.9.2 TEMPERATURE

A. An analysis and/or test **shall** be conducted which shows that operation of the MLE powered payload will not result in incompatibility when exposed to temperatures ranging from 18.3 to 29.4 °C (65 to 85 °F). Verification **shall** be considered successful when the analysis and/or test results show that the payload is capable of operating without producing an unsafe condition and/or resulting in damage to hardware items or the crew when exposed to temperatures ranging from 18.3 to 29.4 °C (65 to 85 °F).

Verification Submittal: CoC

B. An analysis and/or test **shall** be conducted which shows that operation of the MLE powered payload will not result in incompatibility when exposed to the worst case air circulation range of 18 to 36 CFM for a single MLE and at 36 CFM for a double MLE at the exhaust location. Verification **shall** be considered successful when the analysis and/or test results show that the payload is capable of operating without producing an unsafe condition and/or resulting in damage to hardware items or the crew when exposed to the specified air circulation.

Verification Submittal: CoC

E.4.3.10 FIRE PROTECTION INTERFACE REQUIREMENTS

There are no unique fire protection interface verification requirements for payloads on transport vehicles.

E.4.3.11 MATERIALS AND PROCESSES INTERFACE REQUIREMENTS

General materials and processes interface verification requirements are addressed in section 4.3.11.

E.4.3.12 HUMAN FACTORS INTERFACE REQUIREMENTS

E.4.3.12.1 CONTINUOUS NOISE LIMITS

Verification of continuous noise sources **shall** be performed by test. Verification **shall** be considered successful when the test shows that the loudest noise does not exceed the levels specified in E.3.12.1.

SPL test measurements **shall** be obtained at 0.6 meters from all sides of the equipment. The SPL test **shall** use a Type 1 Sound Level Meter (SLM) in accordance with publication IEC 61672-1. The preferred instrument for acoustic verification is the Type 1 integrating-averaging SLM. This meter can either be of the handheld or component system variety.

The SPL **shall** be measured in each of eight octave bands: 63 Hz, 125 Hz, 250 Hz, 500 Hz, 1000 Hz, 2000 Hz, 4000 Hz, and 8000 Hz.

Octave band filters used for verification measurements will meet the Class 1 specifications in accordance with publication IEC 61260-1, Electroacoustics – Octave-band and fractional-octave-band filters, over the frequency range required for verification.

Verification Submittal: Test Report to include Continuous noise Source - SPL decibel (dB) for the eight octave bands (for each serialized unit).

APPENDIX F

EXPRESS RACK TO SUBRACK PAYLOAD INTERFACE REQUIREMENTS

APPENDIX F - EXPRESS RACK TO SUBRACK PAYLOAD INTERFACE REQUIREMENTS

F.1.0 INTRODUCTION

F.1.1 PURPOSE

This section provides requirements, guidelines and data deliverables for payloads interfacing with an EXPRESS Rack.

F.1.2 SCOPE

This appendix addresses subracks or other payloads that interface with an EXPRESS rack.

F.1.3 USE

These requirements, guidelines and data deliverables are applied to EXPRESS subrack payloads in addition to the general requirements, guidelines and data deliverables in Section 3.0 and are allocated to a payload through the payload unique ICD. The PD and the ISS Program must jointly agree on the interfaces and identify requirements as applicable if the interface exists, and not applicable if the interface does not exist for the payload configuration documented in the ICD.

F.2.0 DOCUMENTATION

See Section 5.0.

F.3.0 EXPRESS RACK TO SUBRACK PAYLOAD INTERFACE REQUIREMENTS

Data Deliverable: Provide an interface block diagram showing the payload required EXPRESS Rack resources (such as power, cooling, command and data handling (including video), vacuum, gases, etc.).

F.3.1 PHYSICAL AND MECHANICAL INTERFACES

F.3.1.1 INTERNATIONAL STANDARD PAYLOAD RACK (ISPR) COORDINATE SYSTEMS (LIMITED EFFECTIVITY)

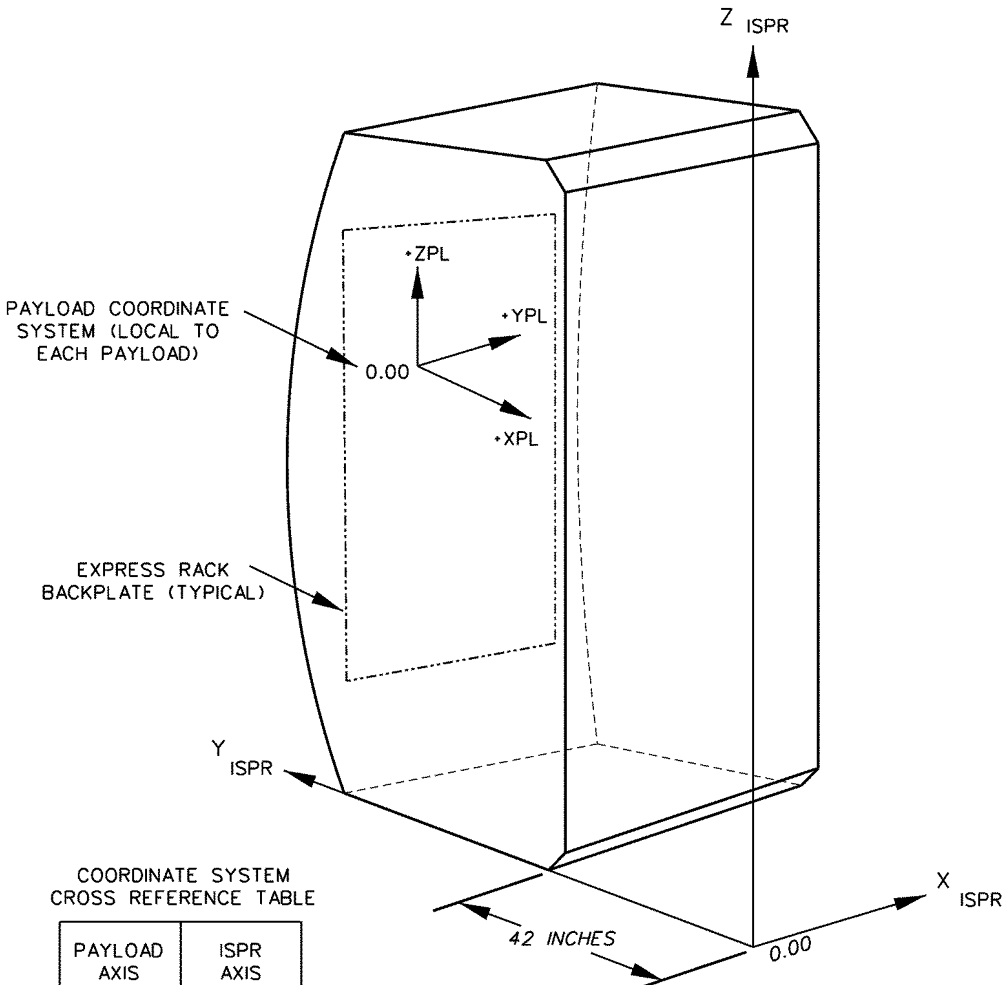
The ISPR coordinate system in any ISS laboratory is shown in Figure F.3.1.1-1 and described as follows:

Origin: Located at the intersection of the rack static envelope bottom, left front side and 42 in (1066.8 millimeter (mm)) projection from front face.

Orientation: The positive Z axis is towards the top of ISPR. The positive X axis is to the right (looking at rack), and the positive Y axis is towards the rear of the rack.

Characteristics: Rotating right-handed Cartesian. The standard subscript is ISPR (e.g., X_{ISPR}).

This section is applicable to the United States (U.S.) Payload, the U.S. Bartered Payload, and the International Partner Payload located in the U.S. pressurized volume.



COORDINATE SYSTEM CROSS REFERENCE TABLE

PAYLOAD AXIS	ISPR AXIS
$-X_{PL}$	$+Y_{ISPR}$
$+Y_{PL}$	$+X_{ISPR}$
$+Z_{PL}$	$+Z_{ISPR}$

FIGURE F.3.1.1-1 ISPR COORDINATE SYSTEM IN THE USL (APPLICABLE TO ANY ON-ORBIT LAB)

F.3.1.1.1 PAYLOAD COORDINATE SYSTEM

The payload (PL) coordinate system is shown in Figure F.3.1.1-1. It is a floating coordinate system local to each individual payload. It is described as follows:

Origin: The PL coordinate system origin is in the plane of the EXPRESS Rack backplate. It is a floating coordinate system located by the payload under consideration.

Orientation: The Xpl axis is toward the front of the ISPR. The Ypl axis is toward the right (looking at the rack). The Zpl axis is toward the top of the ISPR.

Characteristics: Rotating right-handed Cartesian. The standard subscript is PL (e.g., Xpl).

F.3.1.1.2 DIMENSIONS AND TOLERANCES

Unless otherwise specified, all linear dimensions are in inches, all angular dimensions are in degrees, and the tolerances for these are as follows:

Decimal:	X.X	=	±0.1
	X.XX	=	±0.03
	X.XXX	=	±0.010
Fractions:			±1/16
Angles:			±0 30’

F.3.1.2 STRUCTURAL/MECHANICAL INTERFACES

F.3.1.2.1 ISS LOCATIONS

The subrack payload and the ISIS drawer payload are located in the EXPRESS rack as illustrated in Figures F.3.1.2.1-1 and F.3.1.2.1-2.

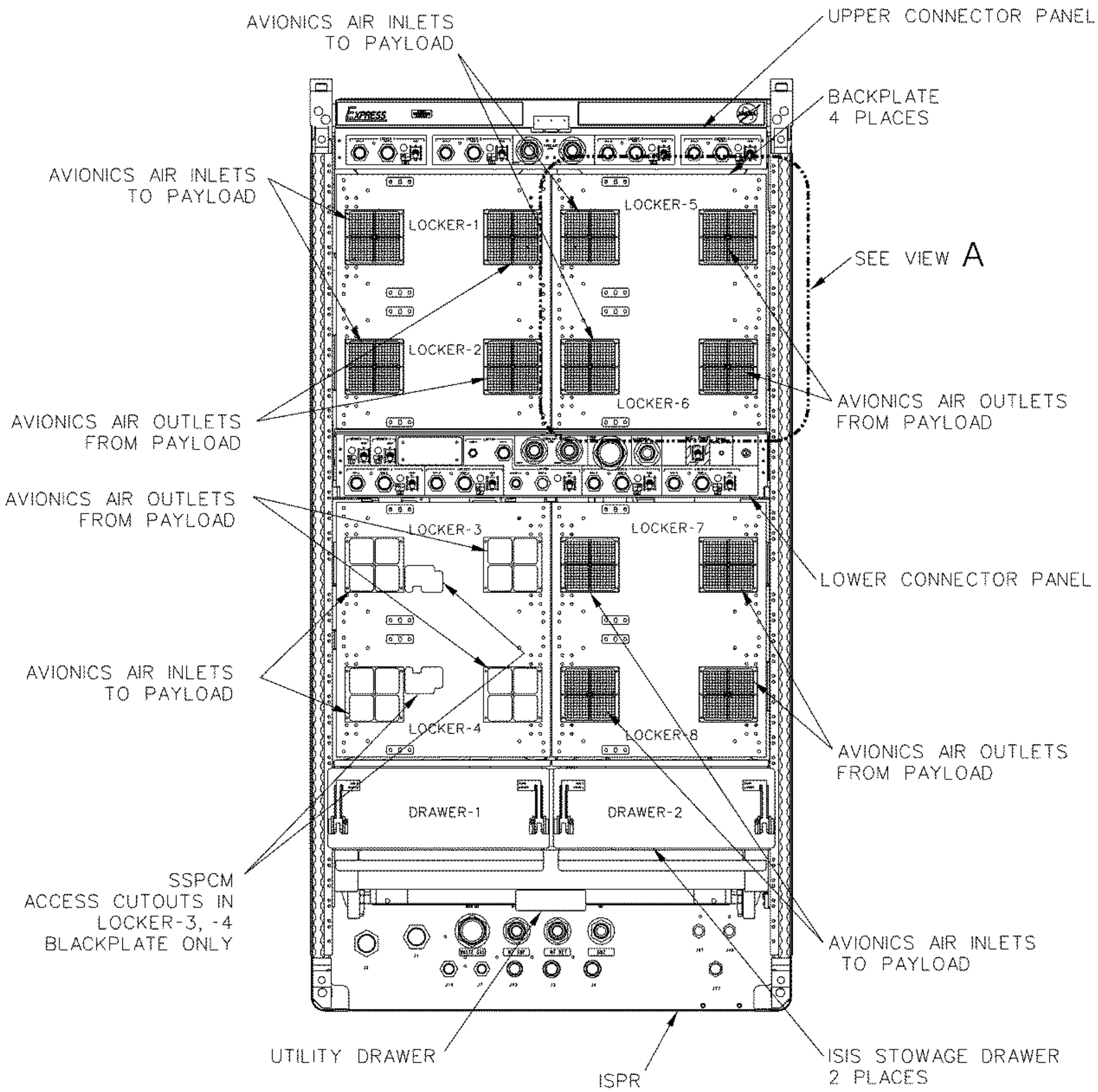


FIGURE F.3.1.2.1-1 EXPRESS RACK STRUCTURAL PROVISIONS FOR SUBRACK PAYLOAD (PAGE 1 OF 3)

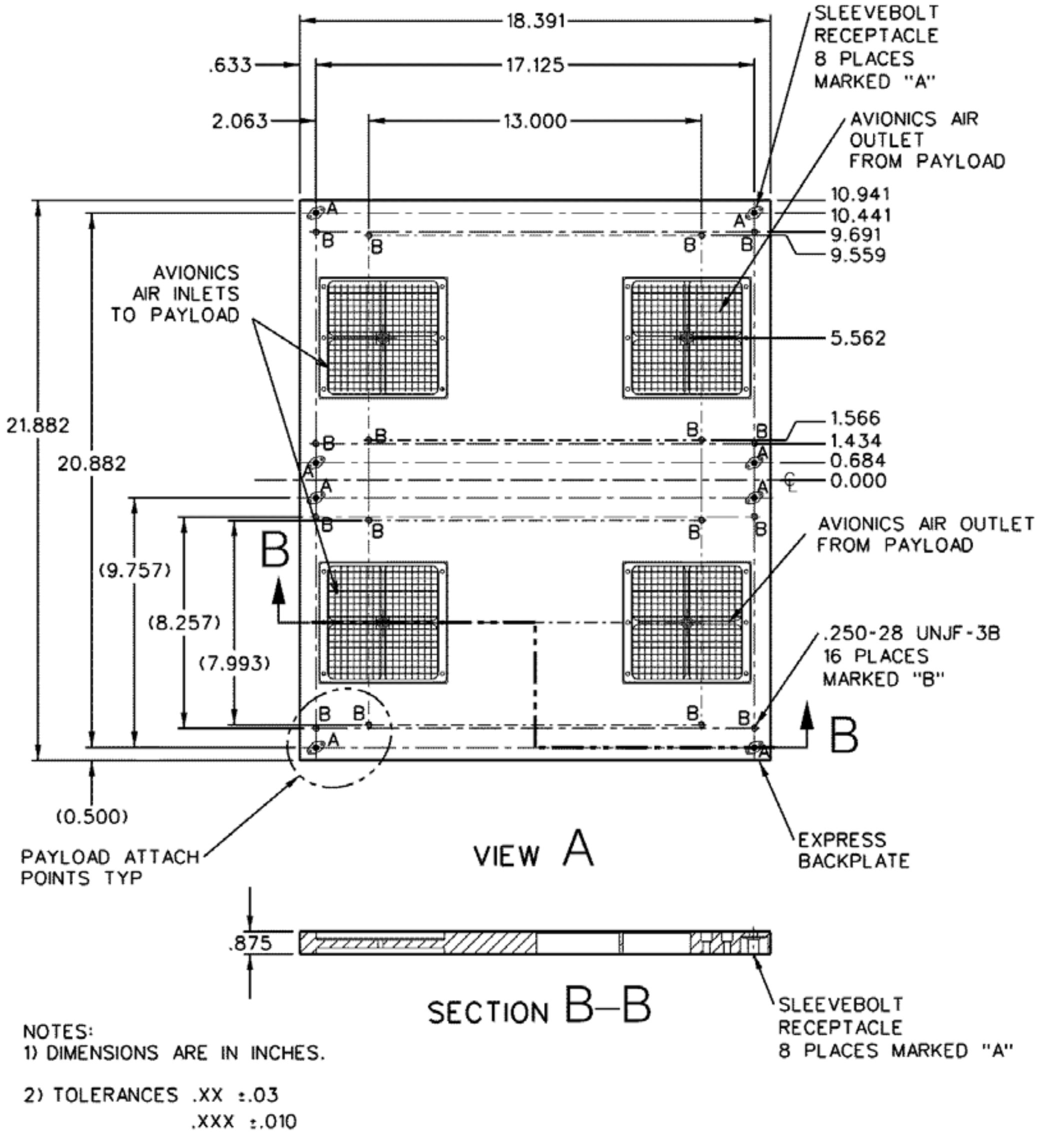


FIGURE F.3.1.2.1-1 EXPRESS RACK STRUCTURAL PROVISIONS FOR THE SUBRACK PAYLOAD (PAGE 2 OF 3)

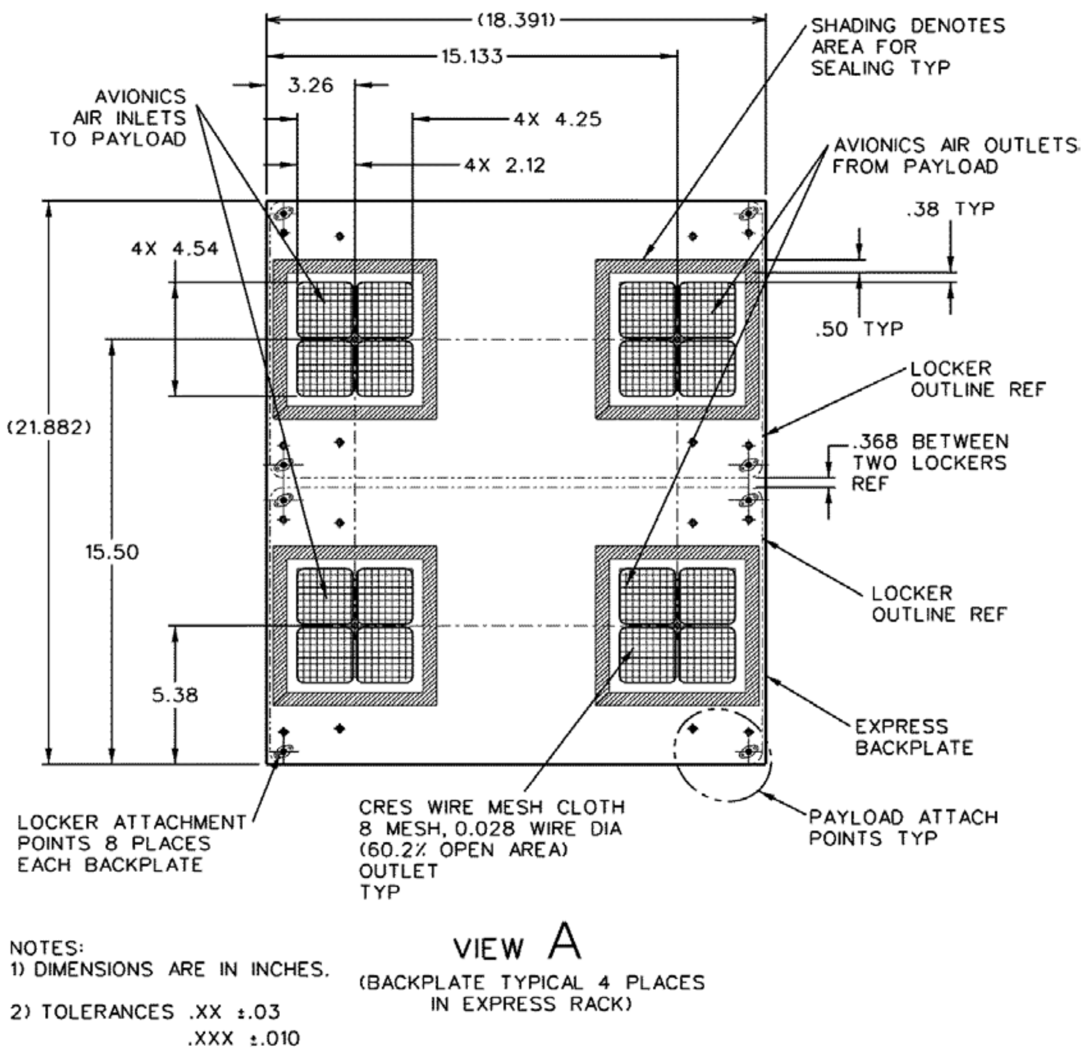


FIGURE F.3.1.2.1-1 EXPRESS RACK STRUCTURAL PROVISIONS FOR THE SUBRACK PAYLOAD (PAGE 3 OF 3)

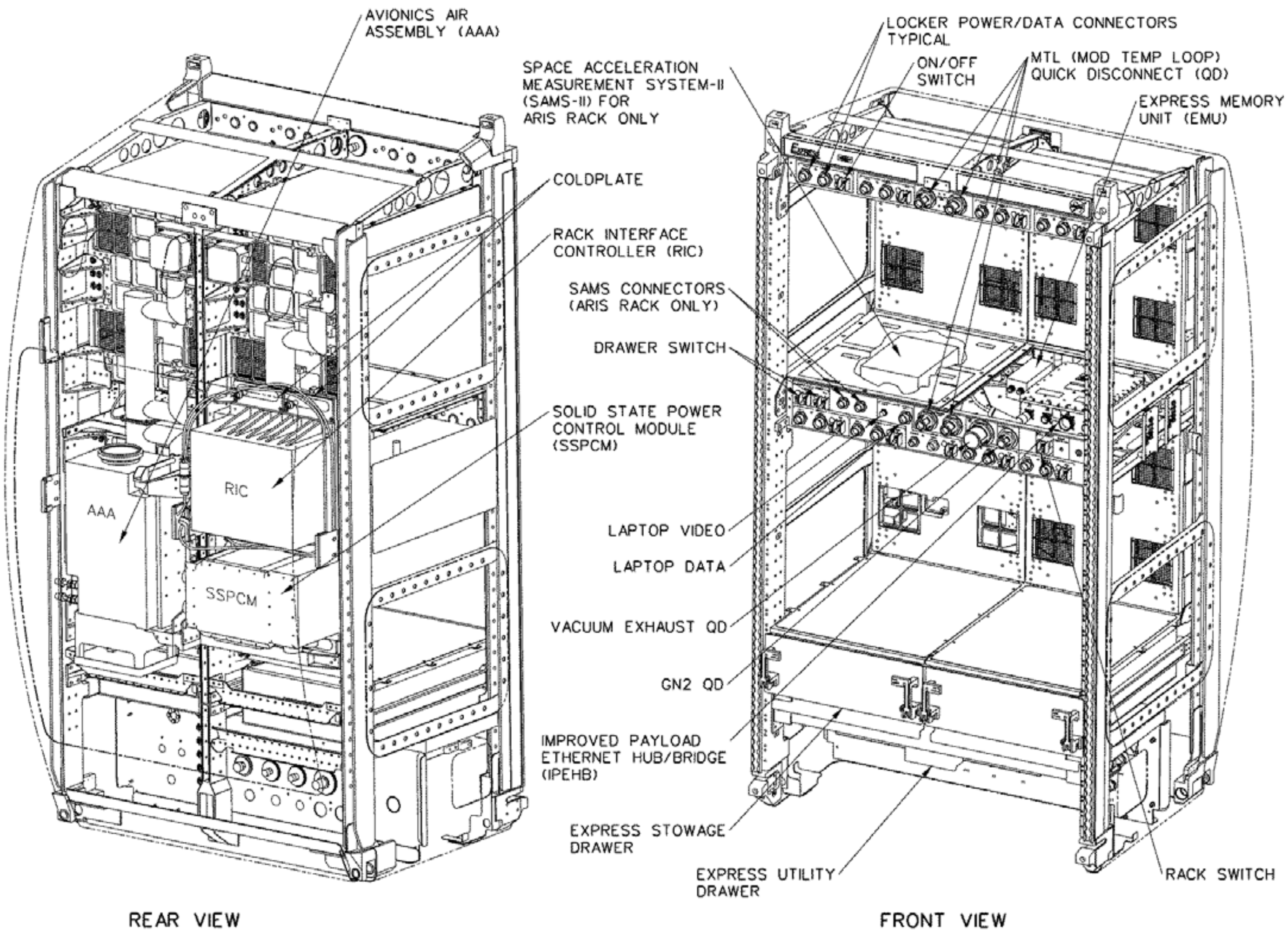


FIGURE F.3.1.2.1-2 EXPRESS RACK CONFIGURATION EXPLODED VIEW

F.3.1.2.2 EXPRESS RACK MOUNTING PLATE

The subrack payload *should* be compatible with the mechanical interfaces defined in Figure F.3.1.2.1-1.

F.3.1.2.3 ISOLATION MATERIAL PROPERTIES

If isolation materials are used by the PD for packaging the payload inside lockers or drawers, then the isolation material (Pyrell or similar material) *should* have a minimum thickness of 0.5 in and be compressed 25 percent.

F.3.1.2.4 ISS-SUPPLIED LOCKERS

The ISS supplies a limited number of lockers for use in the EXPRESS Racks for the ISS payload. These lockers are intended for use in the ISS. The ISS lockers can be configured with or without rear-breathing interfaces.

Each locker is equipped with front panels which can be modified. A modified locker door has three blank removable/exchangeable panels as illustrated in Figures F.3.1.2.4-1 and F.3.1.2.4-2. These blank panels are replaced with payload-unique panels on the ground prior to launch. The PD is responsible for supplying all unique panels.

The locker provides its own captive locking fasteners to interface it with the EXPRESS Rack backplate. There are no provisions for payload equipment to physically attach (i.e., hard mount) to the ISS locker (excluding any unique panels for the modified door).

The mass of the ISS-supplied single locker, door panels and internal close-out cover are shown in Table F.3.1.2.4-1.

TABLE F.3.1.2.4-1 COMPONENT MASS IDENTIFICATION

Component	Part Number	Mass (lbs.)
ISS Locker	SEG46117022-302	11.40 ± 0.40
Center Door Panel	SEG46117124-301	0.34 ± 0.02
Left Door Panel	SEG46117124-302	0.32 ± 0.02
Right Door Panel	SEG46117124-303	0.32 ± 0.02
Internal Close Out Cover	SEG46117024-301	0.63 ± 0.07

The PD must define requirements (need date, quantity, etc.) for these lockers in their PIA. The subrack payload using these lockers *should* be compatible with the mechanical information shown in Figures F.3.1.2.4-1 through F.3.1.2.4-4.

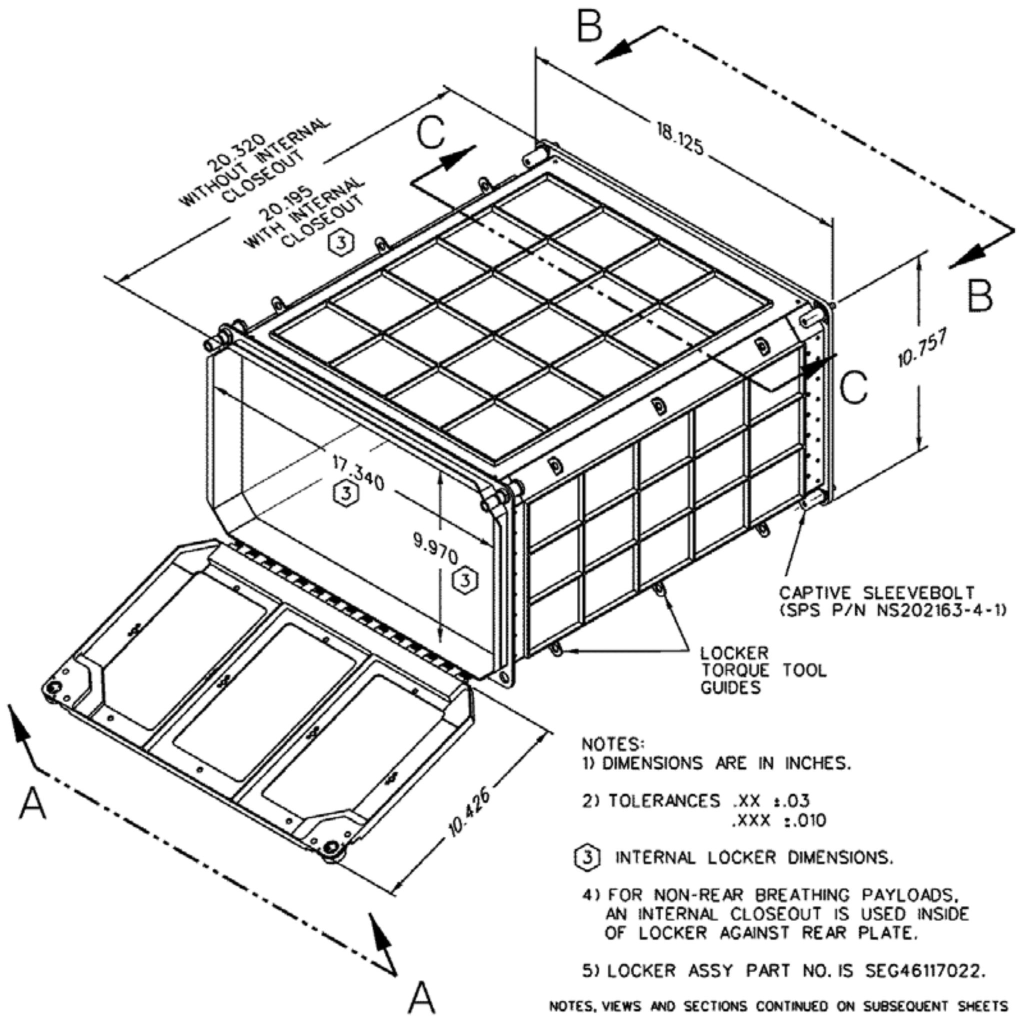


FIGURE F.3.1.2.4-1 ISS LOCKER (PAGE 1 OF 2)

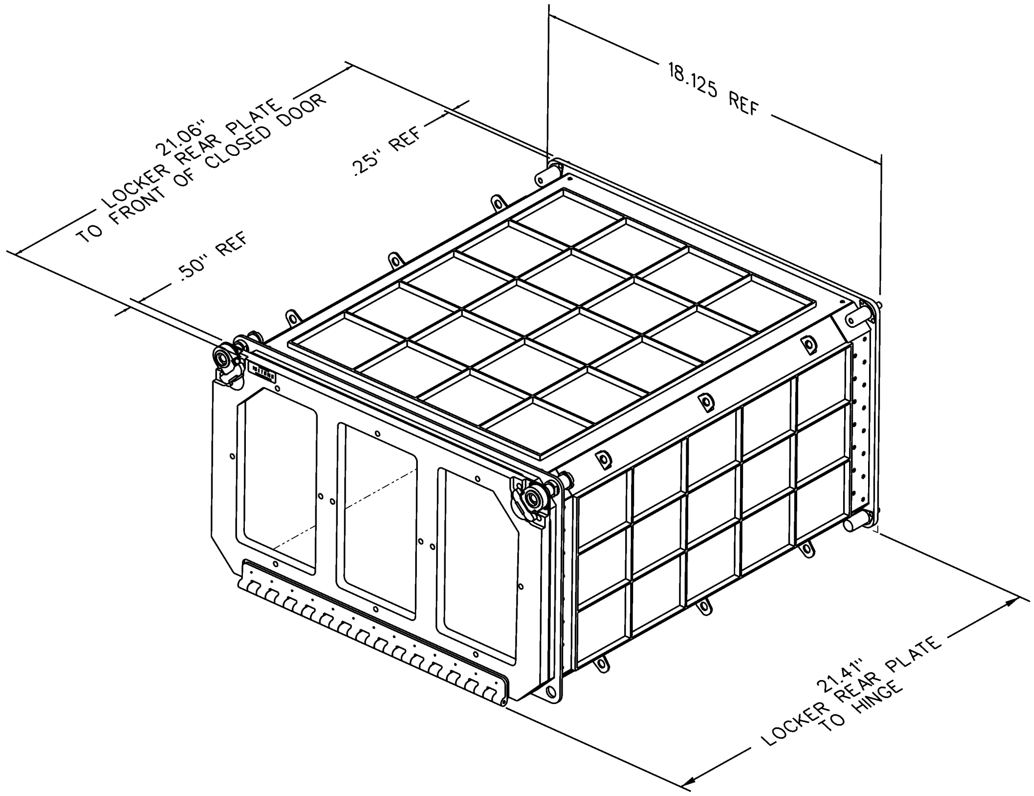
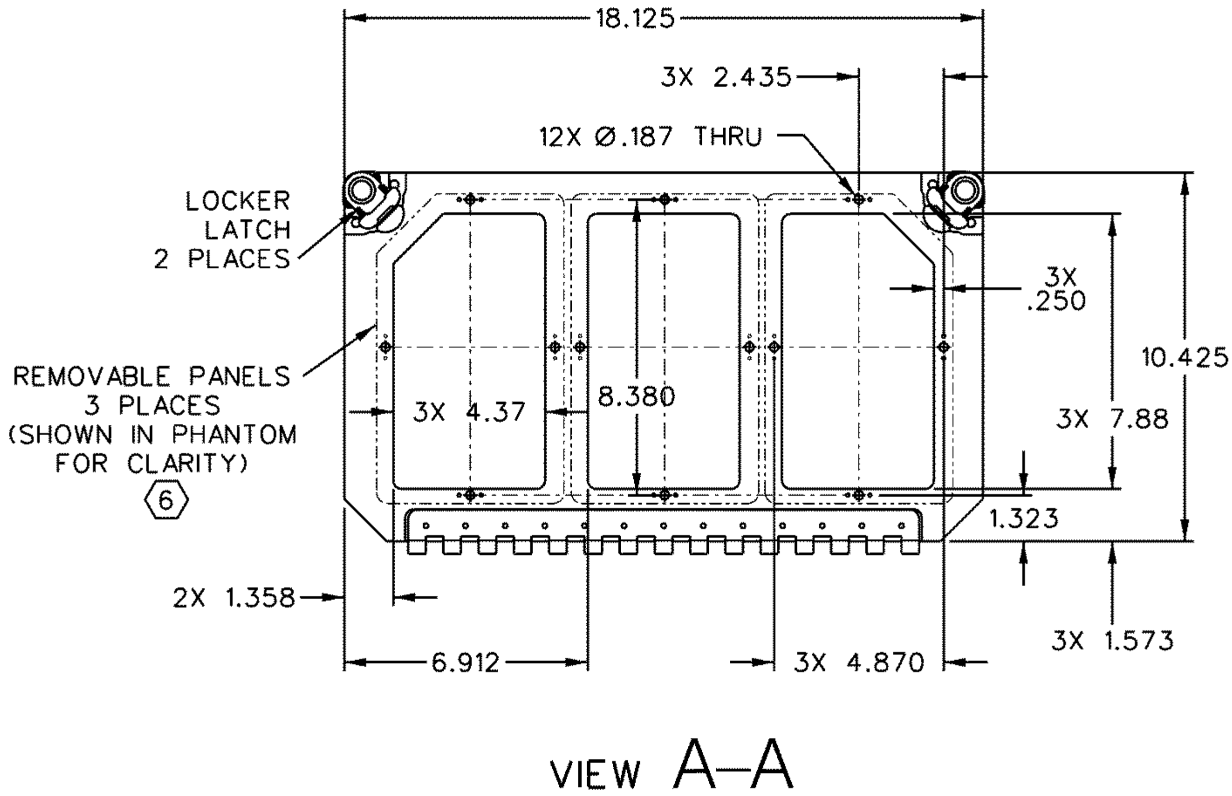


FIGURE F.3.1.2.4-1 ISS LOCKER (PAGE 2 OF 2)



NOTES CONTINUED:

⟨6⟩ FRONT PANEL COVERS INTERFACE TO LOCKER DOOR USING THE FOLLOWING:
A. 1/4 TURN DZUS STUD, P/N APRJ30SS.
B. RETAINER, P/N SR3SS.
C. QUANTITIES = 4 PER PANEL.

FIGURE F.3.1.2.4-2 ISS LOCKER DOOR

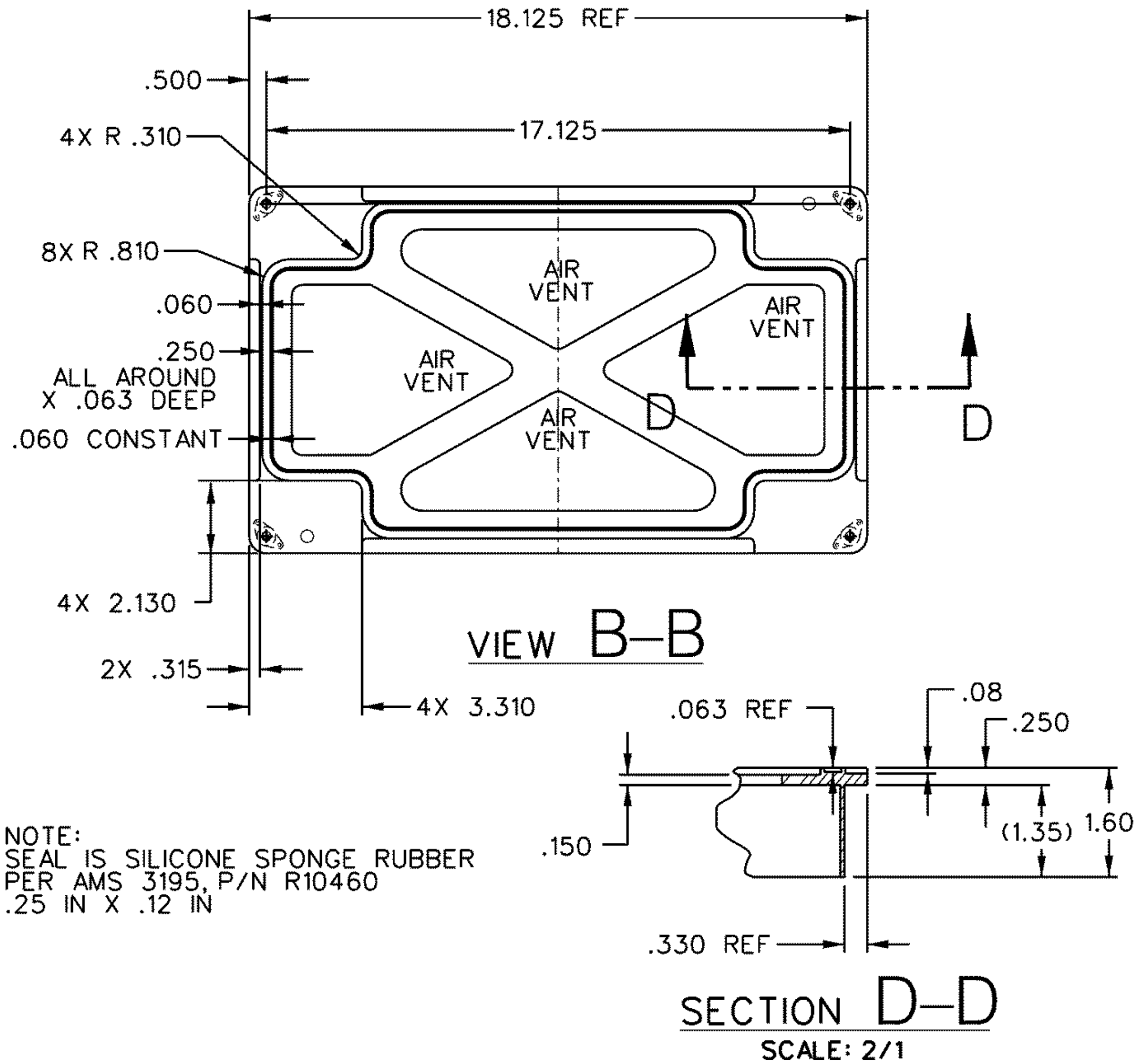


FIGURE F.3.1.2.4-3 ISS SINGLE LOCKER REAR PLATE ASSEMBLY (PAGE 1 OF 2)

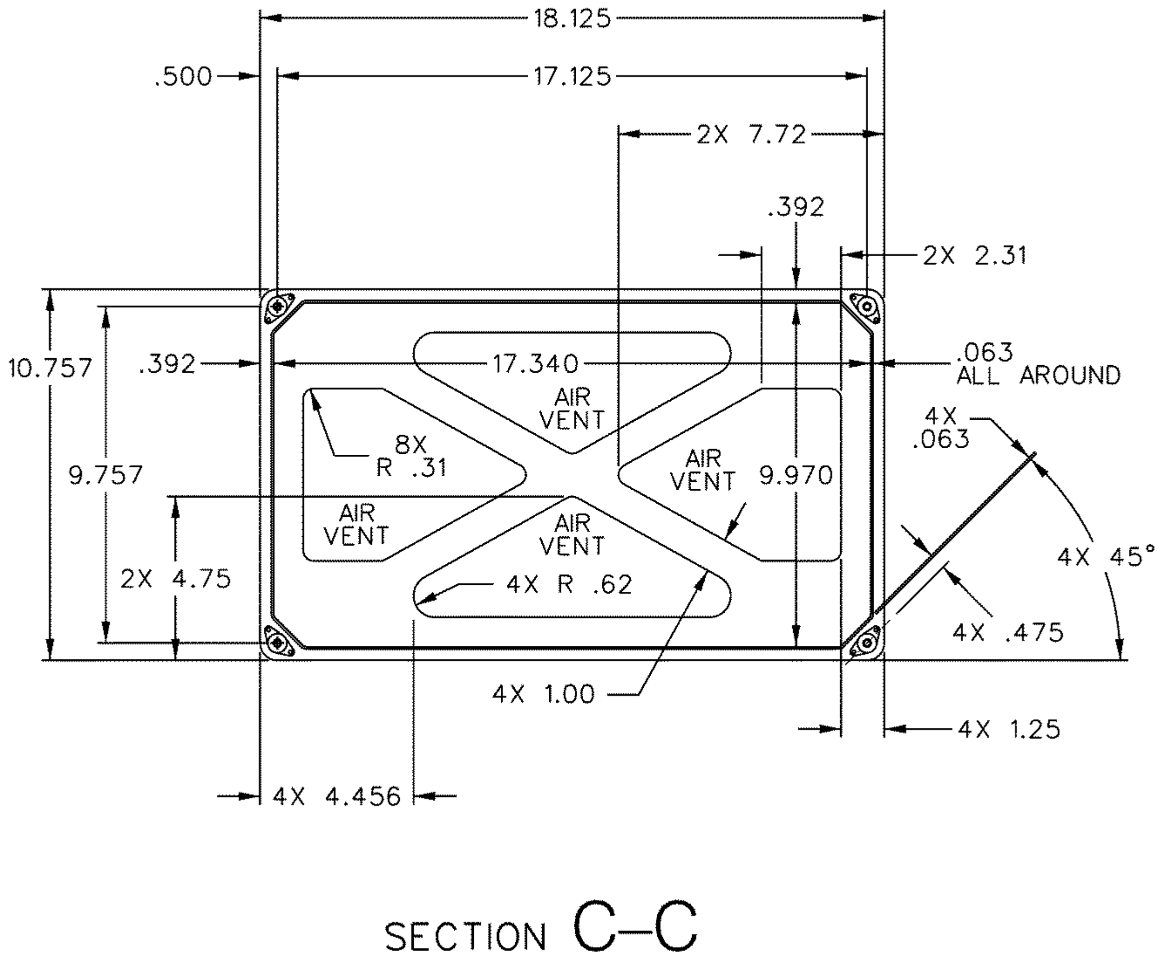
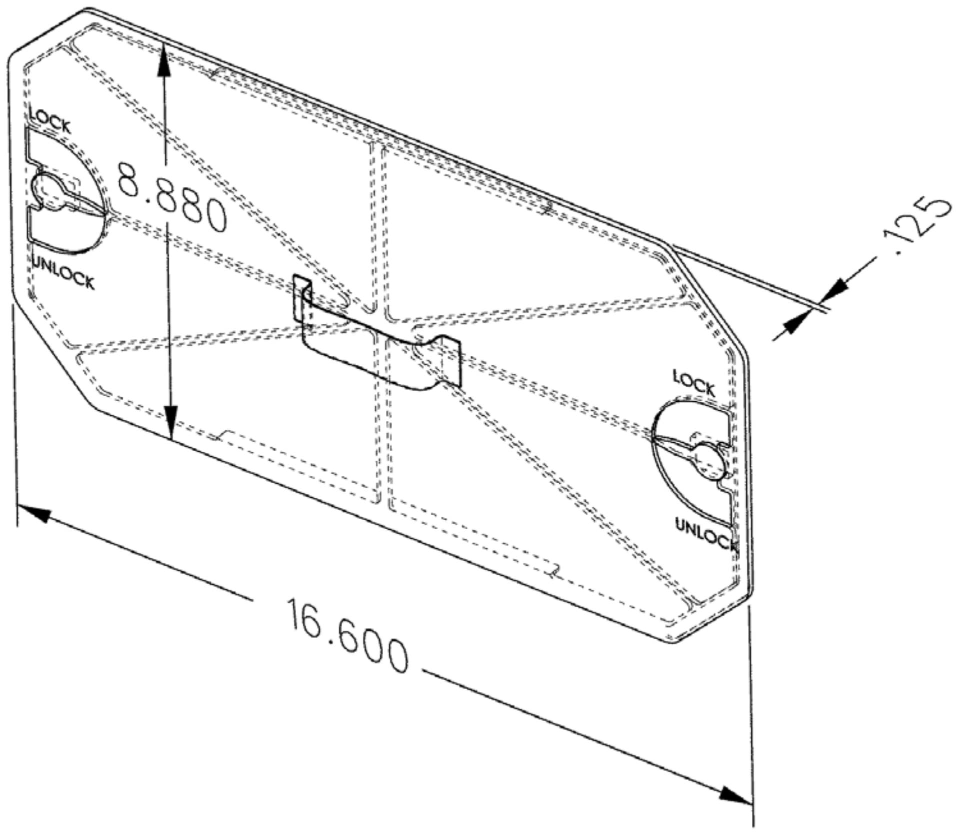


FIGURE F.3.1.2.4-3 ISS SINGLE LOCKER REAR PLATE ASSEMBLY (PAGE 2 OF 2)



DIMENSIONS ARE IN INCHES

FIGURE F.3.1.2.4-4 ISS LOCKER INTERNAL COVER ASSEMBLY FOR REAR PLATE

F.3.1.2.5 PAYLOAD DEVELOPER-SUPPLIED LOCKER LATCHES

In order to maintain commonality and standardization between ISS-supplied and unique PD-supplied lockers, the lockers must meet the requirements within this document.

ISS lockers use the latches defined by the following drawings:

Knob (Drawing (Dwg.) No. SDD39119020)
Stud (Dwg. No. SDD39119023)
Base (Dwg. No. SDD39119021)
Latch Handle (Dwg. No. SDD39119025)
These parts are made of Corrosion Resistant Steel (CRES 15-5 PH (H1025).

F.3.1.2.6 FRONT FACE PROTRUSIONS (PERMANENT)

Permanently attached equipment **shall** not protrude beyond the plane of the NASA ISPR front face GSE attachments which are 24.6 in (62.5 cm) from the backplate of the EXPRESS Rack.

Note: The 24.6 inch dimension includes all parts of the payload (i.e., connectors, QDs, switches, etc.).

F.3.1.2.7 PAYLOAD ATTACHMENT POINTS

The attachment points on the payload mounting structure used to secure to the EXPRESS rack backplate *should* be designed per Figure E.3.1.2-1.

Note: It is recommended that the (1/4-28) threaded inserts be utilized in lieu of the sleeve bolt receptacle attachment points (reference Figure F.3.1.2.1-1) when the additional load carrying capability is required.

F.3.1.2.8 CAPTIVE FASTENERS

The payload provides all interface fasteners which attach payload equipment to mounting plates (single adapter plate, double adapter plate) or to the EXPRESS Rack backplate. These interface fasteners **shall** meet the requirements in Table F.3.1.2.8-1 and Figure E.3.1.2-1.

TABLE F.3.1.2.8-1 CAPTIVE INTERFACE FASTENER REQUIREMENTS

Held captive to the payload side of the interface
Self locking
Self retracting (spring loaded) at least flush with payload mounting flange
Minimum radial float capability of 0.02 inches for single locker size payloads, 0.03 inches for double locker size payloads
Provision to prevent thread seizing through dry film lubrication, silver plating, or application of approved anti-seize compound
Bolt material A286 CRES, 180 ksi ultimate tensile strength maximum
Ancillary parts (housing, springs, retainer, etc.) made from corrosion resistant steel or aluminum
Compatible with MS51831CA-202 insert used in the EXPRESS Rack backplate or with NS202163-4-2 sleeve bolt receptacles

Note: Modification of non-captive fasteners to incorporate a captive feature must be approved by the structures working group. For all interface bolts to be considered (analytically) to share carrying shear loads to the backplate, the total radial clearance at each bolt must not exceed clearance fit requirements.

F.3.1.2.9 POWERED ISIS DRAWER FASTENERS

A. Fasteners engaging inserts in the bottom plate *should* be sized not to extend beyond the bottom surface of the bottom plate.

B. Fasteners installed from the outside of the drawer through the bottom plate *should* have 100° countersunk heads set flush with the bottom surface of the bottom plate.

F.3.1.3 MICROGRAVITY

Microgravity requirements limit the disturbing effects of the EXPRESS Rack subrack payload on the microgravity environment. The requirements are separated into the quasi-steady category (frequencies below 0.01 Hz), the vibratory category (frequencies between 0.01 Hz and 300 Hz), and the transient category. For the EXPRESS Rack subrack payload, the interface points are the backplate for the MLE equivalent payload, the ISIS drawer to ISIS liner interface for the ISIS drawer payload, and the connector panels for payload utility connections.

F.3.1.3.1 QUASI-STEADY REQUIREMENTS

The EXPRESS subrack payload *should* meet quasi-steady limits per paragraph N.3.1.2.1.

F.3.1.3.2 VIBRATORY REQUIREMENTS

Between 0.01 and 300 Hz, the EXPRESS Rack subrack payload **shall** limit vibration so that the force limits of Figure F.3.1.3.2-1 and Table F.3.1.3.2-1 is not exceeded.

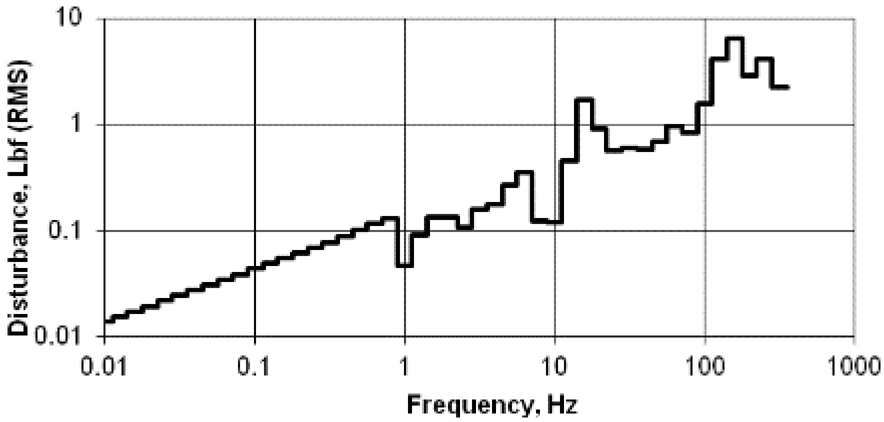


FIGURE F.3.1.3.2-1 EXPRESS RACK SUBRACK PAYLOAD VIBRATORY DISTURBANCES ALLOWABLE

TABLE F.3.1.3.2-1 EXPRESS SUBRACK PAYLOAD DISTURBANCE ALLOWABLE

OTO Band Boundary Frequency Hz	Payload Disturbance Allowable lbf	OTO Band Boundary Frequency Hz	Payload Disturbance Allowable lbf	OTO Band Boundary Frequency Hz	Payload Disturbance Allowable lbf	OTO Band Boundary Frequency Hz	Payload Disturbance Allowable lbf
0.00891	0.0138	0.1413	0.0487	2.239	0.1328	28.18	0.6014
0.01122	0.0138	0.1413	0.0550	2.239	0.1065	35.48	0.6014
0.01122	0.0154	0.1778	0.0550	2.818	0.1065	35.48	0.5856
0.01413	0.0154	0.1778	0.0617	2.818	0.1566	44.67	0.5856
0.01413	0.0174	0.2239	0.0617	3.548	0.1566	44.67	0.6764
0.01778	0.0174	0.2239	0.0690	3.548	0.1758	56.23	0.6764
0.01778	0.0195	0.2818	0.0690	4.467	0.1758	56.23	0.9488
0.02239	0.0195	0.2818	0.0775	4.467	0.2647	70.79	0.9488
0.02239	0.0218	0.3548	0.0872	5.623	0.2647	70.79	0.8287
0.02818	0.0218	0.4467	0.0872	5.623	0.3514	89.13	0.8287
0.02818	0.0245	0.4467	0.1010	7.079	0.3514	89.13	1.5812
0.03548	0.0245	0.5623	0.1010	7.079	0.1244	112.2	1.5812
0.03548	0.0275	0.5623	0.1149	8.913	0.1244	112.2	4.1082
0.04467	0.0275	0.7079	0.1149	8.913	0.1213	141.3	4.1082
0.04467	0.0310	0.7079	0.1309	11.22	0.1213	141.3	6.4103
0.05623	0.0310	0.8913	0.1309	11.22	0.4543	177.8	6.4103
0.05623	0.0347	0.8913	0.0467	14.13	0.4543	177.8	2.9032
0.07079	0.0347	1.122	0.0467	14.13	1.6898	223.9	2.9032
0.07079	0.0390	1.122	0.0903	17.78	1.6898	223.9	4.0825
0.08913	0.0390	1.413	0.0903	17.78	0.9128	281.8	4.0825
0.08913	0.0437	1.413	0.1324	22.39	0.9128	281.8	2.2695
0.1122	0.0437	1.778	0.1324	22.39	0.5690	354.8	2.2695
0.1122	0.0487	1.778	0.1328	28.18	0.5690		

F.3.1.3.3 TRANSIENT REQUIREMENTS

The EXPRESS subrack payload **shall** meet the transient limits per paragraph N.3.1.2.3.

F.3.1.3.4 CONSTRAINTS FOR ARIS EXPRESS RACK ACTIVITY

Note that there is currently no ARIS operating in an EXPRESS rack. If ARIS is reactivated in the future for EXPRESS, this guideline will apply.

The payload is inaccessible when ARIS is operating. The payload located in an ARIS rack *should* not require physical access from the flight crew while the ARIS isolation system is active. This includes operation of switches, key pads, latches, doors, dials, or any other device that the flight crew must physically contact.

F.3.2 ELECTRICAL INTERFACE REQUIREMENTS

F.3.2.1 ELECTRICAL POWER CHARACTERISTICS AND INTERFACES

F.3.2.1.1 VOLTAGE LEVELS

The EXPRESS Rack will provide the interface voltage levels as shown in Figure F.3.2.1.1-1 at current ranges of 1.0 to 20.0 A for all operational turn “on” and turn “off” events

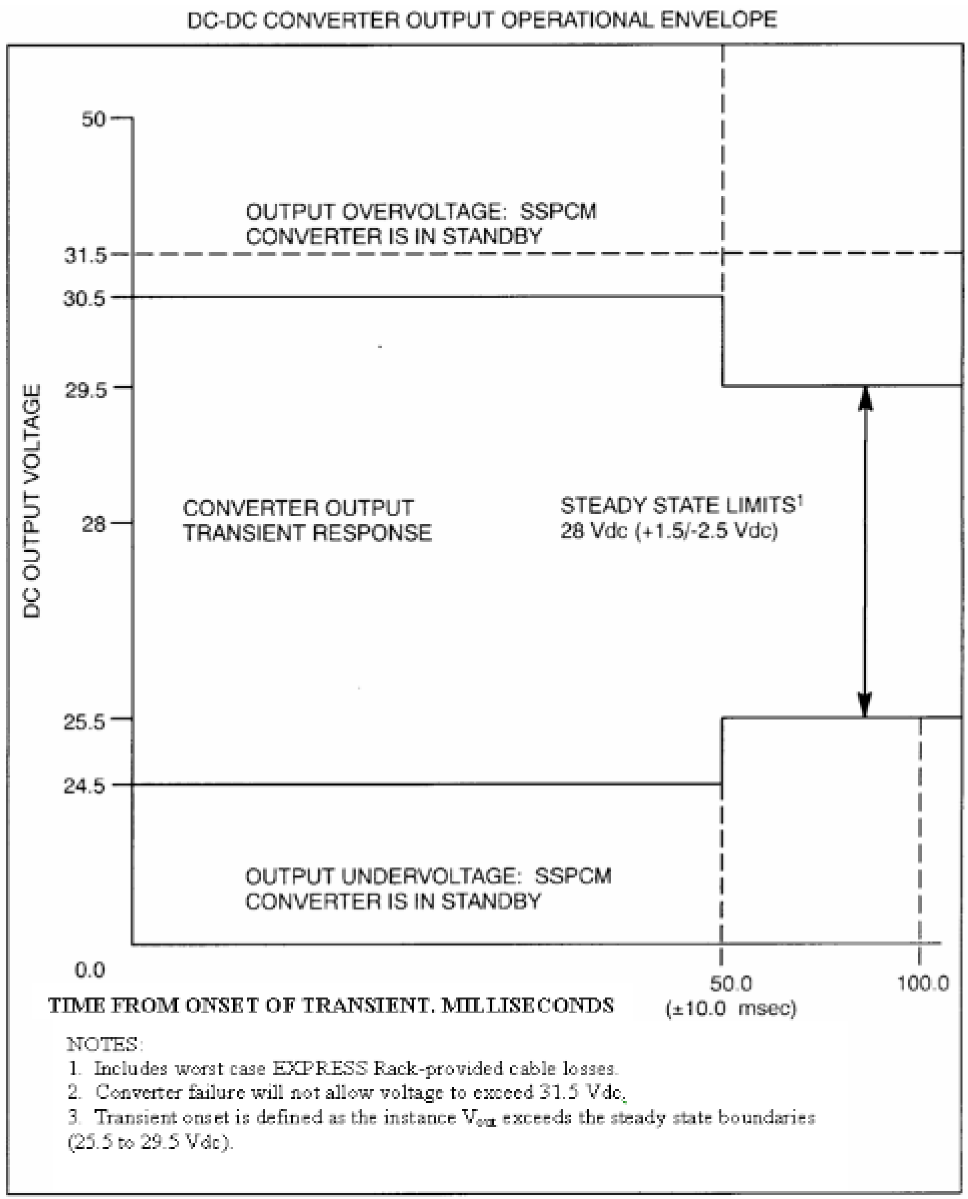


FIGURE F.3.2.1.1-1 1-A TO 20-A (PAYLOAD CURRENT DRAW), 28 VDC OUTLET CHARACTERISTICS

F.3.2.1.2 EXPRESS REVERSE CURRENT CHARACTERISTICS

The EXPRESS Rack reverse current characteristics are defined in Table F.3.2.1.2-1.

TABLE F.3.2.1.2-1 EXPRESS RACK REVERSE CURRENT CHARACTERISTICS

POWER PARAMETER	LIMITS/RATING	VALUE
Reverse Current	Pulse t < 10 μsec Peak t < 1 msec/All Ratings Steady-State (t > 1 sec)/All Ratings	600 A 450 A 2 A
Reverse Energy Capacitive Inductive	 All Ratings All Ratings	 4 Joules 2 Joules

Note:
Temperature reference is 25 °C.

F.3.2.1.3 REVERSE CURRENT

Reverse current is defined as the current flowing into an SSPCM power output from an external source of energy. Reverse current from each payload connection **shall** not exceed the values defined in Table F.3.2.1.2-1.

F.3.2.1.4 REVERSE ENERGY

Reverse energy is defined as the energy flowing into an SSPCM power output from an external source of energy. Reverse energy from each payload connection **shall** not exceed the values defined in Table F.3.2.1.2-1.

This requirement can also be satisfied when the analysis shows the payload's input is capacitive and ≤50 μF/A of the SSPC rated output current.

F.3.2.1.5 SOFT START/STOP

The SSPC provides a soft start/stop of approximately one (1) ms to reach nominal current or to turn "OFF".

F.3.2.1.6 OVERLOAD PROTECTION

The direct current (DC) power is provided to each payload via software commandable SSPCMs. Refer to Figure F.3.2.1.6-1 for a simplified schematic of the power distribution subsystem. Each SSPC may be set via software commands to output current ratings of 5 A, 10 A, 15 A, and 20 A. The trip characteristics for the SSPCs are presented in Figure F.3.2.1.6-2. The family of curves is indicated for 5-A, 10-A, 15-A, and 20-A SSPCM settings.

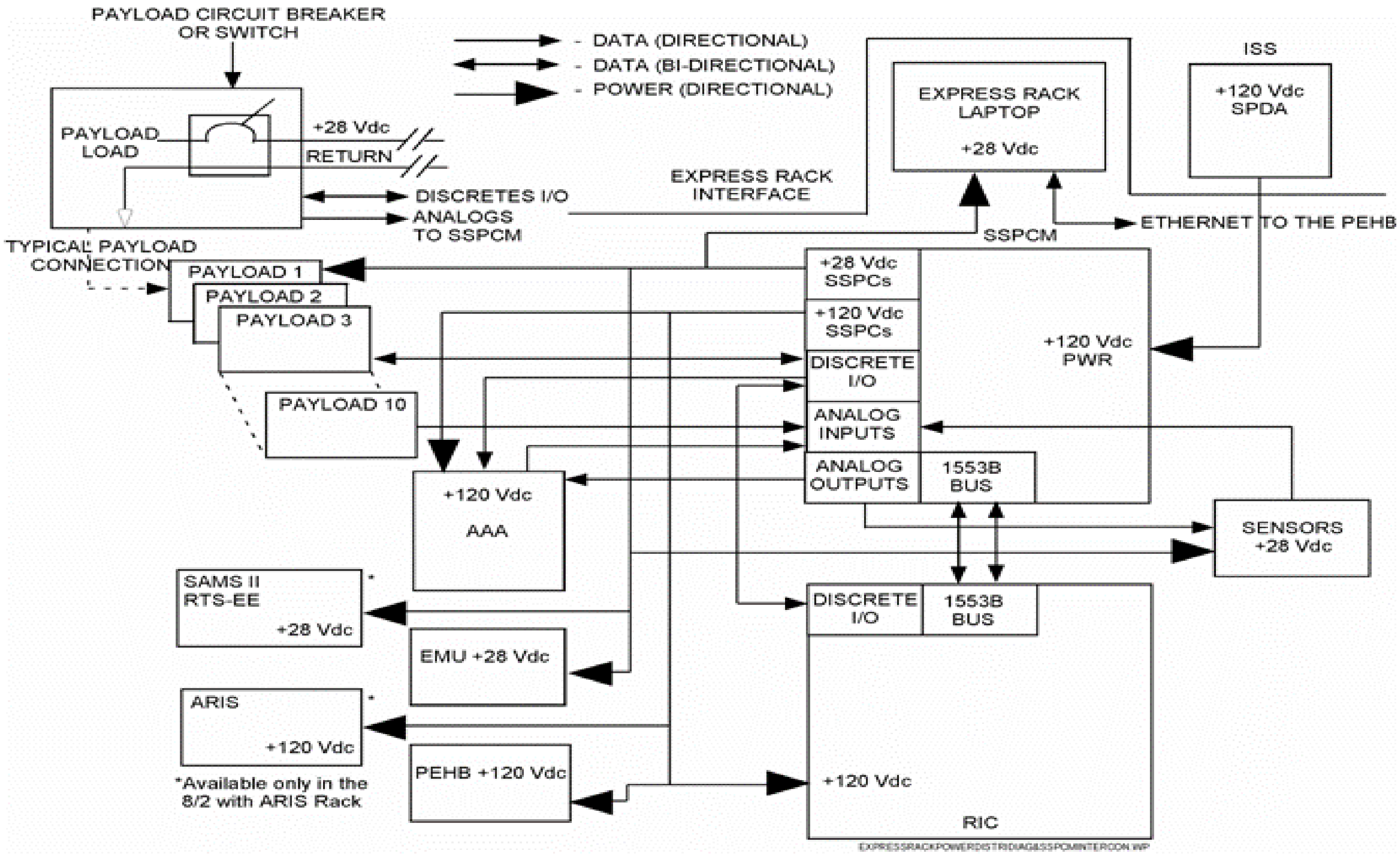
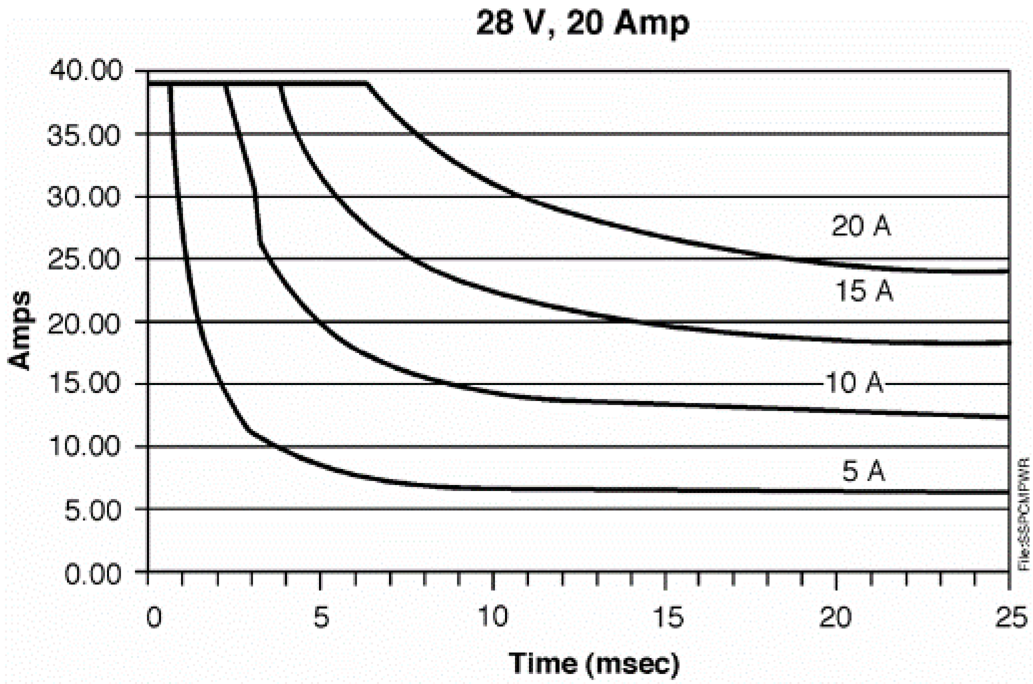


FIGURE F.3.2.1.6-1 EXPRESS RACK POWER DISTRIBUTION DIAGRAM AND SSPCM INTERCONNECTIONS



NOTES:

1. Current limit region shown above is defined for a capacitor load charge. In a direct short condition the actual trip time is ½ of the values shown.
2. For a progressive short in which the change in current has a slow rise time, an absolute maximum current limit of 2.5 times the normal current limit is provided. The time to trip for this condition is dictated by the I2 x t trip limit.
3. Final current limit is obtained within 100 µsecs and the initial current limit is a maximum of 2 times the final. Maximum 78 A ±20% (short circuit current).
4. The current limit is 39.0 A +20 %.
5. The trip values for the long-duration portion of the trip curves are a nominal 120 % of range.

FIGURE F.3.2.1.6-2 SSPCM TRIP CURVE

F.3.2.1.7 CURRENT LIMITING

A. The SSPC is a current limiting device. Each power output of the SSPCM will limit the current within 100.0 µs of an over current to a value less than the maximum current limit value as depicted in Figure F.3.2.1.6-2. The payload equipment *should* be compatible with the current limit depicted in Figure F.3.2.1.6-2, including after a 100 msec power transition for payload equipment needing automatic failover to auxiliary power (reference paragraph F.3.2.1.9.2).

B. The SSPC will activate to a resistive load sized for the rated output current or a capacitive load of 50 µF/A of rated output current. The payload equipment **shall** be compatible with this specification.

C. Wire derating is addressed in paragraph 3.2.1.2.2.

Note: The 28 Vdc power and return wire must be sized to carry 24 A to the payload's first overload protection device. This maximum current considers two failures (incorrect setting of the SSPCM output to 20 A and a "Smart Short").

F.3.2.1.8 RIPPLE LIMITS

Ripple limits for electrical power provided by the EXPRESS Rack SSPCM at the indicated interfaces will not exceed the voltage values shown in Figure F.3.2.1.8-1. Payloads will be compatible with these characteristics.

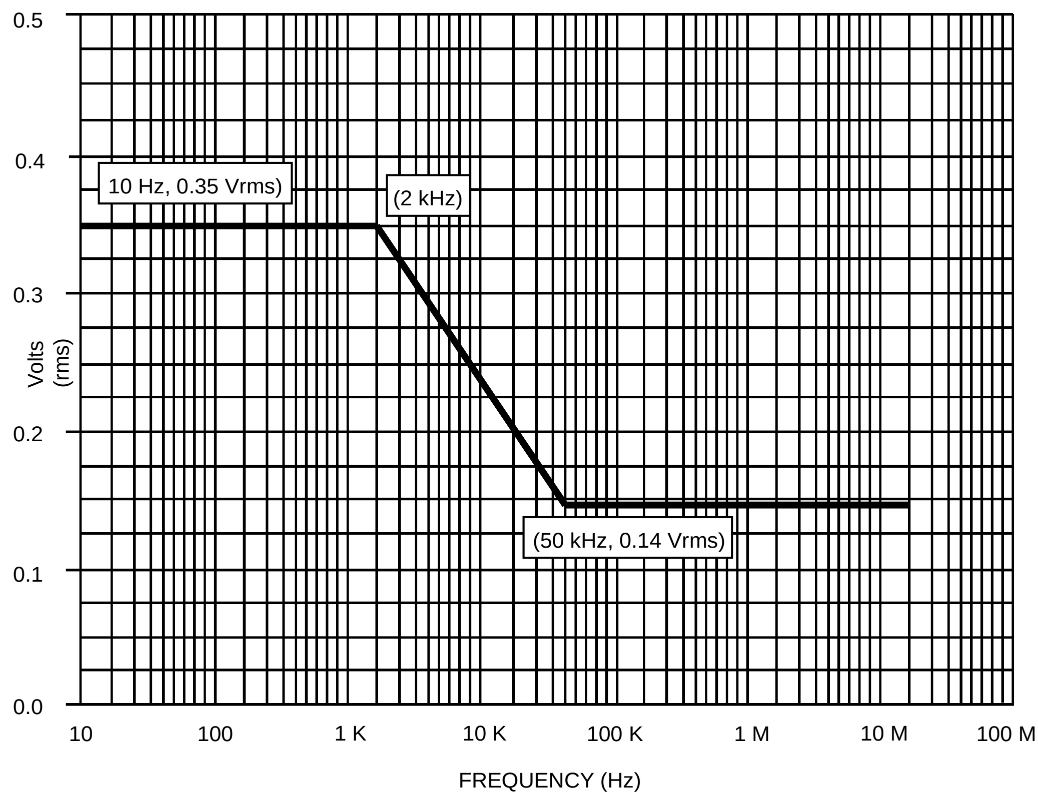


FIGURE F.3.2.1.8-1 MAXIMUM RIPPLE VOLTAGE SPECTRAL COMPONENTS FOR 28 VDC INTERFACE (SSPCM OUTPUT)

F.3.2.1.9 LIMITATIONS ON PAYLOAD UTILIZATION OF ELECTRICAL POWER

F.3.2.1.9.1 POWER LOSS DUE TO RACK POWER CYCLE

When the Payload Operations and Integration Center (POIC) needs to deactivate and reactivate the EXPRESS Rack, payloads will be without power for 45 minutes. Payloads *should* be designed to withstand up to 45 minutes without EXPRESS-supplied power.

F.3.2.1.9.2 PAYLOADS REQUESTING CAPABILITY FOR FAILOVER TO AUXILIARY POWER

The EXPRESS Rack Solid State Power Controller Module (SSPCM) Relay Drivers circuit is used to select either the Main Power input, which is the preferred secondary power bus, or the Auxiliary Power input depending on which ISS secondary power bus is operational. During nominal operations, if the Main Power voltage drops below +107 Vdc for 5 msec the SSPCM will open all Solid State Power Controllers (SSPCs). Then the SSPCM will transfer from the Main Power input to the Auxiliary Power input until Main Power is restored. The SSPCs for Auxiliary Power configuration, as specified in the initial state assignments, are then closed. Upon restoration of Main Power input for 10 seconds, the SSPCM will open all SSPCs. Then the SSPCM will transfer from Auxiliary Power to Main Power, and reconfigure the SSPCs as specified by the under-voltage recovery bit in the initial state assignments. This transfer function from one power input to the other (Main Power and Auxiliary Power) is completed within 100 msec.

Auxiliary power is used to provide backup power to pre-defined keep-alive payloads when Main Power fails.

Note: Keep-alive payloads are defined as payloads which will potentially have loss of science in the event of power interruptions greater than 45 minutes.

F.3.2.1.10 CONNECTOR/PIN INTERFACES

A. Connector pin functions for payloads using EXPRESS provided power cables **shall** be as shown in Table F.3.2.1.10-1, Power Interface Connector For Payloads Using EXPRESS Provided Power Cables.

TABLE F.3.2.1.10-1 POWER INTERFACE CONNECTOR FOR PAYLOADS USING EXPRESS PROVIDED POWER CABLES

EXPRESS CABLE CONNECTOR: NB6GE14-4SNT			MATING CONNECTOR ON PAYLOAD: NB0E14-4PNT
PIN	**FUNCTION**	**AWG**	**SIGNAL NAME**
A	+28 V Power	12	Power
B	Not Used	12	N/A
C	28 V Return	12	Power Return
D	Ground	12	Ground

B. Payloads that do not use EXPRESS provided power cables and the power interface connector in Table F.3.2.1.10-1 **shall** be compatible with the MIL-SPEC connectors and use the mating connector and pin functions per Table F.3.2.1.10-2, Alternate Power Interface Connector to Interface with the EXPRESS Rack. The payload is responsible for the interface cable and mating connector.

TABLE F.3.2.1.10-2 ALTERNATE POWER INTERFACE CONNECTOR TO INTERFACE WITH THE EXPRESS RACK

EXPRESS CONNECTOR: MS27468T17F6SN			MATING CONNECTOR: MS27467T17F6PN
PIN	**FUNCTION**	**AWG**	**SIGNAL NAME**
A	+28 V Power	12	Power
B	28 V Return	12	Power Return
C	Ground	12	Ground
D	Reserved	12	N/A
E	Reserved	12	N/A
F	Reserved	12	N/A

C. Connector pin functions for ISIS drawer payloads **shall** be as shown in Table F.3.2.1.10-3, Power Interface Connector Definition For ISIS Drawers.

TABLE F.3.2.1.10-3 POWER INTERFACE CONNECTOR DEFINITION FOR ISIS DRAWERS

EXPRESS CONNECTOR: M83733/2RA018			MATING CONNECTOR: M83733/3RA018	
PIN	**FUNCTION**	**AWG**	**SIGNAL NAME**	**COMMENT**
1	+28 V Power	12	Power	0 - 20 A
2	+28 V Return	12	Power Return	
3	Reserved	12	N/A	
4	Reserved	12	N/A	
5	Reserved	12	N/A	
6	Reserved	12	N/A	
7	Reserved	12	N/A	
8	Reserved	12	N/A	
9	Reserved	12	N/A	
10	Reserved	12	N/A	
11	Reserved	12	N/A	
12	Ground	12	Ground	
13	Reserved	12	N/A	
14	Reserved	12	N/A	
15	Reserved	12	N/A	
16	Reserved	12	N/A	
17	Reserved	12	N/A	
18	Reserved	12	N/A	

F.3.2.2 ELECTROMAGNETIC COMPATIBILITY (EMC)

General requirements contain Electrical Grounding (3.2.1.4), Electrical Bonding (3.2.2.8), and Electromagnetic Compatibility (3.2.2) requirements applicable to all payloads.

F.3.2.3 ELECTRICAL BONDING OF PAYLOAD HARDWARE

Equipment which generates and/or is susceptible to RF interference must have a Class R bond (see note below). In addition, the metallic shells of all external electrical connectors must be electrically bonded to the payload equipment case or the payload equipment bulkhead mount with a DC resistance of less than 2.5 milliohms per joint.

Note: Insert payloads are inserted into lockers without provisions for a mated surface bond. If inserts meet their EMI/EMC requirements bonded solely through their interface cables, the Class H bond generated by the interface cables will be acceptable in place of the Class R bond.

Wire harness shields external to equipment, requiring grounding at the payload equipment, must have provisions for grounding the shields to the payload equipment through the harness connector backshell or for carrying single point grounded shields through the connector pins.

F.3.2.3.1 PRIMARY PAYLOAD POWER CONNECTOR BOND

The DC resistance from the payload's power connector ground pin (pin D for MLEs or pin 12 for ISIS drawers) to the payload's external conductive chassis **shall** comply with the Class H general requirement 3.2.2.8.1.

Notes: The primary payload Class H bond path is through the rack-to-payload power connector interface. The bond path is through a single 12-American Wire Gauge (AWG) wire in the power connector capable of carrying a current of 24 A.

EXPRESS subrack payloads must meet Class R bond per General requirement 3.2.2.8.2.

F.3.2.3.2 PAYLOAD-TO-EXPRESS RACK MATED SURFACE BOND

A. Removable bonds are those that are expected to be mated or demated as part of the EXPRESS Rack interface. The payload-to-EXPRESS Rack mated surface bond (defined as the payload, adapter plate, or MLE surface that attaches to the EXPRESS Rack backplate) is a removable bond and *should* be nickel or nickel plated per SSP 30245.

B. All aluminum surfaces used for permanent bonding in the payload *should* be originally cleaned to bare metal, then chemically filmed per MIL-DTL-5541F, Chemical Conversion Coatings on Aluminum and Aluminum Alloys, Class 3 (gold alodine 1200LN9368 or equivalent) or nickel plated using methods in MIL-C-26074D, Coatings, Electroless Nickel Requirements for, Class 4, Grade A.

F.3.2.4 GROUNDING

Grounding requirements for the EXPRESS subrack payload are addressed in section 3.2.1.4.

F.3.2.4.1 GROUNDING ISOLATION

EXPRESS Rack DC power supplied to a payload is structure referenced in the EXPRESS Rack and DC isolated from structure ground at the payload by greater than 1 megohm with a parallel capacitance of $\leq$10 µF. The EXPRESS Rack primary DC power return system is a combination of a hardwired return system and a structure-return system, with the use of the wire return restricted to specific load-sensitive areas.

F.3.3 COMMAND AND DATA HANDLING INTERFACE REQUIREMENTS

Command and Data Handling requirements for the EXPRESS subrack payload are addressed in Appendix I.

F.3.4 PAYLOAD NTSC VIDEO INTERFACE REQUIREMENTS

Note: Failure to meet the NTSC video requirements can result in unusable video when the source is routed to the Integrated Communications Unit (ICU) for downlink. The payload source that fails to meet the EIA-RS-170A for color and EIA-RS-170 for monochrome video requirements can cause synchronization issues within the end to end video system.

Recommendation: Perform an engineering evaluation using the payload source and related electronics with the ISS Video Distribution System (VDS) and ICU.

F.3.4.1 DIFFERENTIAL SIGNAL

A. The payload **shall** provide an analog balanced differential video output signal which is derived from the single-ended video signal specified by SMPTE 170M, Television – Composite Analog Video Signal – NTSC for Studio Applications.

B. When differentially terminated in 75 ohms, the differential signal **shall** have the same color encoding, timing, and relative signal levels as defined by SMPTE 170M.

F.3.4.2 INPUT IMPEDANCE

The payload video balanced differential output **shall** be designed with a 75-ohm source impedance, which is equivalent to a single 37.5 ohm resistance across each of the differential legs, and ensures the payload output circuit impedance is matched with the transmit line. Each payload differential video signal is terminated at the receiver (EXPRESS Rack) end of the transmission line with a 75 ± 5 ohm resistor across the differential lines.

F.3.4.3 SYNC TIP AND WHITE REFERENCE

A. The positive pin of the balanced differential output **shall** provide a nominal 0.5 V (Volt) peak to peak signal with sync tip (-40 Institute of Radio Engineers (IRE) in SMPTE 170M) at 0 V and peak white (100 IRE in SMPTE 170M) at 0.5 V.

B. The negative pin of the balanced differential output **shall** provide a nominal 0.5 V peak to peak signal, in phase quadrature (inverted) to the positive output, with sync tip (-40 IRE in SMPTE 170M) at a nominal 0 V and peak white (100 IRE in SMPTE 170M) at a negative 0.5 V.

(Note: As specified in SMPTE 170M for color video signals, the encoded subcarrier may exceed peak white levels).

F.3.4.4 BLANKING LEVEL

The standard blanking level value is (0 IRE in SMPTE 170M) 0.143 V at the positive pin and a nominal - 0.143 V at the negative pin.

F.3.4.5 COMMON VOLTAGE MODE

The balanced differential output *should* have no more than a ± 0.1 Vdc common mode component measured with respect to the input ground reference pin.

F.3.4.6 DEVIATIONS TO VIDEO STANDARD

SMPTE 170M specifies very tight tolerances on video timing and signal levels. The actual video performance requirements for a payload source will be determined by the intended use by that individual payload. Where individual payload video performance requirements are less stringent, the following deviations are permitted to relax required video tolerances:

A. The video source may provide a monochrome video signal, which contains no color burst.

B. The video source may provide a color video signal in which the phase of color burst is not defined with respect to the leading edge of horizontal sync.

C. The video source may provide a color video signal in which the frequency of color subcarrier deviates from nominal as specified in SMPTE 170M by up to ± 100 parts per million, provided that the rate of change of subcarrier frequency does not exceed 0.1 Hz per second.

D. The video source may provide a video signal in which the timing of horizontal and vertical synchronization pulses deviates from nominal as specified in SMPTE 170M by up to ± 100 parts per million, provided that the rate of change of horizontal or vertical timing does not exceed 0.3 parts per million per second.

E. The video source may relax the tolerance specified in SMPTE 170M on the relative amplitudes of sync tip and peak white to -40 ± 4 IRE and 100 ± 10 IRE respectively.

F.3.5 THERMAL CONTROL INTERFACE REQUIREMENTS

<u>Data Deliverable:</u> Provide payload thermal and fluid interfaces data in Table F.3.5-1.

TABLE F.3.5-1 PAYLOAD THERMAL AND FLUID INTERFACES DATA

Hardware Item	Interface Type	Characteristics	Remarks
	Moderate Temp Water Loop	For each mode of operation: Flow Rate: xxx lbm/hr Heat to Loop: xxxx.x W (max/min) Volume: xxx.xx liters Power: xxx.x kW	
	Vacuum Exhaust System Waste Gas System	For each mode of operation: Provide a list of vented gases to include the constituent vented, the total mass vented, initial temperature, initial pressure, concentration of the constituent, mass flow rate, frequency and duration of venting operations, and pressure versus time curve at the payload interface.	
	GN2	For each mode of operation: Flow Rate: xxx.xx lbm/hr Quantity: xxxx.x lbm	
	Avionics Air (Interface to the ER AAA)	For each mode of operation: Flow Rate: xxx.x CFM (include P/L Fan(s)) Heat to Loop: xxxx.x W (max/min)	

F.3.5.1 CONVECTIVE HEAT TRANSFER COEFFICIENT

The ISS design value for the convective heat transfer coefficient from the payload enclosure to the ISS cabin environment is 0.20 British Thermal Unit (BTU)/hr °F ft^2 (1.14 W/m^2 °C) for 14.7 psia. This value must be used in thermal analysis/testing.

F.3.5.2 REMOVAL OF WASTE HEAT

The payload **shall** use the EXPRESS Rack Avionics Air Assembly (AAA) for removing waste sensible heat only.

F.3.5.3 CABIN AIR USAGE

The subrack payload *should* use the cabin air for control of humidity, carbon dioxide, oxygen, and the release of any other gaseous components.

F.3.5.4 PAYLOAD DEBRIS TRAPS

The payload with the ability to generate particulates or debris **shall** provide protection against cabin air contamination by providing a filter of size ≤280 μm.

F.3.5.5 AAA PHYSICAL INTERFACE

In the EXPRESS Rack the AAA supply and return air ducts are not physically connected to the payload inlet and outlet interface. Figure F.3.5.5-1 provides the schematic for the AAA supply and return ducts. The return air is collected by four return air duct inlets located between each MLEs before returning to the AAA.

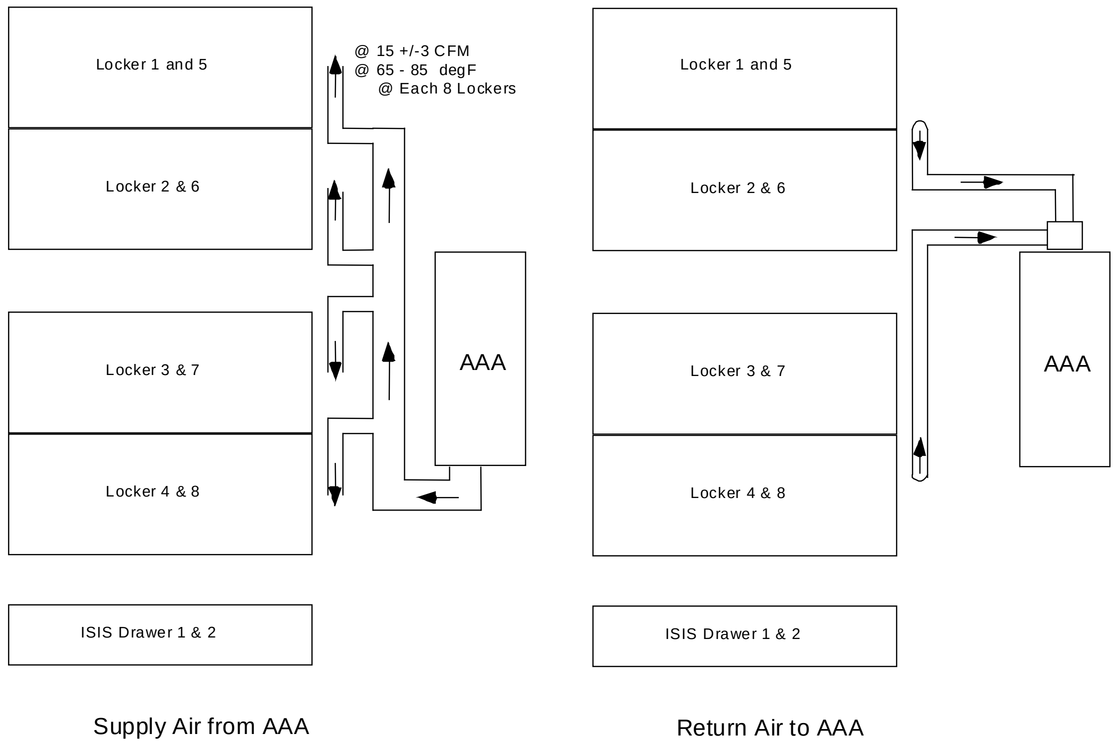


FIGURE F.3.5.5-1 AVIONICS AIR DISTRIBUTION SCHEMATICS WITHIN THE EXPRESS RACK

F.3.5.5.1 MLE AVIONICS AIR INTERFACE

The avionics air cooling for the EXPRESS Rack-mounted payload in MLE positions will be provided to the backplate as shown in Figure F.3.1.2.1-1. The payload's physical interface *should* be compatible with this interface. The avionics air supply and return ducts are not physically connected to the payload's air inlet and outlet. AAA supplies conditioned air behind the MLE backplate near these air inlets as shown in Figure F.3.5.5-1.

F.3.5.5.2 ISIS DRAWERS INTERFACE

Figure F.3.5.5.2-1 illustrates the location of the ISIS drawer air inlets and outlets. The payload's physical interface *should* be compatible with this interface. The AAA supply duct is neither physically connected nor ducted to the inlets of the ISIS Drawers. The nearest AAA supply ducts are located near the MLEs 4 and 8 inlets.

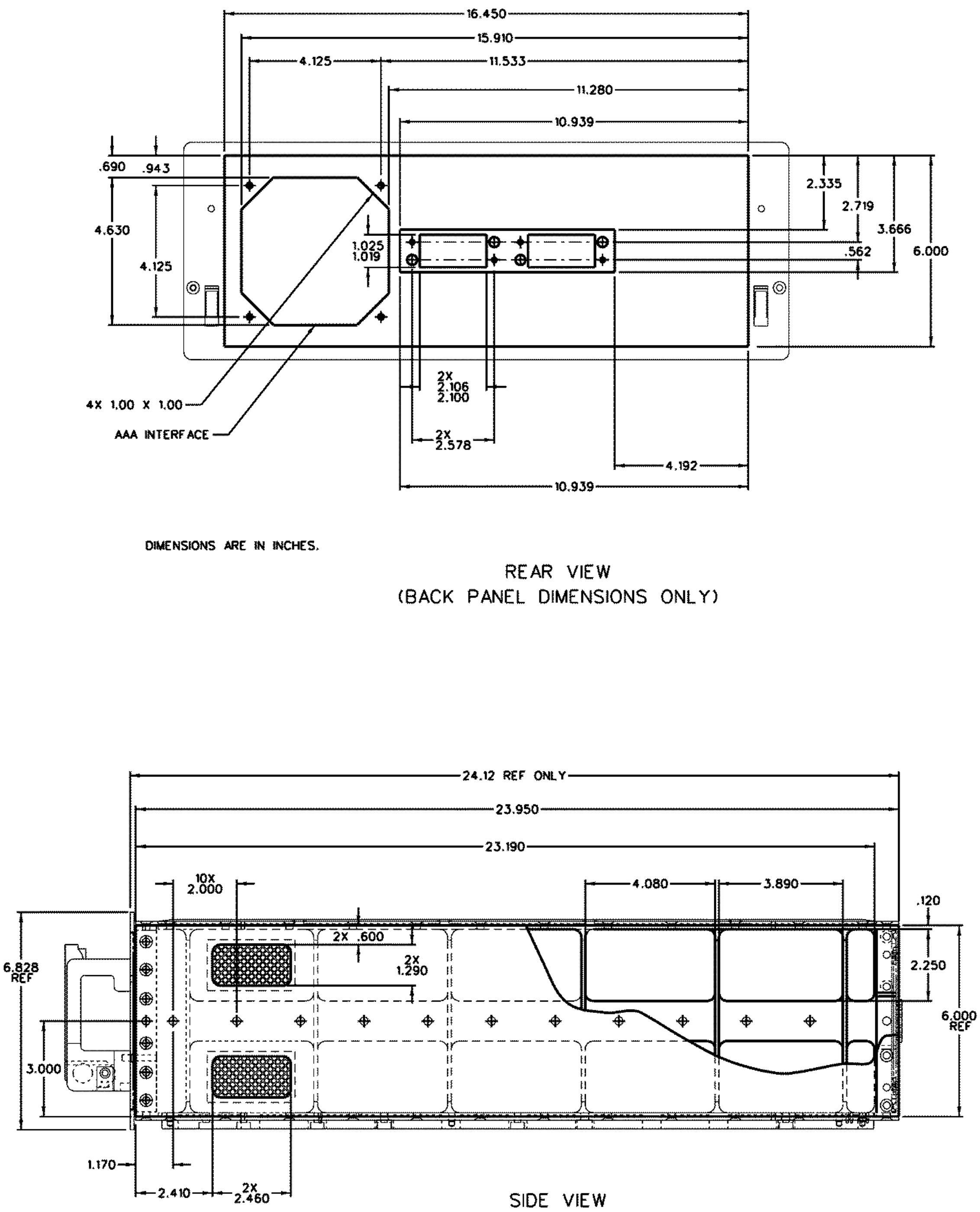


FIGURE F.3.5.5.2-1 POWERED ISIS DRAWER POWER AND DATA CONNECTOR AND FAN INLET/EXHAUST LOCATIONS

F.3.5.5.3 FANS

The payload using AAA *should* provide its own fan for drawing air from the rear open volume of the EXPRESS Rack and for internal air circulation for both the MLE interface and the ISIS drawer interface.

F.3.5.5.4 DUCTED PAYLOAD CONTAMINATION PROTECTION

The ducted payload design *should* be compatible with ingestion of up to one (1) gram of lint-like contamination from the cabin and/or 1.0 square inch material blockage or provide protection from that contamination.

F.3.5.6 AIR SUPPLY TEMPERATURE

The payload *should* be compatible with the nominal temperature of the avionics air supplied by the AAA between 65 to 85 °F (18.3 to 29.4 °C) for MLEs and between 65 to 95 °F (18.3 to 35 °C) for ISIS drawers. The actual EXPRESS Rack avionics air temperature is driven by the heat load recirculated into the AAA system by the specific EXPRESS subrack payload complement.

Note: Internal temperature sensors in the payload hardware (even though not required) will enhance the determination of the actual/real-time temperature due to air mixing and configuration changes in the EXPRESS Rack.

F.3.5.7 AIR SUPPLY FLOW RATE

A. The payload *should* be compatible with the EXPRESS Rack AAA supplied conditioned air at a flow rate of 15±3 cubic feet per minute (cfm), which is supplied near the eight MLE inlets.

B. The ISIS drawer payload *should* be compatible with the EXPRESS Rack AAA supplied conditioned air at a flow rate of 15±3 cfm. The avionics air is supplied to the nearest MLEs (MLE 4 and 8) at a flow rate of 15±3 cfm.

Note: The payload with an air flow requirement greater than 15 cfm must draw air from the rear area of the rack. The exhaust air recirculation effect must be considered in determining the payload's inlet air temperature. The payload’s inlet air temperature depends upon the avionics air temperature and the recirculation of its own exhaust air temperature. For example, a payload uses a 25 cfm fan to circulate air from EXPRESS Rack AAA. The payload’s average air inlet temperature will result in a combination of air consisting of EXPRESS AAA supply air provided at a flow rate of 15 cfm (nominal) and the recirculation of payload exhaust air at a flow rate of ten (10) cfm at the payload’s exhaust air temperature.

F.3.5.8 AIR RETURN TEMPERATURE

The maximum exhaust air return temperature from the payload to the EXPRESS Rack avionics air loop **shall** not exceed 120 °F (48.9 °C) for either an ISIS drawer or MLE-type payload, given AAA supplied Avionics air of 15 cfm at 85 °F (29.4 °C) for MLE and 95 °F (35 °C) for ISIS Drawers.

F.3.5.9 PAYLOAD INLET DEBRIS TRAPS

The payload interfacing to the EXPRESS Rack avionics air system *should* be filtered at the payload inlet with a filter of size ≤280 μm.

F.3.5.10 PAYLOAD LIMITATIONS ON HEAT CONDUCTED TO STRUCTURE

The payload *should* not design to account for conducting payload heat to the rack structure. It is intended that all payload internal temperature requirements be met by heat rejection to only the cooling water loops, cabin ambient air, and avionics air cooling circulated through the payload. The payload does not need to be designed to be thermally isolated from the rack structure.

F.3.5.11 CABIN AND AAA AIR MIXING LIMITATIONS

The payload exchanging air with the cabin, and using the avionics air cooling, **shall** preclude mixing of the two air sources. This ensures isolation of the fire protection zone of the rack that is monitored by the rack smoke detector.

Note: When a subrack payload is removed from the EXPRESS rack, it is the responsibility of the ISS Program to prevent mixing of cabin and AAA air by mounting a cover plate or replacement payload in the vacated location.

F.3.5.12 WATER COOLING INTERFACE REQUIREMENTS

The EXPRESS Rack provides two interface connections to the ISS moderate temperature water loop. A total of 200 lb/hr is available and will be suballocated to each payload by the rack integrator.

F.3.5.12.1 PHYSICAL INTERFACE

The payload requiring EXPRESS Rack-provided water cooling *should* interface to the EXPRESS Rack-provided Quick Disconnect (QD) at the end of the water line as shown in Figure F.3.5.12.1-1, Moderate Temperature Water Loop Physical Interface. Physical dimensions of the MTL QDs (-219, -247, -1248 and -1249) can be found in drawing 683-16348. Standard water lines and QDs will be provided to the PD from the EXPRESS Rack Office. The PD will consider the QD in all of the required design analyses (e.g., leakage, ΔP, etc.).

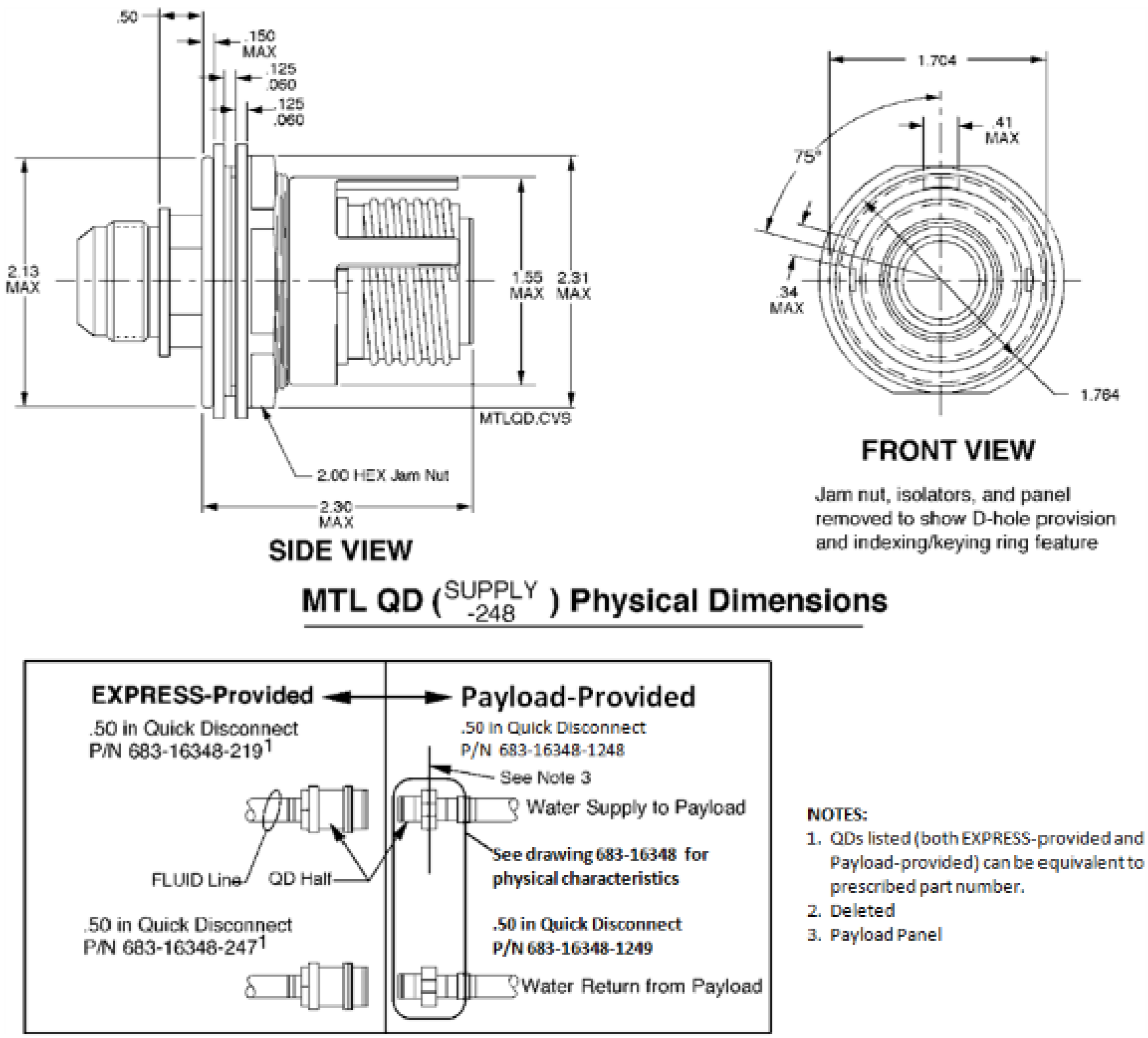


FIGURE F.3.5.12.1-1 MODERATE TEMPERATURE WATER LOOP PHYSICAL INTERFACE

F.3.5.12.2 WATER LOOP PRESSURE DROP

The pressure drop between the inlet and outlet QDs (including the QDs and connecting hoses) of the payload utilizing the EXPRESS Rack water cooling system interface **shall** be 2.80 ± 0.15 pounds per square inch differential (psid) (19.3 ± 1.03 kPa) at the desired flow rate.

F.3.5.12.3 LEAK RATE

The total allowable leakage of water by the payload equipment **shall** be less than 0.002 cc/hr at 121 psia (834 kPa).

F.3.5.12.4 WATER COOLANT FLOW RATE

The payload requiring the water cooling system *should* be designed to a value within the available range of 50 to 200 lbm/hr.

F.3.6 VACUUM SYSTEM REQUIREMENTS

F.3.6.1 VACUUM EXHAUST SYSTEM (VES)/WASTE GAS SYSTEM (WGS) REQUIREMENTS

The EXPRESS Rack provides one interface to the ISS VES/WGS. The EXPRESS Rack does not provide an interface to the ISS Vacuum Resource System (VRS).

F.3.6.1.1 PHYSICAL INTERFACE (USL, COL, JEM)

The payload requiring ISS-provided VES/WGS vacuum exhaust services *should* interface to the EXPRESS Rack-provided QD at the end of the VES/WGS lines as shown in Figure F.3.6.1.1-1. Physical dimensions of the VES QDs (-1058 and -60) can be found in drawing 683-16348. Standard vent lines and QDs will be provided to the PD from the ISS Program. The PD must consider the QD in all of the required design analyses (e.g., leakage, ΔP, flow, etc.).

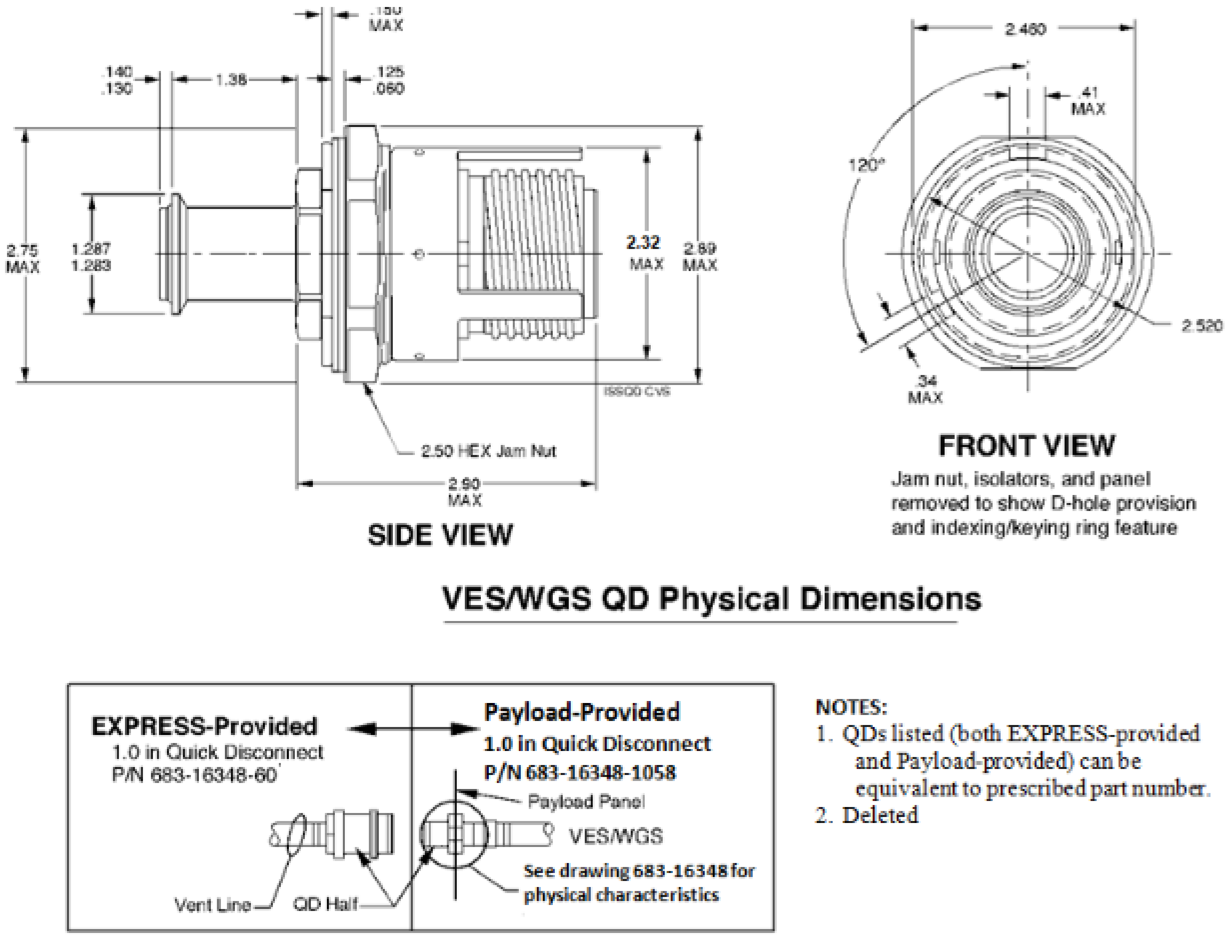


FIGURE F.3.6.1.1-1 VES/WGS PHYSICAL INTERFACE

F.3.6.1.2 INPUT PRESSURE LIMIT (USL, COL, JEM)

The input pressure limit requirements **shall** be per paragraph N.3.6.1.2.

F.3.6.1.3 INPUT TEMPERATURE LIMIT (USL, COL, JEM)

The initial input temperature of gases disposed into the VES/WGS by the payload **shall** be 60 to 113 °F (16 to 45 °C).

F.3.6.1.4 INPUT DEWPOINT LIMIT (USL, COL, JEM)

The initial dewpoint of gases disposed into the VES/WGS by the payload **shall** be ≤60 °F (15.5 °C).

F.3.6.1.5 ACCEPTABLE EXHAUST GASES (USL, COL, JEM)

A. Payload exhaust gases that are vented into the ISS VES/WGS of the USL, COL, and JEM **shall** be per paragraph N.3.6.1.5.A

B. Payload gases disposed into the ISS VES/WGS of the USL, COL, and JEM must be compatible with the EXPRESS Rack wetted materials listed below.

304 CRES
15-5 CRES
316L CRES
321 CRES
347 CRES
6AL-4V Titanium
302 CRES
301 CRES
316 CRES
Nedox
Chemlock 236A Bonding Agent/Chemlock 205 Primer
EPR (Ethylene Propylene Rubber)
Teflon
815Z Braycote Lubricant

F.3.6.1.6 ACCEPTABLE GASES (USL, COL, JEM)

A. Payload exhaust gases vented to the ISS VES/WGS **shall** be non-reactive with other vent gas mixture constituents created by the respective payload.

B. The payload venting to the ISS VES/WGS **shall** provide a means of removing gases that would adhere to the ISS VES/WGS tubing walls at a wall temperature of 40 °F (4 °C) and at a pressure of 10^{-3} torr.

C. The payload venting to the ISS VES/WGS **shall** remove particulates that are larger than 100 micrometers in size from vent gases.

F.3.6.1.7 LIMIT VES VENTING PROFILE

Data Deliverable: Provide a list of vented gases to include the constituent vented, the total mass vented, initial temperature, initial pressure, concentration of the constituent, mass flow rate, frequency and duration of venting operations, and pressure versus time curve at the payload interface.

F.3.6.1.8 UTILITY CONTROL

The payload isolation valve requirements **shall** be per paragraph N.3.6.1.6.

F.3.6.2 VACUUM RESOURCE SYSTEM (VRS)/VACUUM VENT SYSTEM (VVS) REQUIREMENTS

The EXPRESS Rack does not provide an interface to the ISS VRS.

F.3.6.3 VACUUM OUTGASSING REQUIREMENTS

Vacuum outgassing requirements **shall** be per paragraph N.3.6.3.

F.3.6.4 LIMIT AMOUNT OF VENTED GASES

A. Payloads interfacing with the VES **shall** meet the requirements listed in Table F.3.6.4-1.

TABLE F.3.6.4-1 LIMIT AMOUNT OF VENTED GASES REQUIREMENTS

SSP 57000 Requirement	Title/Subject
N.3.6.1.7.A	LIMIT AMOUNT OF VENTED GASES
N.3.6.1.7.B	LIMIT AMOUNT OF VENTED GASES

B. Payloads interfacing with the VES *should* limit individual vented gas species to the mass flow rate defined in N.3.6.1.7.C.

F.3.7 PRESSURIZED GASES INTERFACE REQUIREMENTS

Payloads interfacing to nitrogen **shall** meet the applicable requirements and guidelines and submit data deliverables per N.3.7, excluding requirement N.3.7.4 which is substituted by F.3.7.1.

F.3.7.1 LEAK RATE

The total allowable leakage by the payload equipment including payload provided quick disconnect and hoses **shall** be less than 5 x 10^{-4} sccs of GN2 at 200 psia equivalent at 70 ± 5 °F (18 to 23.9 °C).

F.3.8 PAYLOAD SUPPORT SERVICES INTERFACE REQUIREMENTS

N/A

F.3.9 ENVIRONMENT INTERFACE REQUIREMENTS

N/A

F.3.10 FIRE PROTECTION INTERFACE REQUIREMENTS

F.3.10.1 PAYLOAD USE OF BATTERY BACKUP POWER

The payload **shall** be prohibited from using battery power to maintain payload operations when power to the rack/Rack Interface Controller (RIC) is not available and/or payload Health and Status data cannot be processed/received beyond the payload or rack envelope. This requirement does not apply to aisle-deployed hardware or to small batteries used to maintain memory and data loggers.

F.3.10.2 PORTABLE FIRE EXTINGUISHER ACCESS PORT

A. Payload equipment that does not interface with the EXPRESS Rack AAA cooling system and has internal to the payload forced convection (i.e., cooling fan) **shall** have a PFE access port. This does not apply to the payload defined as a sealed container.

B. For the payload or payload equipment item that requires a PFE access port, the port **shall** be labeled with a subrack location code to clearly distinguish it from any other PFE access port. Location codes are provided by the ISS Program.

C. PFE access ports **shall** meet the requirements listed in Table F.3.10.2-1.

TABLE F.3.10.2-1 PFE PORT REQUIREMENTS

SSP 57000 Requirement	Title/Subject
N.3.10.2.1	PORTABLE FIRE EXTINGUISHER ACCESS PORT
N.3.10.2.2.A	FIRE SUPPRESSION ACCESS PORT ACCESSIBILITY
N.3.10.2.2.B	FIRE SUPPRESSION ACCESS PORT ACCESSIBILITY
N.3.10.3	PFE ACCESS PORT AND FIRE DETECTION INDICATOR LABELING

F.3.10.3 PARAMETER MONITORING

Parameter monitoring to detect a potential fire event **shall** be per requirements paragraph N.3.10.1.2.1.

F.3.11 MATERIALS AND PROCESSES INTERFACE REQUIREMENTS

F.3.11.1 FLUID CHEMICAL COMPOSITION

EXPRESS subrack payloads connecting to ISS nitrogen fluid system **shall** meet the requirement in paragraph N.3.11.1.A.

F.3.11.2 FLUID SYSTEM CLEANLINESS

EXPRESS subrack payload fluid systems connecting to the ISS nitrogen fluid system **shall** meet the requirement in paragraph N.3.11.2.A.

F.3.12 HUMAN FACTORS INTERFACE REQUIREMENTS

F.3.12.1 CONTINUOUS NOISE LIMITS

Subrack payloads operating within an EXPRESS or WORF facility **shall** not exceed the continuous noise limits in Table G.3.12.1-1 for all octave bands (NC-34 equivalent).

NOTE: This acoustic requirement does not apply during failure or maintenance operations.

F.4.0 VERIFICATION

F.4.1 RESPONSIBILITIES

The PD is responsible for providing verification for all applicable requirements in this appendix, as allocated to the payload through the payload unique ICD. The ISS Program is responsible for review and approval of the submitted verification.

F.4.2 VERIFICATION METHODS

Compliance with the requirements stated in Section F.3.0 are proven using one or more of the methods described in paragraph 4.2.

F.4.3 EXPRESS RACK TO SUBRACK PAYLOAD INTERFACE VERIFICATION REQUIREMENTS

<u>Data Deliverable</u>

F.4.3.1 PHYSICAL AND MECHANICAL INTERFACES

F.4.3.1.1 INTERNATIONAL STANDARD PAYLOAD RACK (ISPR) COORDINATE SYSTEMS (LIMITED EFFECTIVITY)

NVR

F.4.3.1.1.1 PAYLOAD COORDINATE SYSTEM

NVR

F.4.3.1.1.2 DIMENSIONS AND TOLERANCES

NVR

F.4.3.1.2 STRUCTURAL/MECHANICAL INTERFACES

F.4.3.1.2.1 ISS LOCATIONS

NVR

F.4.3.1.2.2 EXPRESS RACK MOUNTING PLATE

Verification of payload compatibility with EXPRESS rack mechanical interfaces *should* be verified by inspection of the flight hardware to show compliance with the mechanical interfaces defined in paragraph F.3.1.2.2. The verification *should* be considered successful when the inspection shows the flight hardware is in compliance with EXPRESS rack mechanical interfaces.

Note: The subrack payload launched in the EXPRESS Rack must restrict itself to either a single or double MLE configuration.

Verification Submittal: CoC

F.4.3.1.2.3 ISOLATION MATERIAL PROPERTIES

Verification of isolation material properties *should* be verified by analysis of the payload installation design that the isolation material has a minimum thickness of 0.5 inches and is compressed 25 percent. The verification *should* be considered successful when the analysis confirms the isolation material properties.

Verification Submittal: CoC

F.4.3.1.2.4 ISS-SUPPLIED LOCKERS

Verification of payload use of ISS-Supplied Lockers *should* be by inspection of the payload design that the payload is compatible with the mechanical information shown in paragraph F.3.1.2.4. Verification *should* be considered successful when the inspection shows the payload is in compliance with ISS-Supplied Locker mechanical information.

Verification Submittal: CoC

F.4.3.1.2.5 PAYLOAD DEVELOPER-SUPPLIED LOCKER LATCHES

NVR

F.4.3.1.2.6 FRONT FACE PROTRUSIONS (PERMANENT)

Verification that payload equipment remains within its required envelope **shall** be by inspection or analysis of payload drawings. Verification **shall** be considered successful when inspection or analysis of the data certification shows the payload equipment remains within the required envelope. Any new protrusions or changes to previous data certification must be provided in an updated data certification.

Verification Submittal: Data Certification (update) providing drawings identifying any new protrusions or changes to previous data certification.

F.4.3.1.2.7 PAYLOAD ATTACHMENT POINTS

Verification of payload attachment points on the payload mounting structure *should* be by inspection of the flight hardware to show compliance with the EXPRESS rack backplate interface as defined in paragraph F.3.1.2.7. The verification *should* be considered successful when the inspection shows the flight hardware is in compliance with the EXPRESS rack backplate interface.

Verification Submittal: CoC

F.4.3.1.2.8 CAPTIVE FASTENERS

Verification of captive fasteners **shall** be by inspection. Verification **shall** be considered successful when an inspection of the as-built flight hardware shows the attachment fasteners meet the requirements specified in paragraph F.3.2.1.8.

Verification Submittal: CoC

F.4.3.1.2.9 POWERED ISIS DRAWER FASTENERS

A. Verification that fasteners used to attach hardware to the powered ISIS drawer engaging inserts in the bottom plate are sized not to extend beyond the bottom surface of the bottom plate *should* be by inspection of the payload flight hardware. Verification *should* be considered successful when the inspection shows the fasteners do not extend beyond the bottom surface of the bottom plate.

Verification Submittal: CoC

B. Verification that fasteners used to attach hardware to the powered ISIS drawer installed from the outside of the drawer through the bottom plate have 100° countersunk heads set flush with the bottom surface of the bottom plate *should* be by inspection of the payload design and flight hardware. Verification *should* be considered successful when the inspection shows the fasteners have 100° countersunk heads set flush with the bottom surface of the bottom plate.

Verification Submittal: CoC

F.4.3.1.3 MICROGRAVITY

NVR

F.4.3.1.3.1 QUASI-STEADY REQUIREMENTS

The EXPRESS subrack payload *should* verify quasi-steady limits per paragraph N.4.3.1.2.1.

F.4.3.1.3.2 VIBRATORY REQUIREMENTS

Verification that the EXPRESS Rack subrack payload meets the microgravity vibratory requirement in F.3.1.3.2 **shall** be by test or analysis. Test is the preferred method of verification. Analysis may be used only to characterize narrowband disturbances such as rotating imbalances or oscillating masses where a clear analytical solution is possible. Analysis must not be used for determination of wideband disturbances. If disturbance testing is performed at the subassembly level, then the dynamic effects of the payload structure must be accounted for analytically using finite element analysis or statistical energy analysis models. The verification **shall** be considered successful when the test and/or analysis of the payload flight hardware and/or design do not exceed the allowable force limits of Figure F.3.1.3.2-1 and Table F.3.1.3.2-1.

Verification Submittal: Final Test Report

F.4.3.1.3.3 TRANSIENT REQUIREMENTS

The EXPRESS subrack payload **shall** verify transient limits per paragraph N.4.3.1.2.3.

F.4.3.1.3.4 CONSTRAINTS FOR ARIS EXPRESS RACK ACTIVITY

Note that there is currently no ARIS operating in an EXPRESS rack. If ARIS is reactivated in the future for EXPRESS, this verification guideline will apply.

Verification that the payload located in an ARIS rack does not require physical access from the flight crew while the ARIS isolation system is active *should* be by analysis. The verification *should* be considered successful when the analysis of the payload flight hardware and/or design shows that the payload located in an ARIS rack does not require physical access from the flight crew while the ARIS isolation system is active. This includes operation of switches, key pads, latches, doors, dials, or any other device that the flight crew must physically contact.

Verification Submittal: Analysis Report

F.4.3.2 ELECTRICAL INTERFACE REQUIREMENTS

F.4.3.2.1 ELECTRICAL POWER CHARACTERISTICS AND INTERFACES

F.4.3.2.1.1 VOLTAGE LEVELS

NVR

F.4.3.2.1.2 EXPRESS REVERSE CURRENT CHARACTERISTICS

NVR

F.4.3.2.1.3 REVERSE CURRENT

Verification that reverse current from each payload connection does not exceed the values defined in paragraph F.3.2.1.3 **shall** be by analysis. The verification **shall** be considered successful when the analysis shows the reverse current from each payload connection does not exceed the values defined in paragraph F.3.2.1.3.

Verification Submittal: Signed Analysis Report

F.4.3.2.1.4 REVERSE ENERGY

Verification that reverse energy from each payload connection does not exceed the values defined in paragraph F.3.2.1.4 **shall** be by analysis. The verification **shall** be considered successful when the analysis shows the reverse energy from each payload connection does not exceed the values defined in paragraph F.3.2.1.4.

This requirement can also be satisfied when the analysis shows that the payload’s input is capacitive and <50 μF/A of the SSPC rated output current setting.

Verification Submittal: Signed Analysis Report

F.4.3.2.1.5 SOFT START/STOP

NVR

F.4.3.2.1.6 OVERLOAD PROTECTION

NVR

F.4.3.2.1.7 CURRENT LIMITING

A. Verification that the payload equipment is compatible with the SSPC current limit characteristics per paragraph F.3.2.1.7.A *should* be by test. The verification *should* be considered successful when the test results show that the payload equipment is compatible with the current limit depicted in Figure F.3.2.1.6-2, including after a 100 msec power transition for payload equipment needing automatic failover to auxiliary power (reference paragraph F.3.2.1.9.2).

Verification Submittal: CoC

B. Verification that the payload is compatible with the SSPC activation characteristics per paragraph F.3.2.1.7.B **shall** be by test or analysis. The verification **shall** be considered successful when the test or analysis shows the payload equipment is compatible with the specification defined in paragraph F.3.2.1.7.B.

Verification Submittal: CoC

C. NVR

F.4.3.2.1.8 RIPPLE LIMITS

NVR

F.4.3.2.1.9 LIMITATIONS ON PAYLOAD UTILIZATION OF ELECTRICAL POWER

F.4.3.2.1.9.1 POWER LOSS DUE TO RACK POWER CYCLE

Verification that the payload can withstand up to 45 minutes without EXPRESS-supplied power *should* be by analysis or demonstration. The verification *should* be considered successful when the analysis or demonstration of the payload hardware shows that the payload will properly function after a 45 minute loss of power.

Verification Submittal: CoC

F.4.3.2.1.9.2 PAYLOADS REQUESTING CAPABILITY FOR FAILOVER TO AUXILIARY POWER

NVR

F.4.3.2.1.10 CONNECTOR/PIN INTERFACES

A. Verification that the payload connector pin functions for payloads using EXPRESS provided power cables are as defined in paragraph F.3.2.1.10.A **shall** be by inspection.

The verification **shall** be considered successful when the inspection of drawings shows the payload connector pin functions for payloads using EXPRESS provided power cables are as defined in paragraph F.3.2.1.10.A.

Verification Submittal: Inspection of drawings with CoC

B. Verification that the payload provided cable mating connector and pin functions are as defined in paragraph F.3.2.1.10.B **shall** be by inspection. The verification **shall** be considered successful when the inspection of drawings shows the payload provided cable mating connector and pin functions are as defined in paragraph F.3.2.1.10.B.

Verification Submittal: Inspection of drawings with CoC

C. Verification that the connector pin functions for ISIS drawer payloads are as defined in paragraph F.3.2.1.10.C **shall** be by inspection. The verification **shall** be considered successful when the inspection of drawings shows the connector pin functions for ISIS drawer payloads are as defined in paragraph F.3.2.1.10.C.

Verification Submittal: Inspection of drawings with CoC

F.4.3.2.2 ELECTROMAGNETIC COMPATIBILITY (EMC)

NVR

F.4.3.2.3 ELECTRICAL BONDING OF PAYLOAD HARDWARE

NVR

F.4.3.2.3.1 PRIMARY PAYLOAD POWER CONNECTOR BOND

Verification **shall** be by inspection. The verification **shall** be considered successful when the inspection of drawings and quality records (Quality records include workmanship resistance measurements) indicates that power connector ground pin connection to chassis complies with the Class H general requirement 3.2.2.8.1.

Verification Submittal: CoC

F.4.3.2.3.2 PAYLOAD-TO-EXPRESS RACK MATED SURFACE BOND

A. Verification *should* be by inspection. The verification *should* be considered successful when the inspection of drawings shows that the payload-to-EXPRESS Rack mated surface bond (defined as the payload, adapter plate, or MLE surface that attaches to the EXPRESS Rack backplate) is nickel or nickel-plated per SSP 30245 using methods in MIL-C-26074D.

Verification Submittal: CoC

B. Verification *should* be by inspection. The verification *should* be considered successful when inspection of drawings shows that all aluminum surfaces used for permanent bonding in the payload are originally cleaned to bare metal, then chemically filmed per MIL-DTL-5541F, Class 3 (gold alodine 1200LN9368 or equivalent) or nickel-plated using methods in MIL-C-26074D.

Verification Submittal: CoC

F.4.3.2.4 GROUNDING

NVR

F.4.3.2.4.1 GROUNDING ISOLATION

NVR

F.4.3.3 COMMAND AND DATA HANDLING INTERFACE REQUIREMENTS

Command and Data Handling requirements for the EXPRESS subrack payload are addressed in Appendix I.

F.4.3.4 PAYLOAD NTSC VIDEO INTERFACE REQUIREMENTS

NVR

F.4.3.4.1 DIFFERENTIAL SIGNAL

A. Verification that the payload provides an analog balanced differential video signal **shall** be by analysis and test. Verification **shall** be considered successful when the analysis of the test data shows the payload provides an analog balanced differential video signal which is derived from the single-ended video signal specified by SMPTE 170M.

Verification Submittal: CoC

B. Verification that the payload differential video output signal has the same color coding, time, and relative signal levels as defined in SMPTE 170M **shall** be by test. The verification **shall** be considered successful when the test of the payload GSE shows the payload differential video output signal has the same color coding, timing, and relative signal levels as defined in SMPTE 170M.

Verification Submittal: CoC

F.4.3.4.2 INPUT IMPEDANCE

Verification that the balanced differential signal output has been designed with 75 ± 5 ohms source impedance **shall** be by test. The verification **shall** be considered successful when the test of the payload flight hardware shows the balanced differential signal output has been designed with 75 ± 5 ohms source impedance.

Verification Submittal: CoC

F.4.3.4.3 SYNC TIP AND WHITE REFERENCE

A. Verification that the positive pin of the balanced differential output provides a nominal 0.5 V peak to peak signal with sync tip at a nominal 0 V and peak white at a nominal 0.5 V **shall** be by test. The verification **shall** be considered successful when the test of the payload flight hardware shows the positive pin of the balanced differential output provides a nominal 0.5 V peak signal with sync tip (-40 IRE in SMPTE 170M) at a nominal 0 V and peak white (100 IRE in SMPTE 170M) at a nominal 0.5 V.

Verification Submittal: CoC

B. Verification that the negative pin of the balanced differential output provides a nominal 0.5 V peak to peak signal with sync tip at a nominal 0 V and peak white at a negative 0.5 V **shall** be by test. The verification **shall** be considered successful when the test of the payload flight hardware shows the negative pin of the balanced differential output provides a nominal 0.5 V peak signal, in phase quadrature (inverted) to the positive output, with sync tip (-40 IRE in SMPTE 170M) at a nominal 0 V and peak white (100 IRE in SMPTE 170M) at a negative 0.5 V.

Verification Submittal: CoC

F.4.3.4.4 BLANKING LEVEL

NVR

F.4.3.4.5 COMMON VOLTAGE MODE

Verification that the balanced differential output does not have more than a ± 0.1 Vdc common mode component *should* be by test. The verification *should* be considered successful when the test of the payload flight hardware shows the balanced differential output does not have more than a ± 0.1 Vdc common mode component measured with respect to the input ground reference pin.

Verification Submittal: CoC

F.4.3.4.6 DEVIATIONS TO VIDEO STANDARD

A. NVR
B. NVR
C. NVR
D. NVR
E. NVR

F.4.3.5 THERMAL CONTROL INTERFACE REQUIREMENTS

<u>Data Deliverable</u>

F.4.3.5.1 CONVECTIVE HEAT TRANSFER COEFFICIENT

NVR

F.4.3.5.2 REMOVAL OF WASTE HEAT

Verification that the payload uses the EXPRESS AAA for removing waste sensible heat only **shall** be by analysis and inspection of payload flight hardware. The verification **shall** be considered successful when the analysis shows the payload uses the EXPRESS AAA for removing waste sensible heat only.

Verification Submittal: CoC

F.4.3.5.3 CABIN AIR USAGE

Verification that cabin air is used to control humidity, carbon dioxide, oxygen, and the release of any other gaseous components *should* be by analysis and inspection of payload flight hardware. The verification *should* be considered successful when the analysis shows that cabin air is used for control of humidity, carbon dioxide, oxygen, and the release of any other gaseous components.

Verification Submittal: CoC

F.4.3.5.4 PAYLOAD DEBRIS TRAPS

Verification that the payload with the ability to generate particulates or debris provides protection against cabin air contamination **shall** be by inspection. The verification **shall** be considered successful when the inspection shows the payload provides a filter of size ≤280 μm.

Verification Submittal: CoC

F.4.3.5.5 AAA PHYSICAL INTERFACE

NVR

F.4.3.5.5.1 MLE AVIONICS AIR INTERFACE

Verification that the payload’s physical interface is compatible with the EXPRESS Rack backplate *should* be by inspection. The verification *should* be considered successful when the inspection shows the payload’s physical interface is compatible with the EXPRESS Rack backplate per Figure F.3.1.2.1-1.

Verification Submittal: CoC

F.4.3.5.5.2 ISIS DRAWERS INTERFACE

Verification that the payload’s physical interface is compatible with the ISIS drawer air inlets and outlets *should* be by inspection. The verification *should* be considered successful when the inspection shows the payload’s physical interface is compatible with the ISIS drawer inlets and outlets per Figure F.3.5.5.2-1.

Verification Submittal: CoC

F.4.3.5.5.3 FANS

Verification the payload using AAA provides its own fan *should* be by inspection. The verification *should* be considered successful when inspection of drawings and/or design documentation show that the design includes a fan.

Verification Submittal: CoC

F.4.3.5.5.4 DUCTED PAYLOAD CONTAMINATION PROTECTION

Verification that the payload hardware cooling system design does not contribute to further contamination of the cabin *should* be by analysis or test of the payload hardware cooling system design. Verification *should* be considered successful when the analysis or test results show that the payload hardware cooling system design is compatible with ingestion of up to one (1) gram of lint-like contamination from the cabin and/or 1.0 square inch material blockage, or provide protection from the contamination.

Verification Submittal: CoC

F.4.3.5.6 AIR SUPPLY TEMPERATURE

Verification that the MLE payload and ISIS drawer payload are compatible with the nominal temperature range of the avionics air supplied by the AAA *should* be by analysis or test. The verification *should* be considered successful when the analysis or test of the MLE payload and ISIS drawer payload show they are compatible with the temperature ranges per paragraph F.3.5.6.

Verification Submittal: Analysis Report or Test Report

F.4.3.5.7 AIR SUPPLY FLOW RATE

A. Verification that the payload is compatible with the EXPRESS Rack AAA supplied conditioned air *should* be by analysis or test. The verification *should* be considered successful when the analysis or test shows the payload is compatible with a flow rate at 15±3 cubic feet per minute (cfm).

Verification Submittal: Analysis Report or Test Report

B. Verification that the ISIS drawer payload is compatible with the EXPRESS Rack AAA supplied conditioned air *should* be by analysis or test. The verification *should* be considered successful when the analysis or test shows the ISIS drawer payload is compatible with a flow rate at 15±3 cubic feet per minute (cfm).

Verification Submittal: Analysis Report or Test Report

F.4.3.5.8 AIR RETURN TEMPERATURE

Verification that the maximum exhaust air return temperature meets the requirements in paragraph F.3.5.8 **shall** be by analysis or test. The analysis or test **shall** take into consideration the inlet conditions of 85 °F (29.4 °C) for MLE or 95 °F (35 °C) for an ISIS Drawer and 15 cfm airflow capability provided by the AAA. If the payload exceeds 15 cfm, the analysis **shall** take into account the recirculation effect and determine the steady state temperature of the exhaust considering this recirculation effect. The verification **shall** be considered successful when the analysis shows that the return air temperature is less than 120 °F (48.9 °C) given the inlet avionics air conditions and the payload air flow.

Verification Submittal: Analysis Report or Test Report

F.4.3.5.9 PAYLOAD INLET DEBRIS TRAPS

Verification that the payload has a filter *should* be by inspection. The verification *should* be considered successful when the inspection of the as-built flight hardware shows a filter size of ≤280 μm at the payload inlet.

Verification Submittal: CoC

F.4.3.5.10 PAYLOAD LIMITATIONS ON HEAT CONDUCTED TO STRUCTURE

Verification that the payload was not designed to account for conducting payload heat to the rack structure *should* be by inspection. The verification *should* be considered successful when the inspection shows that all payload internal temperature requirements are met by heat rejection to only the cooling water loops, cabin ambient air, and avionics air cooling circulated through the payload.

Verification Submittal: CoC

F.4.3.5.11 CABIN AND AAA AIR MIXING LIMITATIONS

Verification that the payload exchanging air with the cabin, and using the avionics air cooling, is designed to preclude mixing of the two air sources **shall** be by inspection of drawings or flight hardware. Verification **shall** be considered successful when the inspection of drawings or flight hardware shows that the payload hardware design does not allow mixing of cabin and AAA air.

Verification Submittal: CoC

F.4.3.5.12 WATER COOLING INTERFACE REQUIREMENTS

NVR

F.4.3.5.12.1 PHYSICAL INTERFACE

Verification that the payload requiring EXPRESS Rack-provided water cooling can interface to the EXPRESS Rack-provided QD at the end of the water line *should* be by inspection. The verification *should* be considered successful when the payload interface is per Figure F.3.5.12.1-1.

Verification Submittal: CoC

F.4.3.5.12.2 WATER LOOP PRESSURE DROP

Verification that the pressure drop is per requirements in paragraph F.3.5.12.2 **shall** be by test. Testing **shall** be performed at the desired flow rates. The pressure differential **shall** be measured across the rack interface panel supply and return interfaces. Verification **shall** be considered successful when the test shows the pressure drop between the inlet and outlet QDs is 2.80 ± 0.15 pounds per square inch differential (psid) (19.3 ± 1.03 kPa) at the desired flow rate.

Verification Submittal: Test Report

F.4.3.5.12.3 LEAK RATE

Verification that the total leakage of water by the payload equipment is less than 0.002 cm^3/hr at 121 psia (834 kPa) **shall** be by test. An integrated leak test of the payload loop including all payload equipment, jumpers and connections **shall** be performed. The leakage test **shall** be performed after the proof pressure test. The leakage test **shall** be performed as a minimum at MDP. If helium, or some other medium, is used in testing, the results **shall** be converted to an equivalent water leakage in standard cubic centimeters per hour. The verification **shall** be considered successful when the test results show the leakage rate to be less than .002 cm^3/hr of liquid per each thermal loop.

Note: A conversion factor of cm^3/hr of water = 233.22 cm^3/hr of helium at 121 psia **shall** be used when converting helium leakage to an equivalent water leakage.

Appendix S provides guidance for payload leak testing during qualification and acceptance environmental testing.

Verification Submittal: Test Report

F.4.3.5.12.4 WATER COOLANT FLOW RATE

Verification that the payload requiring the water cooling system is designed to a value within the available range of 50 to 200 lbm/hr *should* be by analysis or test. Verification *should* be considered successful when the analysis or test shows the payload is designed to a value within the available range of 50 to 200 lbm/hr.

Verification Submittal: CoC

F.4.3.6 VACUUM SYSTEM REQUIREMENTS

F.4.3.6.1 VACUUM EXHAUST SYSTEM (VES)/WASTE GAS SYSTEM (WGS) REQUIREMENTS

NVR

F.4.3.6.1.1 PHYSICAL INTERFACE (USL, COL, JEM)

Verification that the payload interface to the EXPRESS Rack-provided QD at the end of the VES/WGS lines *should* be by inspection of drawings with COC. The verification *should* be considered successful when the inspection of the drawings shows that the payload interface is per Figure F.3.6.1.1-1.

Verification Submittal: CoC and Drawings

F.4.3.6.1.2 INPUT PRESSURE LIMIT (USL, COL, JEM)

Verification of input pressure limit requirements **shall** be performed per paragraph N.4.3.6.1.2.

F.4.3.6.1.3 INPUT TEMPERATURE LIMIT (USL, COL, JEM)

Verification of the EXPRESS subrack vacuum exhaust gas temperature **shall** be verified by test or analysis. The test **shall** utilize a PRCU or equivalent to measure the temperature at the interface plane. The EXPRESS subrack volumes that are connected to VES **shall** be pressurized to the expected pressures for the test. The experiment **shall** be subjected to the same heat generating operations that will be experienced on-orbit and vented at the same relative time during the experiment operation as would be experienced on-orbit. The verification **shall** be considered successful when the analysis shows that the temperature at the interface is within the allowable temperature range.

Verification Submittal: Test Report or Analysis Report

F.4.3.6.1.4 INPUT DEWPOINT LIMIT (USL, COL, JEM)

Verification of the EXPRESS subrack dewpoint **shall** be verified by test or analysis. The test **shall** utilize a PRCU or equivalent to measure the dewpoint at the interface plane. The EXPRESS subrack volumes that are connected to VES **shall** be pressurized to the expected pressures for the test. The experiment **shall** be subjected to the same operations that will be experienced on-orbit and vented at the same relative time during the experiment operation as would be experienced on-orbit. The verification **shall** be considered successful when the analysis shows that the dewpoint is below the limit.

Verification Submittal: Test Report or Analysis Report

F.4.3.6.1.5 ACCEPTABLE EXHAUST GASES (USL, COL, JEM)

A. Verification of payload exhaust gases that are vented into the ISS VES/WGS of the USL, COL, and JEM **shall** be performed per paragraph N.4.3.6.1.5.A.

B. NVR

F.4.3.6.1.6 ACCEPTABLE GASES (USL, COL, JEM)

A. Verification that payload exhaust gases vented to the ISS VES/WGS are non-reactive with other gas mixture constituents created by the respective payload **shall** be by analysis. The verification **shall** be considered successful when the analysis report shows the payload exhaust gases vented to the ISS VES/WGS are non-reactive with other vent gas mixture constituents.

Verification Submittal: Analysis Report

B. Verification that the payload venting to the ISS VES/WGS provides a means of removing gases that would adhere to the ISS VES/WGS tubing walls at a wall temperature of 40 °F (4 °C) and at a pressure of 10^{-3} torr **shall** be by analysis. The verification **shall** be considered successful when the analysis report shows that the payload venting to the ISS VES/WGS provides a means to remove gases that would adhere to the VES/WGS tubing walls at a wall temperature of 40 °F (4 °C) and at a pressure of 10^{-3} torr.

Verification Submittal: Analysis Report

C. Verification that the payload venting to the ISS VES/WGS removes particulates that are larger than 100 micrometers in size from vent gases **shall** be by analysis. The verification **shall** be considered successful when the analysis report shows that the payload venting to the ISS VES/WGS removes particulates that are larger than 100 micrometers in size from vent gases.

Verification Submittal: Analysis Report

F.4.3.6.1.7 LIMIT VES VENTING PROFILE

Data Deliverable

F.4.3.6.1.8 UTILITY CONTROL

Verification of the payload isolation valve requirements **shall** be performed per paragraph N.4.3.6.1.6.

F.4.3.6.2 VACUUM RESOURCE SYSTEM (VRS)/VACUUM VENT SYSTEM (VVS) REQUIREMENTS

NVR

F.4.3.6.3 VACUUM OUTGASSING REQUIREMENTS

Verification of vacuum outgassing requirements **shall** be performed per paragraph N.4.3.6.3.

F.4.3.6.4 LIMIT AMOUNT OF VENTED GASES

A. Payloads interfacing with the VES **shall** verify per the requirements listed in Table F.4.3.6.4-1.

TABLE F.4.3.6.4-1 LIMIT AMOUNT OF VENTED GASES REQUIREMENTS

SSP 57000 Requirement	Title/Subject
N.4.3.6.1.7.A	LIMIT AMOUNT OF VENTED GASES
N.4.3.6.1.7.B	LIMIT AMOUNT OF VENTED GASES

B. Verification that the subrack payload limits individual vented gas species *should* be per paragraph N.4.3.6.1.7.C.

F.4.3.7 PRESSURIZED GASES INTERFACE REQUIREMENTS

Payloads interfacing to nitrogen **shall** verify the applicable requirements and guidelines per N.4.3.7, excluding verification requirement N.4.3.7.4 which is substituted by F.4.3.7.1.

F.4.3.7.1 LEAK RATE

Verification of the total leakage by the payload equipment **shall** be by test. The integrated leak test **shall** be of the payload loop including all payload equipment/connections and the rack interface panel supply at the rack interface panel. Leakage **shall** not exceed the leak test specification value. The leakage test **shall** be performed after the proof pressure test.

If helium, or some other medium, is used in testing of the QD, the results **shall** be converted to an equivalent GN2 leakage.

Appendix S provides guidance for payload leak testing during qualification and acceptance testing.

Verification Submittal: Payload leakage test data for rack level assessment

F.4.3.8 PAYLOAD SUPPORT SERVICES INTERFACE REQUIREMENTS

N/A

F.4.3.9 ENVIRONMENT INTERFACE REQUIREMENTS

N/A

F.4.3.10 FIRE PROTECTION INTERFACE REQUIREMENTS

F.4.3.10.1 PAYLOAD USE OF BATTERY BACKUP POWER

Verification that the payload does not use battery power to maintain payload operations when power to the rack/RIC is not available, and/or payload Health and Status data cannot be processed/received beyond the payload or rack envelope, **shall** be by inspection. The verification **shall** be considered successful when the inspection of drawings shows the payload does not use battery power.

Verification Submittal: Inspection of drawings

F.4.3.10.2 PORTABLE FIRE EXTINGUISHER ACCESS PORT

A. Verification that PD hardware not interfacing with the EXPRESS Rack AAA cooling system and having internal air circulation does have a PFE access port **shall** be performed by inspection. The verification **shall** be considered successful when inspection of the as-built hardware shows that that PD hardware not interfacing with the EXPRESS Rack AAA cooling system and having internal air circulation does have a PFE access port.

Verification Submittal: CoC

B. Verification that the PFE access port is labeled and distinctly different **shall** be performed by inspection. The verification **shall** be considered successful when inspection of the as-built hardware shows that the PFE access port is labeled and distinctly different (IPLAT review).

Verification Submittal: CoC

C. PFE access port requirements **shall** be verified per the requirements listed in Table F.4.3.10.2-1.

TABLE F.4.3.10.2-1 PFE PORT REQUIREMENTS

SSP 57000 Requirement	Title/Subject
N.4.3.10.2.1	PORTABLE FIRE EXTINGUISHER ACCESS PORT
N.4.3.10.2.2.A	FIRE SUPPRESSION ACCESS PORT ACCESSIBILITY
N.4.3.10.2.2.B	FIRE SUPPRESSION ACCESS PORT ACCESSIBILITY
N.4.3.10.3	PFE ACCESS PORT AND FIRE DETECTION INDICATOR LABELING

F.4.3.10.3 PARAMETER MONITORING

Verification of parameter monitoring to detect a potential fire event **shall** be performed per paragraph N.4.3.10.1.2.1.

F.4.3.11 MATERIALS AND PROCESSES INTERFACE REQUIREMENTS

F.4.3.11.1 FLUID CHEMICAL COMPOSITION

Verification of EXPRESS subrack payloads connecting to ISS nitrogen fluid system **shall** be per paragraph N.4.3.11.1.A.

F.4.3.11.2 FLUID SYSTEM CLEANLINESS

Verification of EXPRESS subrack payload fluid systems connecting to the ISS nitrogen fluid system **shall** be per paragraph N.4.3.11.2.A.

F.4.3.12 HUMAN FACTORS INTERFACE REQUIREMENTS

F.4.3.12.1 CONTINUOUS NOISE LIMITS

Verification of Continuous Noise Sources (See Glossary of Terms) for subrack payloads operating within an EXPRESS or WORF facility **shall** be performed by test.

SPL test measurements **shall** be obtained at 0.6 meters from all sides of the equipment. The SPL test **shall** use a Type 1 SLM in accordance with publication IEC 61672-1. The preferred instrument for acoustic verification is the Type 1 integrating-averaging sound level meter. This meter can either be of the handheld or component system variety.

The SPL **shall** be measured in each of eight octave bands: 63 Hz, 125 Hz, 250 Hz, 500 Hz, 1000 Hz, 2000 Hz, 4000 Hz, and 8000 Hz.

Octave band filters used for verification measurements will meet the Class 1 specifications in accordance with publication IEC 61260-1, over the frequency range required for verification.

SPL test measurements **shall** be made for each serialized payload flight hardware (or ancillary flight equipment operated outside the rack) until repeatability and acoustic level are demonstrated to produce acceptably low risk of exceeding the composite acoustic environment requirement with minimal operational constraints. The JSC Acoustics Office, with consultation of the Acoustics Working Group (AWG), **shall** determine, on a case-by-case basis, if serial number unit testing can be suspended for a particular payload design based on the following factors: 1) Repeatability of serial number unit test results of first flight units, 2) impact of exceedances (if any), 3) SPLs compared to requirement, 4) frequency bands where repeatability and exceedance issues reside, and 5) impact on composite acoustic environment.

Rear-breathing subrack payloads will apply an insertion loss to their rear surface continuous noise emissions to account for the reduction in noise caused by integration into a rack. The octave band insertion loss values shown in Table F.4.3.12.1-1 **shall** be subtracted from the rear surface continuous noise emissions of the rear-breathing subrack payload. The following equation illustrates how to subtract the insertion loss value, IL, from the measured rear surface data, L_{TEST}, to obtain the measurement data with insertion loss applied, L_{IL}.

$$L_{IL}=L_{TEST} - IL$$

This equation is used to correct all eight octave band measurements.

TABLE F.4.3.12.1-1 REAR SURFACE INSERTION LOSS VALUES FOR REAR-BREATHING SUBRACK PAYLOADS

Frequency Band [Hz]	IL [dB re 10^{-6} Pa]*
63	5
125	5
250	8
500	13
1000	11
2000	12
4000	19
8000	20

*To be subtracted from rear surface octave band emissions only of rear-breathing subrack payloads

The verification **shall** be considered successful when the test shows the EXPRESS or WORF subrack payload's SPL noise level on all sides are at or below the levels specified in Table G.3.12.1-1.

Verification Submittal: Test Report

APPENDIX G

ISS TO NON-RACK PAYLOAD INTERFACE REQUIREMENTS

APPENDIX G – ISS TO NON-RACK PAYLOAD INTERFACE REQUIREMENTS

G.1.0 INTRODUCTION

G.1.1 PURPOSE

This appendix provides requirements, guidelines and data deliverables for non-rack payloads.

G.1.2 SCOPE

This appendix addresses non-rack payloads on ISS. Non-rack payloads are those that are not a rack or subrack. Non-rack payloads are typically mounted in the aisle and may get power from a UOP or portable power converter.

G.1.3 USE

These requirements, guidelines and data deliverables are applied to non-rack payloads in addition to the general requirements, guidelines and data deliverables in Section 3.0 and are allocated to a payload through the payload unique ICD. The PD and the ISS Program must jointly agree on the interfaces and identify requirements as applicable if the interface exists, and not applicable if the interface does not exist for the payload configuration documented in the ICD.

G.2.0 DOCUMENTATION

See Section 5.0.

G.3.0 ISS TO NON-RACK PAYLOAD INTERFACE REQUIREMENTS

G.3.1 PHYSICAL AND MECHANICAL INTERFACES

G.3.1.1 CONNECTOR PHYSICAL MATE

A. Non-rack payloads **shall** physically mate with the UOP and SUP connectors intended to be used by the payload as listed in Table G.3.1.1-1.

Note: Utility Interface Panel (UIP) connectors are listed in Table N.3.1.1.7-1.

B. Non-rack payload connectors, including EPCE connectors P3 and P4 to UOP and EPCE connectors P1, P2 and P3 to SUP, **shall** meet the requirements of SSQ 21635 or equivalent.

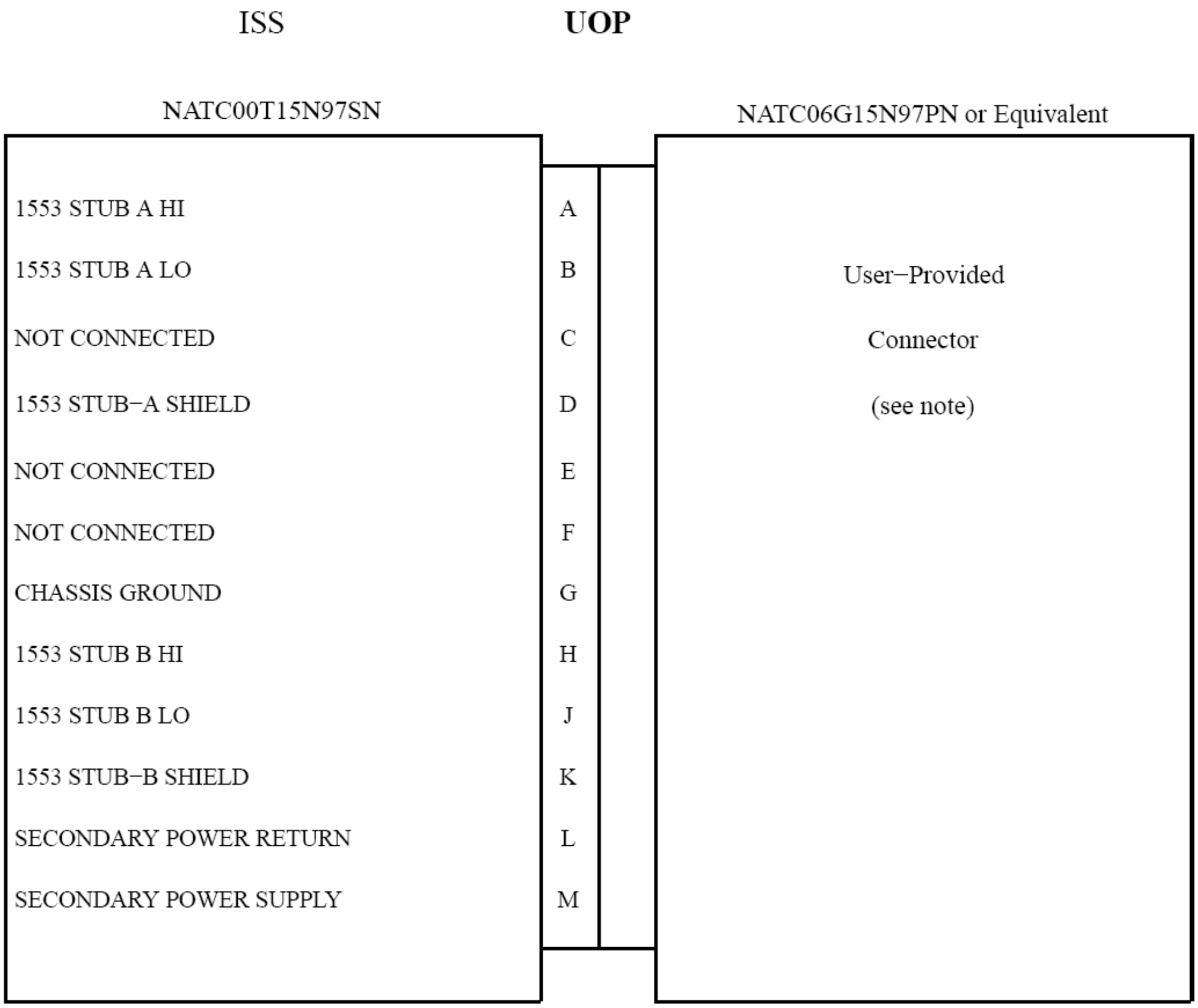
C Payloads **shall** provide protection for all de-mated UOP connectors to prevent physical damage and contamination.

TABLE G.3.1.1-1 MODULE CONNECTORS

	Module Connector	Module Part Number	Resource
UOP			
X	J3	NATC00T15N97SN	Power/1553 Bus
Y	J4	NATC00T15N97SN	Power/1553 Bus
Z	J4	NATC00T15N97SA	Power/Ethernet
SUP			
AA	J01	NATC00T15N97SN	See Table G.3.1.1.2-1
AB	J02	NATC00T15N97SN	See Table G.3.1.1.2-1
AC	J03	NATC00T15N97SA	See Table G.3.1.1.2-1
AD	J04 (SUP - 1 & 4 only)	NATC00T15N35SN	See Table G.3.1.1.2-1
AE	J05	NATC00T11N98SN	See Table G.3.1.1.2-1
AF	J06 (SUP - 1 & 4 only)	NATC00T15N97SA	See Table G.3.1.1.2-1
AG	J07 (SUP - 1 & 4 only)	NATC00T13N35SA	See Table G.3.1.1.2-1
AH	J08 (SUP - 1 & 4 only)	NATC00T15N19SN	See Table G.3.1.1.2-1 (Not for payload use.)
AI	J09	NATC00T11N98SN	See Table G.3.1.1.2-1

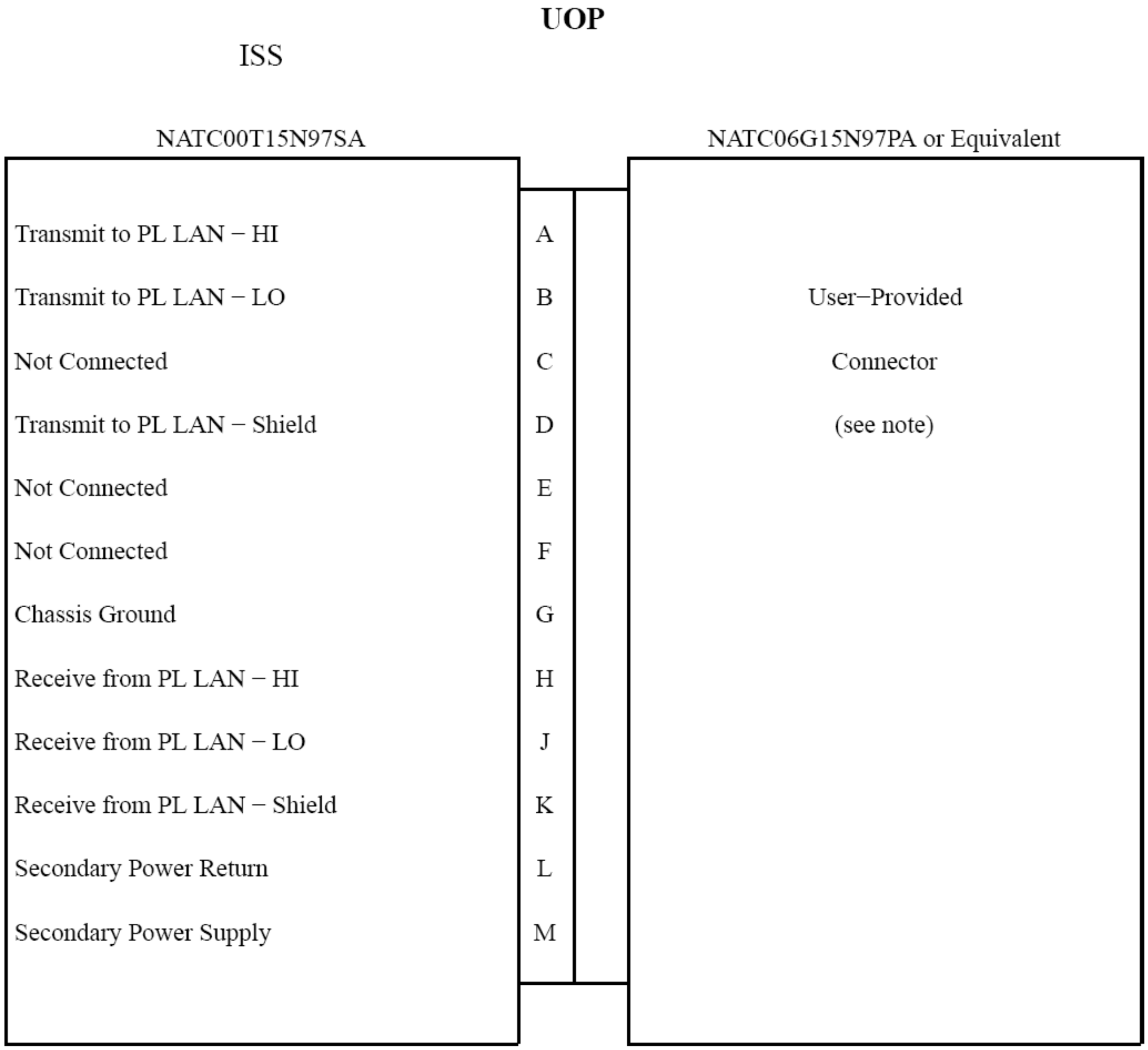
G.3.1.1.1 UTILITY OUTLET PANEL

The UOP electrical power and data connectors, J3 and J4, part numbers are defined in Table G.3.1.1-1. EPCE connectors to the UOP connectors **shall** meet the pin out interfaces as specified in this paragraph. The pin assignments for the UOP, module connector numbers NATC00T15N97SN and NATC00T15N97SA, are defined in Figure G.3.1.1.1-1 and Figure G.3.1.1.1-2, respectively. UOP locations for the USL and JEM are shown in Figure G.3.1.1.1-3 and Figure G.3.1.1.1-4, respectively. The UOP capabilities by module are summarized in Table G.3.1.1.1-1 and Table G.3.1.1.1-2. In the USL payloads will interface to UOP #1, 3, and 4, defined in Table G.3.1.1.1-1.



Note: User has the option of connecting data cable shields directly to connector backshell or mating shields to shield pins D and K respectively.

FIGURE G.3.1.1.1-1 UOP ELECTRICAL POWER/1553B CONNECTOR AND PIN ASSIGNMENTS



Note: User has the option of connecting data cable shields directly to connector backshell or mating shields to shield pins D and K respectively. Payload LAN pin assignments apply to both Payload LAN-1 (UOP-1) and Payload LAN-2 (UOP-4).

FIGURE G.3.1.1.1-2 UOP ELECTRICAL POWER/ETHERNET CONNECTOR AND PIN ASSIGNMENTS

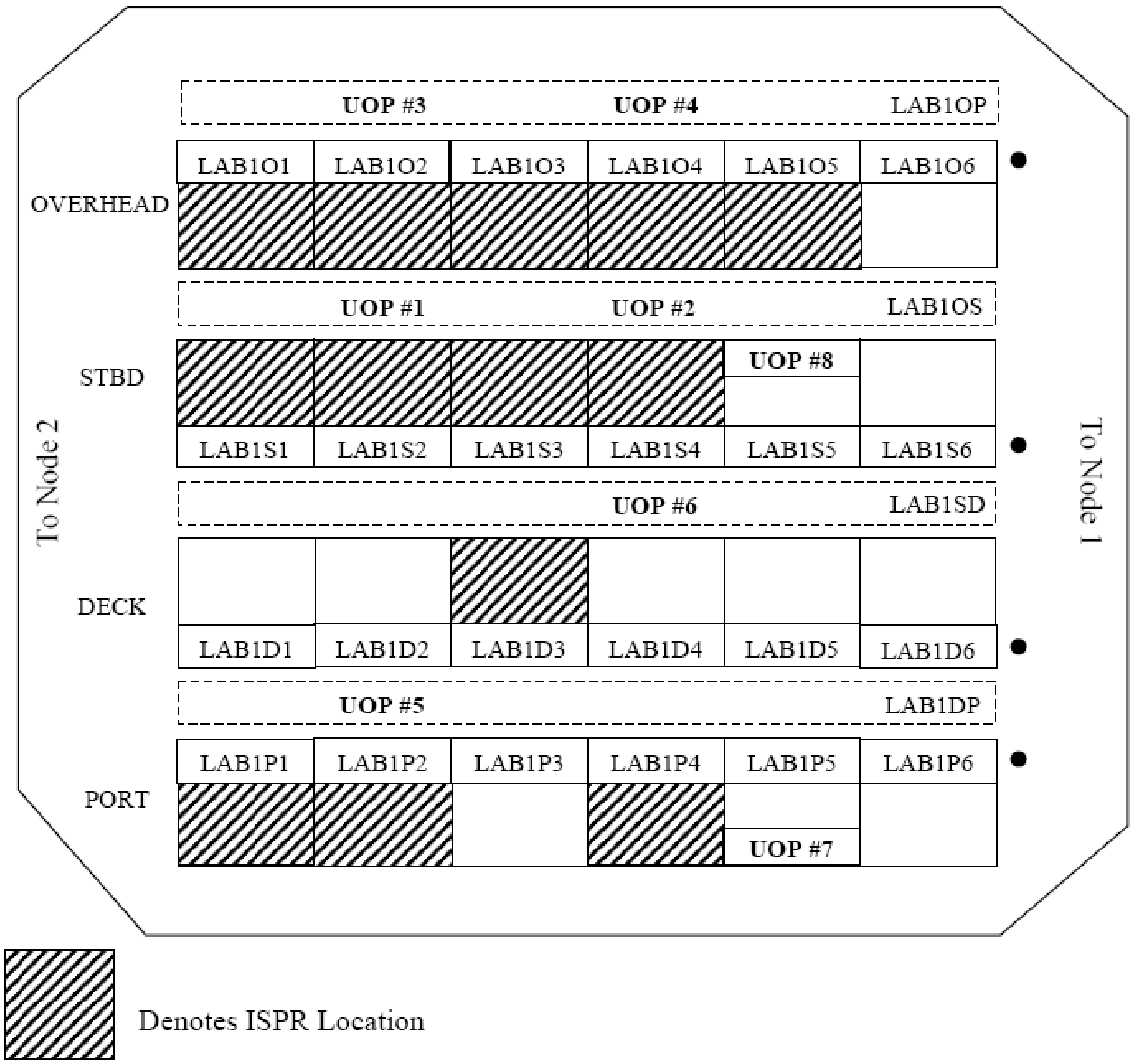


FIGURE G.3.1.1.1-3 UOP LOCATIONS - USL

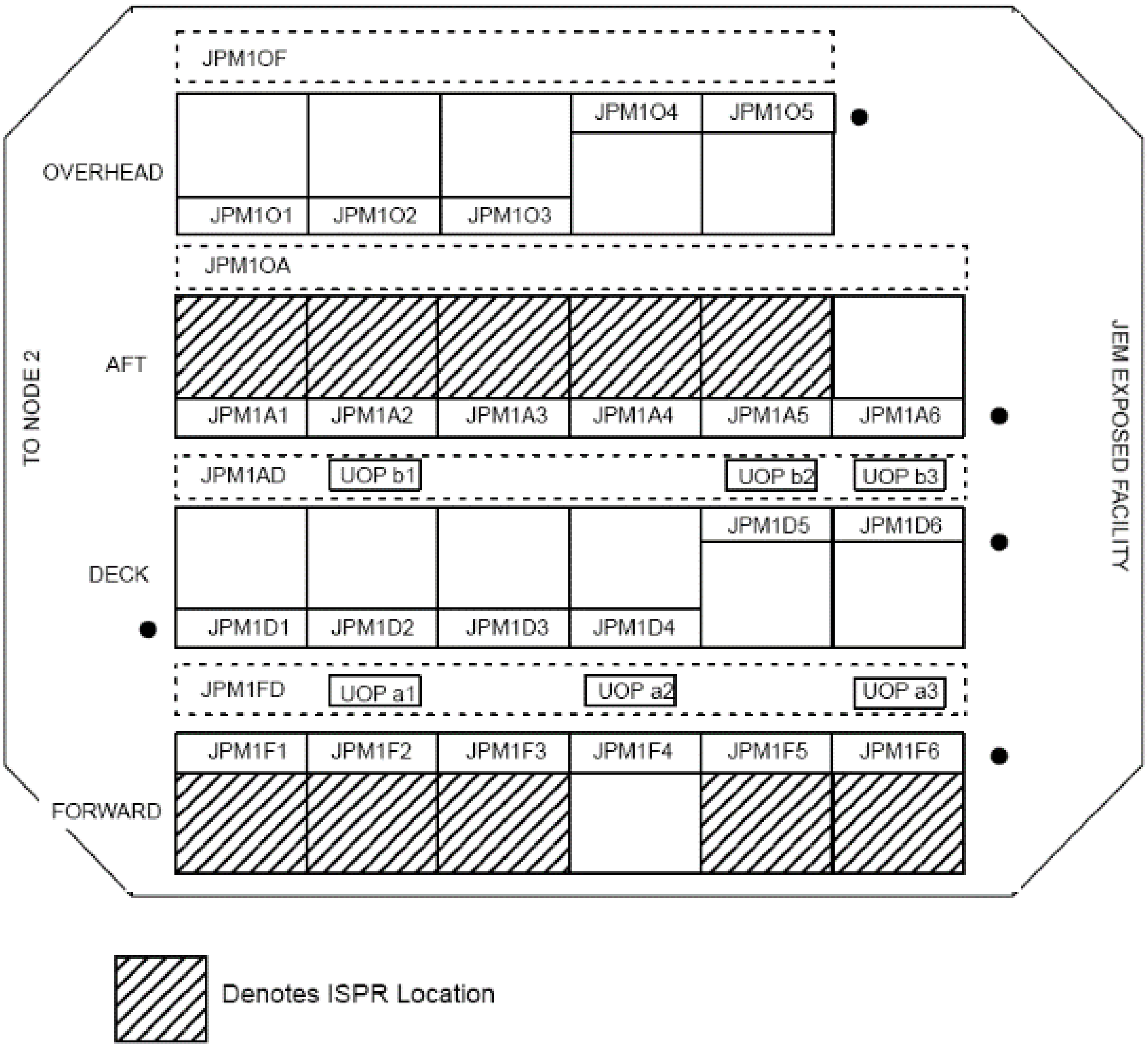


FIGURE G.3.1.1.1-4 UOP LOCATIONS - JEM

TABLE G.3.1.1.1-1 UOP SUMMARY - USL

Module	UOP #1		UOP#2		UOP#3		UOP#4		UOP#5		UOP#6		UOP#7		UOP#8	
	J3	J4	J3	J4	J3	J4	J3	J4	J3	J4	J3	J4	J3	J4	J3	J4
USL	PL1	PLE1	Ch	Ch	NPL	PL2	C	PLE2	C	Ch	C	C	PW	C	PW	C

Notes:

Key:
- C Power/Core 1553B Bus
- Ch Power/CHeCS 1553B Bus
- NPL Power/JAXA Payload 1553B Bus
- PL1 Power/Payload PL-1 1553B Bus
- PL2 Power/Payload PL-2 1553B Bus
- PLE1 Power/Ethernet LAN-1
- PLE2 Power/Ethernet LAN-2
- PW Power Only

TABLE G.3.1.1.1-2 UOP SUMMARY - JEM

Module	UOP #a1		UOP #a2		UOP #a3		UOP #b1		UOP #b2		UOP #b3	
	J3	J4	J3	J4	J3	J4	J3	J4	J3	J4	J3	J4
JEM	Ch	PW	NPL	PLL2	C	J	PL	NPL	C	J	Ch	PJSL

Notes:

Key:
- C Power/Core 1553B Bus
- Ch Power/CHeCS 1553B Bus
- J Power/JEM System Bus
- NPL Power/JAXA Payload 1553B Bus
- PL Power/Payload PL-JEM 1553B Bus
- PLL2 Power/ P/L LAN-2 (MRDL)
- PJSL Power/JSL
- PW Power Only

G.3.1.1.2 STANDARD UTILITY PANEL - COLUMBUS

The Columbus Standard Utility Panel (SUP) provides 120 Volts, Direct Current (Vdc) power, Columbus (COL) Institute of Electrical and Electronic Engineers (IEEE) 802.3 Local Area Network (LAN), 1553B COL Payload Bus, Payload LAN-2, and United States (U.S.) Operations (Ops) LAN connections for payload use. EPCE connectors to the SUP connectors **shall** meet the pin out interfaces as specified in this paragraph. The connector part numbers are provided in Table G.3.1.1-1. The layout of the SUP is shown in Figure G.3.1.1.2-1. The pin assignments for the SUP connectors are defined in Figure G.3.1.1.2-2 through Figure G.3.1.1.2-14. The SUP locations for the Columbus are shown in Figure G.3.1.1.2-15. The SUP capabilities are summarized in Table G.3.1.1.2-1.

Notes:

1. For Figures G.3.1.1.2-2 through G.3.1.1.2-10, shields for 1553B data bus/LAN pairs are terminated at the back shells of the portable equipment cable.
2. For Figures G.3.1.1.2-2 through G.3.1.1.2-9, second green wire or outside cable shield is terminated at both back shells of the portable equipment power cable.

3. For Figures G.3.1.1.2-2 through G.3.1.1.2-9, portable equipment cable ensures correct cross section for second green wire (shield).
4. For Figures G.3.1.1.2-11 and G.3.1.1.2-14, shields for IEEE 802.3 LAN pairs are terminated at the back shells of the portable equipment cable.

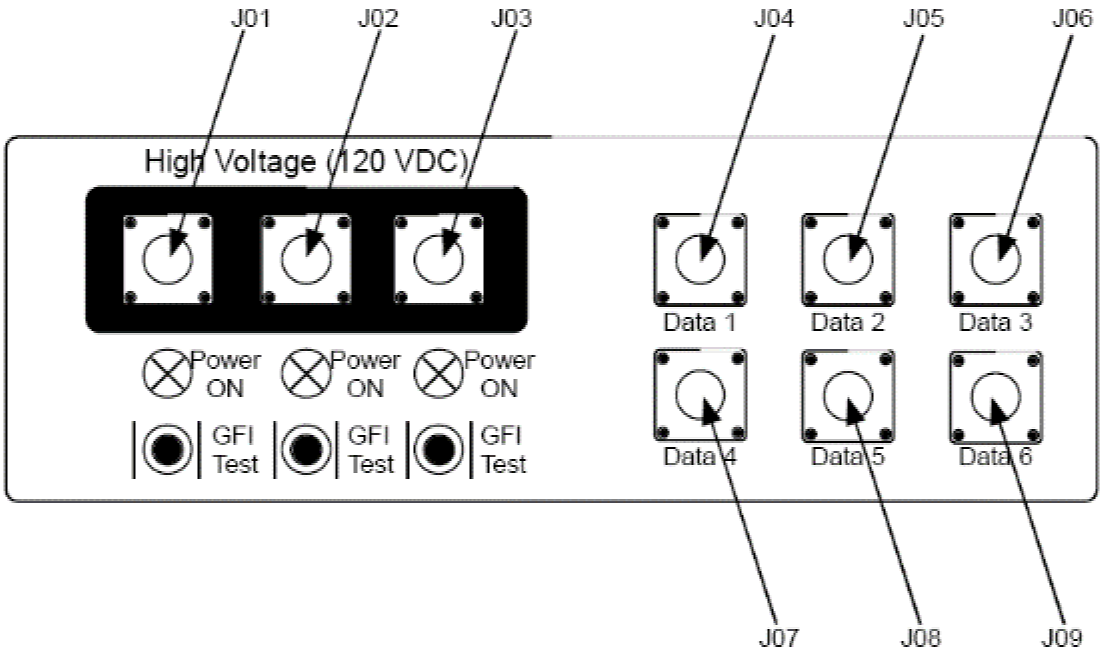


FIGURE G.3.1.1.2-1 SUP PANEL LAYOUT

COL NATC00T15N97SN	SUP	Experiment NATC06G15N97PN
CHECS DATA A HI	A	
CHECS DATA A LO	B	
CHASSIS GROUND (COL Internal – Not for equipment use)	C	
NOT CONNECTED	D	
NOT CONNECTED	E	
NOT CONNECTED	F	
CHASSIS GROUND	G	
CHECS BUS B HI	H	
CHECS BUS B LO	J	
NOT CONNECTED	K	
POWER RETURN	L	
120 V POWER	M	
CHASSIS GROUND	SHELL	

FIGURE G.3.1.1.2-2 SUP-1/SUP-4 CONNECTOR J01 PIN ASSIGNMENTS

COL NATC00T15N97SN	SUP		Experiment NATC06G15N97PN
ISS C&C BUS 1 A HI	A		
ISS C&C BUS 1 A LO	B		
CHASSIS GROUND (COL Internal – Not for equipment use)	C		
NOT CONNECTED	D		
NOT CONNECTED	E		
NOT CONNECTED	F		
CHASSIS GROUND	G		
ISS C&C BUS 1 B HI	H		
ISS C&C BUS 1 B LO	J		
NOT CONNECTED	K		
POWER RETURN	L		
120 V POWER	M		
CHASSIS GROUND	SHELL		

FIGURE G.3.1.1.2-3 SUP-2 CONNECTOR J01 PIN ASSIGNMENTS

COL NATC00T15N97SN	SUP		Experiment NATC06G15N97PN
ISS C&C BUS 2 A HI	A		
ISS C&C BUS 2 A LO	B		
CHASSIS GROUND (COL Internal – Not for equipment use)	C		
NOT CONNECTED	D		
NOT CONNECTED	E		
NOT CONNECTED	F		
CHASSIS GROUND	G		
ISS C&C BUS 2 B HI	H		
ISS C&C BUS 2 B LO	J		
NOT CONNECTED	K		
POWER RETURN	L		
120 V POWER	M		
CHASSIS GROUND	SHELL		

FIGURE G.3.1.1.2-4 SUP-3 CONNECTOR J01 PIN ASSIGNMENTS

COL NATC00T15N97SN	SUP		Experiment NATC06G15N97PN
1553B BUS A HI (COL internal)	A		
1553B BUS A LO (COL internal)	B		
CHASSIS GROUND (COL Internal – Not for equipment use)	C		
NOT CONNECTED	D		
NOT CONNECTED	E		
NOT CONNECTED	F		
CHASSIS GROUND	G		
1553B BUS B HI (COL Internal)	H		
1553B BUS B LO (COL Internal)	J		
NOT CONNECTED	K		
POWER RETURN	L		
120 V POWER	M		
CHASSIS GROUND	SHELL		

FIGURE G.3.1.1.2-5 SUP-1/SUP-4 CONNECTOR J02 PIN ASSIGNMENTS

COL NATC00T15N97SN	SUP		Experiment NATC06G15N97PN
ISS P/L 1553B BUS A HI	A		
ISS P/L 1553B BUS A LO	B		
CHASSIS GROUND (COL Internal – Not for equipment use)	C		
NOT CONNECTED	D		
NOT CONNECTED	E		
NOT CONNECTED	F		
CHASSIS GROUND	G		
ISS P/L 1553B BUS B HI	H		
ISS P/L 1553B BUS B LO	J		
NOT CONNECTED	K		
POWER RETURN	L		
120 V POWER	M		
CHASSIS GROUND	SHELL		

FIGURE G.3.1.1.2-6 SUP-2/SUP-3 CONNECTOR J02 PIN ASSIGNMENTS

COL NATC00T15N97SA	SUP	Experiment NATC06G15N97PA
PL LAN-2 HI TX	A	
PL LAN-2 LO TX	B	
CHASSIS GROUND (COL Internal – Not for equipment use)	C	
NOT CONNECTED	D	
NOT CONNECTED	E	
NOT CONNECTED	F	
CHASSIS GROUND	G	
PL LAN-2 HI RX	H	
PL LAN-2 LO RX	J	
NOT CONNECTED	K	
POWER RETURN	L	
120 V POWER	M	
CHASSIS GROUND	SHELL	

FIGURE G.3.1.1.2-7 SUP-1/SUP-4 CONNECTOR J03 PIN ASSIGNMENTS

COL NATC00T15N97SA	SUP	Experiment NATC06G15N97PA
US OPS LAN HI TX	A	
US OPS LAN LO TX	B	
CHASSIS GROUND (COL Internal – Not for equipment use)	C	
NOT CONNECTED	D	
NOT CONNECTED	E	
NOT CONNECTED	F	
CHASSIS GROUND	G	
US OPS LAN HI RX	H	
US OPS LAN LO RX	J	
NOT CONNECTED	K	
POWER RETURN	L	
120 V POWER	M	
CHASSIS GROUND	SHELL	

FIGURE G.3.1.1.2-8 SUP-2 CONNECTOR J03 PIN ASSIGNMENTS

COL NATC00T15N97SA	SUP	Experiment NATC06G15N97PA
NOT CONNECTED	A	
NOT CONNECTED	B	
CHASSIS GROUND (COL Internal – Not for equipment use)	C	
NOT CONNECTED	D	
NOT CONNECTED	E	
NOT CONNECTED	F	
CHASSIS GROUND	G	
NOT CONNECTED	H	
NOT CONNECTED	J	
NOT CONNECTED	K	
POWER RETURN	L	
120 V POWER	M	
CHASSIS GROUND	SHELL	

FIGURE G.3.1.1.2-9 SUP-3 CONNECTOR J03 PIN ASSIGNMENTS

COL NATC00T15N35SN	SUP	Experiment NATC06G15N35PN
NOT CONNECTED	1	
NOT CONNECTED	2	
COL REDUNDANT P/L BUS +	3	
NOT CONNECTED	4	
NOT CONNECTED	5	
NOT CONNECTED	6	
NOT CONNECTED	7	
COL NOMINAL P/L BUS -	8	
NOT CONNECTED	9	
NOT CONNECTED	10	
NOT CONNECTED	11	
COL REDUNDANT P/L BUS -	12	
COL NOMINAL P/L BUS +	13	
NOT CONNECTED	14	
NOT CONNECTED	15	
NOT CONNECTED	16	
NOT CONNECTED	17	
NOT CONNECTED	18	
NOT CONNECTED	19	
NOT CONNECTED	20	
NOT CONNECTED	21	
NOT CONNECTED	22	
NOT CONNECTED	23	
NOT CONNECTED	24	
NOT CONNECTED	25	
NOT CONNECTED	26	
NOT CONNECTED	27	
NOT CONNECTED	28	
NOT CONNECTED	29	
NOT CONNECTED	30	
NOT CONNECTED	31	
NOT CONNECTED	32	
NOT CONNECTED	33	
NOT CONNECTED	34	
NOT CONNECTED	35	
NOT CONNECTED	36	
NOT CONNECTED	37	

FIGURE G.3.1.1.2-10 SUP-1/SUP-4 CONNECTOR J04 PIN ASSIGNMENTS

COL NATC00T11N98SN	SUP	Experiment NATC06G11N98PN or D38999 26FB98PN
NOT CONNECTED	A	
COL LAN-1 HI RX	B	
COL LAN-1 LO RX	C	
NOT CONNECTED	D	
COL LAN-1 LO TX	E	
COL LAN-1 HI TX	F	
CHASSIS GROUND	SHELL	

FIGURE G.3.1.1.2-11 SUP-1 TO SUP-4 CONNECTORS J05 PIN ASSIGNMENTS

COL NATC00T15N97SA	SUP	Experiment NATC06G15N97PA
NOT CONNECTED	A	
NOT CONNECTED	B	
NOT CONNECTED	C	
NOT CONNECTED	D	
NOT CONNECTED	E	
NOT CONNECTED	F	
F.O. VIDEO/DATA	G	
NOT CONNECTED	H	
NOT CONNECTED	J	
NOT CONNECTED	K	
F.O. VIDEO/DATA	L	
F.O. SYNC	M	

FIGURE G.3.1.1.2-12 SUP-1/SUP-4 CONNECTOR J06 PIN ASSIGNMENTS

COL NATC00T13N35SA	SUP	Experiment NATC06G13N35PA
SAFING CMD 1 RTN	1	
SAFING CMD 2	2	
SAFING CMD 2 RTN	3	
SMOKE DET. BIT ENABLE – RTN	4	
SMOKE DET. BIT ENABLE +	5	
NOT CONNECTED	6	
SMOKE INDICATION CMD	7	
SMOKE INDICATION CMD RTN	8	
NOT CONNECTED	9	
WARNING FLAG	10	
WARNING FLAG RTN	11	
NOT CONNECTED	12	
NOT CONNECTED	13	
EMERGENCY FLAG	14	
SAFING CMD 1	15	
SMOKE DET. OBSCURATION	16	
SMOKE DET. OBSCURATION RTN	17	
SMOKE DET. SCATTER	18	
FAN VENTILATION	19	
FAN VENTILATION RTN	20	
EMERGENCY FLAG RTN	21	
SMOKE DET. SCATTER RTN	22	

FIGURE G.3.1.1.2-13 SUP-1/SUP-4 CONNECTOR J07 PIN ASSIGNMENTS

COL NATC00T11N98SN	SUP	Experiment NATC06G11N98PN or D38999 26FB98PN
NOT CONNECTED	A	
COL LAN-2 HI RX	B	
COL LAN-2 LO RX	C	
NOT CONNECTED	D	
COL LAN-2 LO TX	E	
COL LAN-2 HI TX	F	
CHASSIS GROUND	SHELL	

FIGURE G.3.1.1.2-14 SUP-1 TO SUP-4 CONNECTOR J09 PIN ASSIGNMENTS

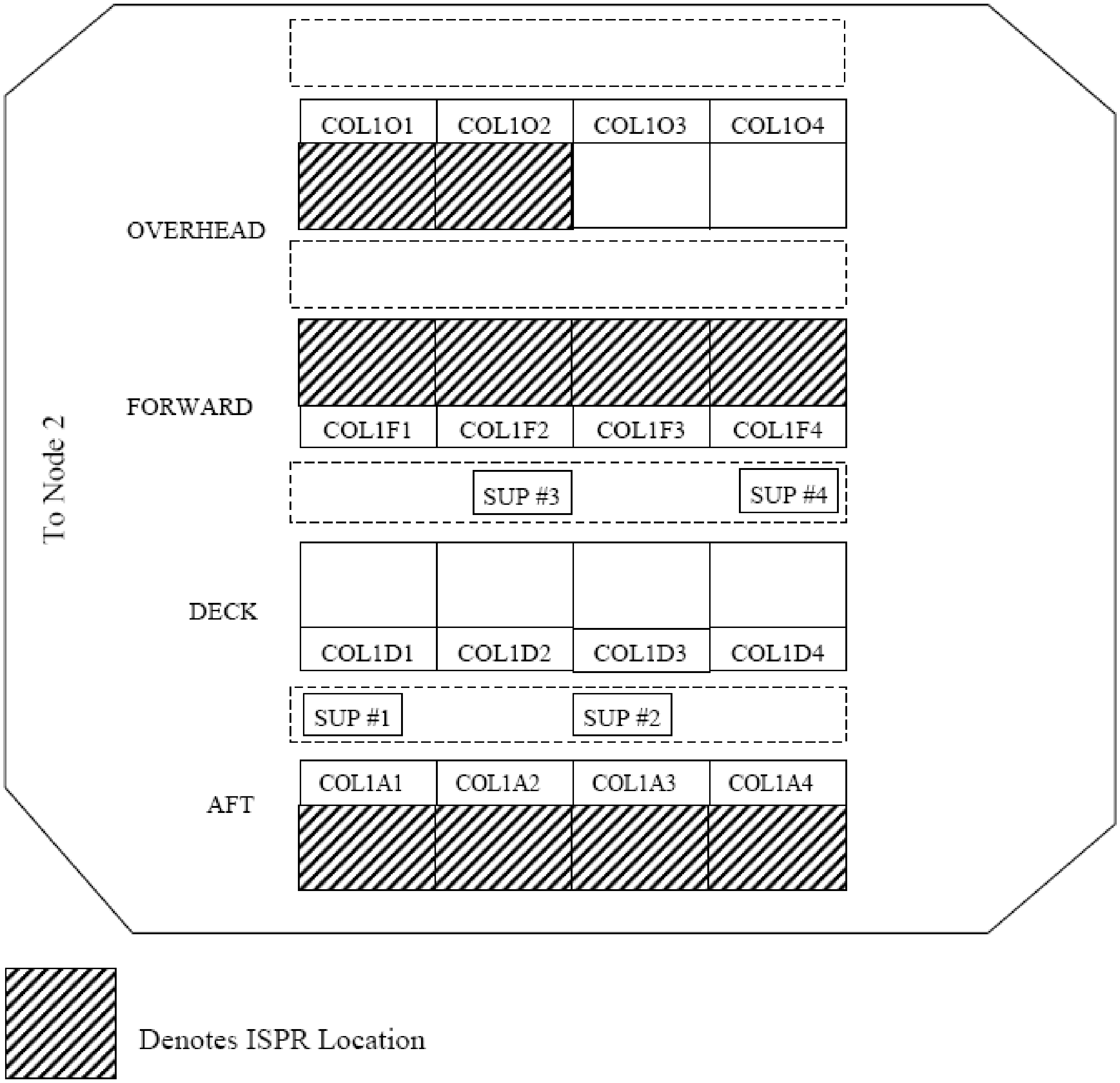


FIGURE G.3.1.1.2-15 SUP LOCATIONS – COLUMBUS

TABLE G.3.1.1.2-1 SUP SUMMARY

Connector	SUP #1	SUP #2	SUP #3	SUP #4
J01/Power	Ch	C	C	Ch
J02/Power	P	PL	PL	P
J03/Power	PL2	POL	P	PL2
J04/Data 1	AB	Spare	Spare	AB
J05/Data 2	EN	EN	EN	EN
J06/Data 3	VHR	Spare	Spare	VHR
J07/Data 4	SS	Reserved	Reserved	SS
J08/Data 5	VCA	Reserved	Reserved	VCA
J09/Data 6	ER	ER	ER	ER

Key:
- C Power/Core 1553B Bus
- Ch Power/CheCS 1553B Bus
- P Power Only
- PL Power/ISS Payload 1553B Bus
- PAB Power/COL 1553B Bus
- PL2 Power/Payload LAN-2
- POL Power/Payload Ops LAN
- AB Columbus Payload 1553B Bus[1]
- EN COL IEEE 802.3 LAN
- SS Smoke Sensor/EWACS
- VCA Video Camera Assembly (Not for payload use)[1]
- ER COL IEEE 802.3 LAN-2
- VHR Video and High Rate Data (Fiber Optics)[1]

Note 1: The characteristics for this interface are not defined in SSP 57000. Payloads interfacing with this data type would need to refer to the Columbus IRD.

G.3.1.2 MICROGRAVITY

Microgravity requirements limit the disturbing effects of non-rack payloads on the microgravity environment. The requirements are separated into the quasi-steady category (frequencies below 0.01 Hz), the vibratory category (frequencies between 0.01 Hz and 300 Hz), and the transient category. For non-rack payloads, the interface points are the locations on the ISS structure or payload rack where the non-rack payload structurally mounts.

G.3.1.2.1 QUASI-STEADY REQUIREMENTS

For frequencies below 0.01 Hz, non-rack payloads *should* limit unbalanced translational average impulse to generate less than 10 lb·s (44.5 N·s) within any 10 to 500 second period, along any ISS coordinate system vector.

G.3.1.2.2 VIBRATORY REQUIREMENTS

For frequencies between 0.01 Hz and 300 Hz, non-rack payloads **shall** limit produced forces to the values shown in Table N.3.1.2.2-1 (Figure N.3.1.2.2-1) or the acceleration limits in Table N.3.1.2.2-2 (Figure N.3.1.2.2-2).

G.3.1.2.3 TRANSIENT REQUIREMENTS

Non-rack payloads **shall** limit force applied to the ISS over any 10 second period to an impulse of no greater than 10 lb·s (44.5 N·s).

G.3.2 ELECTRICAL INTERFACE REQUIREMENTS

G.3.2.1 ELECTRICAL POWER CHARACTERISTICS

Electrical power characteristics are specified in this section for Interface C. Payload associated hardware and payload hardware connected to UOPs in the USL and JEM or the SUPs in the COL are required to be compatible with the prescribed characteristics of the Electrical Power System (EPS). For purposes of this document, compatibility is defined as operating without producing an unsafe condition or one that could result in damage to ISS equipment or payload hardware.

G.3.2.1.1 INTERFACE C STEADY-STATE VOLTAGE CHARACTERISTICS

The ISS will provide the Interface C steady-state voltage limits of 113 to 126 Vdc.

G.3.2.1.2 RIPPLE VOLTAGE CHARACTERISTICS

G.3.2.1.2.1 RIPPLE VOLTAGE AND NOISE

The EPCE connected to Interface C **shall** operate and be compatible with the EPS time domain ripple voltage and noise level of 2.5 Vrms maximum within the frequency range of 30 Hz to 1 MHz.

G.3.2.1.2.2 RIPPLE VOLTAGE SPECTRUM

The EPCE connected to Interface C **shall** operate and be compatible with the EPS ripple voltage spectrum as shown in Figure G.3.2.1.2.2-1.

Note: This limit is 6 dB below the EMC CS-01, CS-02 requirement in SSP 30237, Space Station Electromagnetic Emission and Susceptibility Requirements, up to 30 MHz.

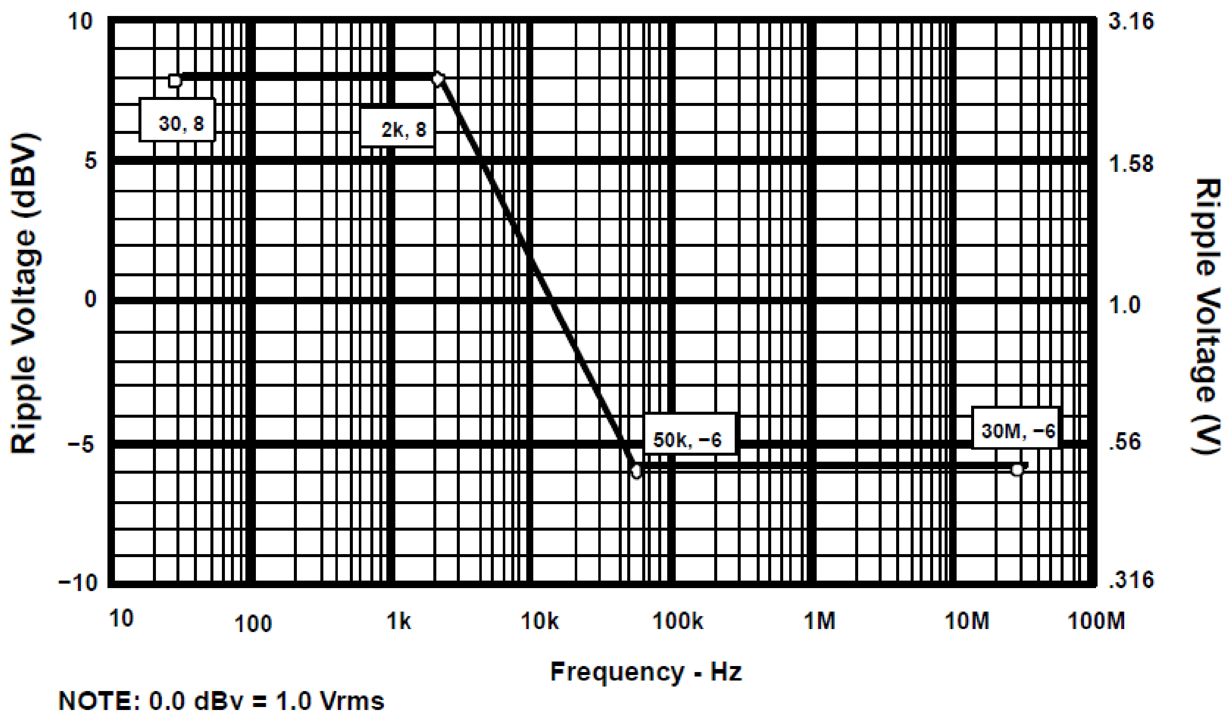


FIGURE G.3.2.1.2.2-1 MAXIMUM INTERFACES B AND C RIPPLE VOLTAGE SPECTRUM

G.3.2.1.3 TRANSIENT VOLTAGES

G.3.2.1.3.1 INTERFACE C

The EPCE at Interface C **shall** operate and be compatible with the limits of magnitude and duration for the voltage transients at Interface C as shown in Figure G.3.2.1.3.1-1. The envelope shown in this figure applies to the transient responses exclusive of any periodic ripple or noise components that may be present.

Note: Columbus EPS transients less than 100 microseconds are defined in COL-ESA-RQ-014, paragraphs 4.1.5.3 and 4.1.7.2 (in compliance with CS06 requiring a 10 microsecond pulse injection). Payloads meeting CS06 requirements in SSP 30237 are in compliance with the Columbus requirements.

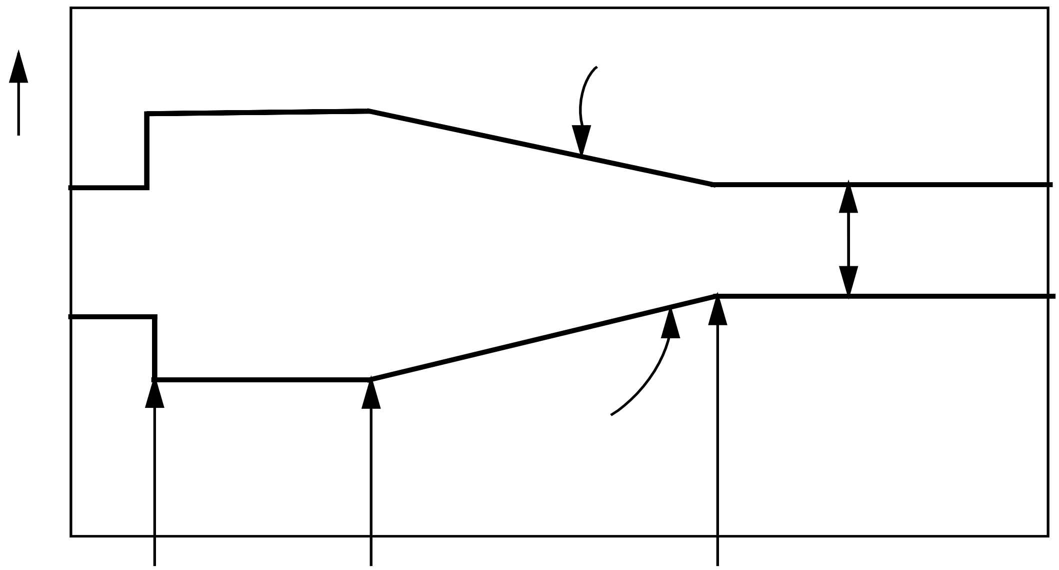
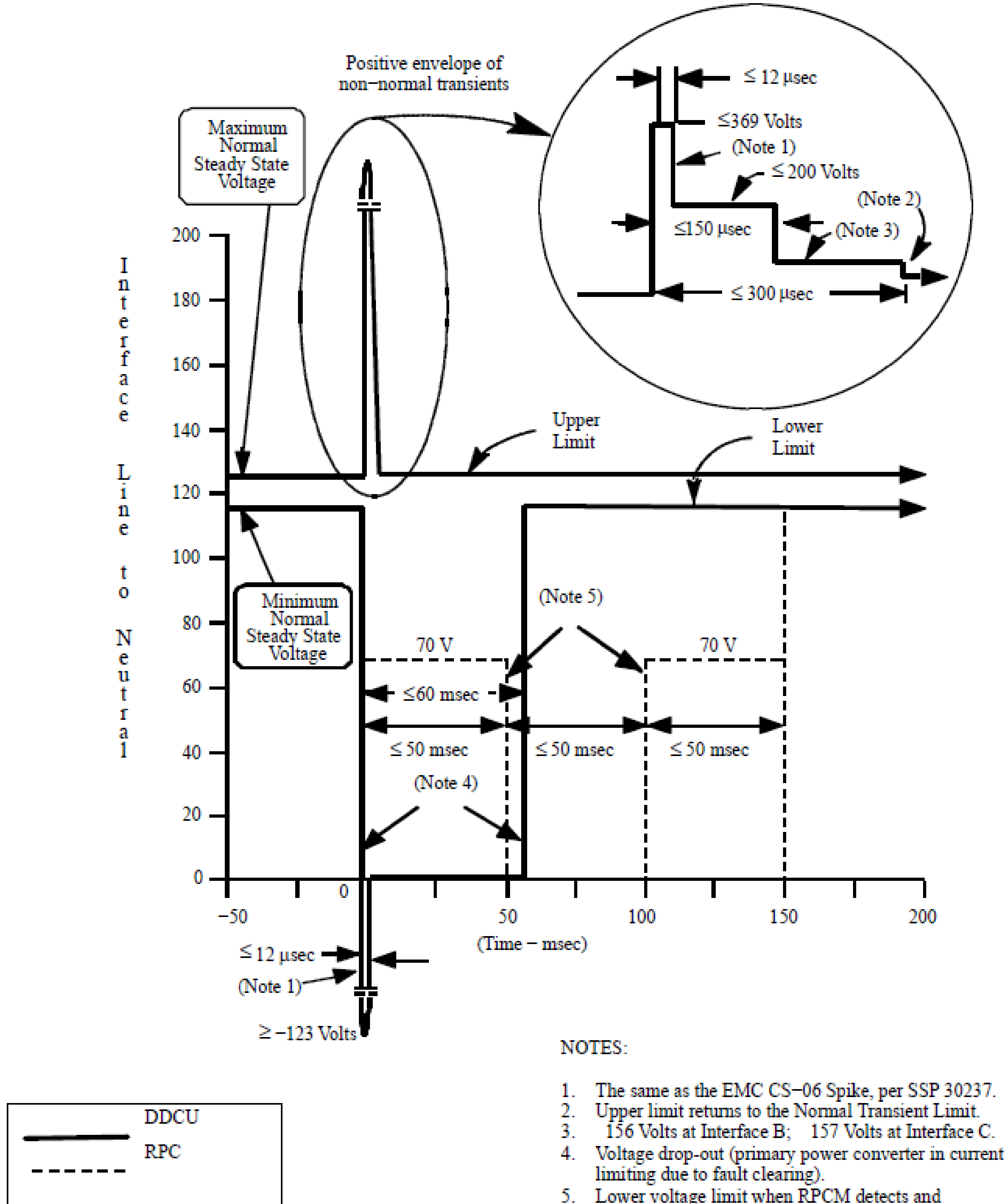


FIGURE G.3.2.1.3.1-1 INTERFACE C VOLTAGE TRANSIENTS

G.3.2.1.3.2 FAULT CLEARING AND PROTECTION

The EPCE connected to Interface C *should* not be damaged by the transient voltage conditions that are within the limits shown in Figure G.3.2.1.3.2-1. Loads may be exposed to transient overvoltage conditions during operation of the power system's fault protection components.



NOTES:

1. The same as the EMC CS−06 Spike, per SSP 30237.
2. Upper limit returns to the Normal Transient Limit.
3. 156 Volts at Interface B; 157 Volts at Interface C.
4. Voltage drop-out (primary power converter in current limiting due to fault clearing).
5. Lower voltage limit when RPCM detects and responds to under voltage conditions.

FIGURE G.3.2.1.3.2-1 FAULT CLEARING AND PROTECTION TRANSIENT LIMITS

G.3.2.1.3.3 NON-NORMAL VOLTAGE RANGE

The EPCE connected to Interface C *should* not be damaged when exposed to a maximum overvoltage of +165 Vdc for 10 seconds and undervoltage conditions of +102 Vdc for an indefinite period of time.

Note: In this case, damage to the payload refers to damage of the EMI filter and Power Converters as a result of overvoltage and undervoltage conditions. For example, damage to the EMI filter can impact limiting emission and the immunity of equipment to electrical disturbances, and cannot shunt unwanted interference.

G.3.2.2 ELECTRICAL POWER INTERFACE

G.3.2.2.1 SURGE CURRENT

The surge current at the power input to the EPCE connected to Interface C **shall** not exceed a duration of 10 ms when powered from a voltage source with characteristics specified in paragraph G.3.2.1, with the exception that the source impedance is considered to be 0.1 ohm. The duration of surge current is measured as the duration in which the current exceeds the maximum steady state input current derived from the payload maximum continuous power. These requirements apply to all operating modes and changes including power-up and power-down.

G.3.2.2.2 REVERSE CURRENT

The EPCE **shall** limit reverse current transients into the upstream power that can occur when a hard fault occurs across the power source within the applicable transient envelope shown in Figure G.3.2.2.2-1, Reverse Current Envelopes for Time Duration Shorter than 300 Microseconds, Figure G.3.2.2.2-2, Reverse Current Envelopes for Time Duration Between 300 Microseconds and 10 Milliseconds, and Figure G.3.2.2.2-3, Reverse Current Envelopes for Time Duration Between 10 and 300 Milliseconds.

For purposes of this interface definition, the fault is 10 milliohms or less applied within 2 micro-seconds or less. For the EPCE exhibiting reverse current transient peaks within ±100 Amperes, the fault resistance is 40 milliohms or less.

If the reverse current exceeds the envelope limits defined in this paragraph for one or more short time intervals, the transient peak current and the ratio of the times of intersection with the envelope must satisfy the following inequality

$$\left(\frac{i_{pk}}{i_e}\right)^2 \cdot ln\left(\frac{t_2}{t_1}\right) \leq 1$$

where *1n* represents the natural logarithm, t_1 and t_2 correspond to the beginning and end times, respectively, of each interval when the transient is outside the envelope, i_{pk} is the peak of the transient occurring between t_2 and t_1, and i_e is the point on the envelope at the time of the peak i_{pk}. For multiple intervals in which the envelope is exceeded, the left-hand side of this expression will be evaluated for each interval and the sum of all such results will total less than unity.

Note:

1. This criterion is based on approximation of the real transient by a vertical-sided pulse which begins at t1, follows a t-2 function through ipk point, and ends at t2. This vertical-sided pulse has the stress property equivalent to the stress that the RPCMs in USL, JEM and Columbus can sustain.

2. An example of such a case is illustrated in Figure G.3.2.2.2-4 where the transient for a hypothetical Load “A” is overlaid with the envelope for a U.S. Type II RPCM, rated at 25 A. The figure shows the transient crossing the envelope at times t1 = 5.1 ms and t2 = 7.1 ms with a peak ipk = 27.5 A and an envelope value, ie = 21 A. Substituting these values into the left-hand side of the inequality in this paragraph leads to

$$\left(\frac{27.5}{21}\right)^2 \cdot ln\left(\frac{7.1}{5.1}\right) \leq 1$$

$$0.567 \leq 1$$

which satisfies the inequality, and since there are no additional envelope crossings, this calculation demonstrates compatibility.

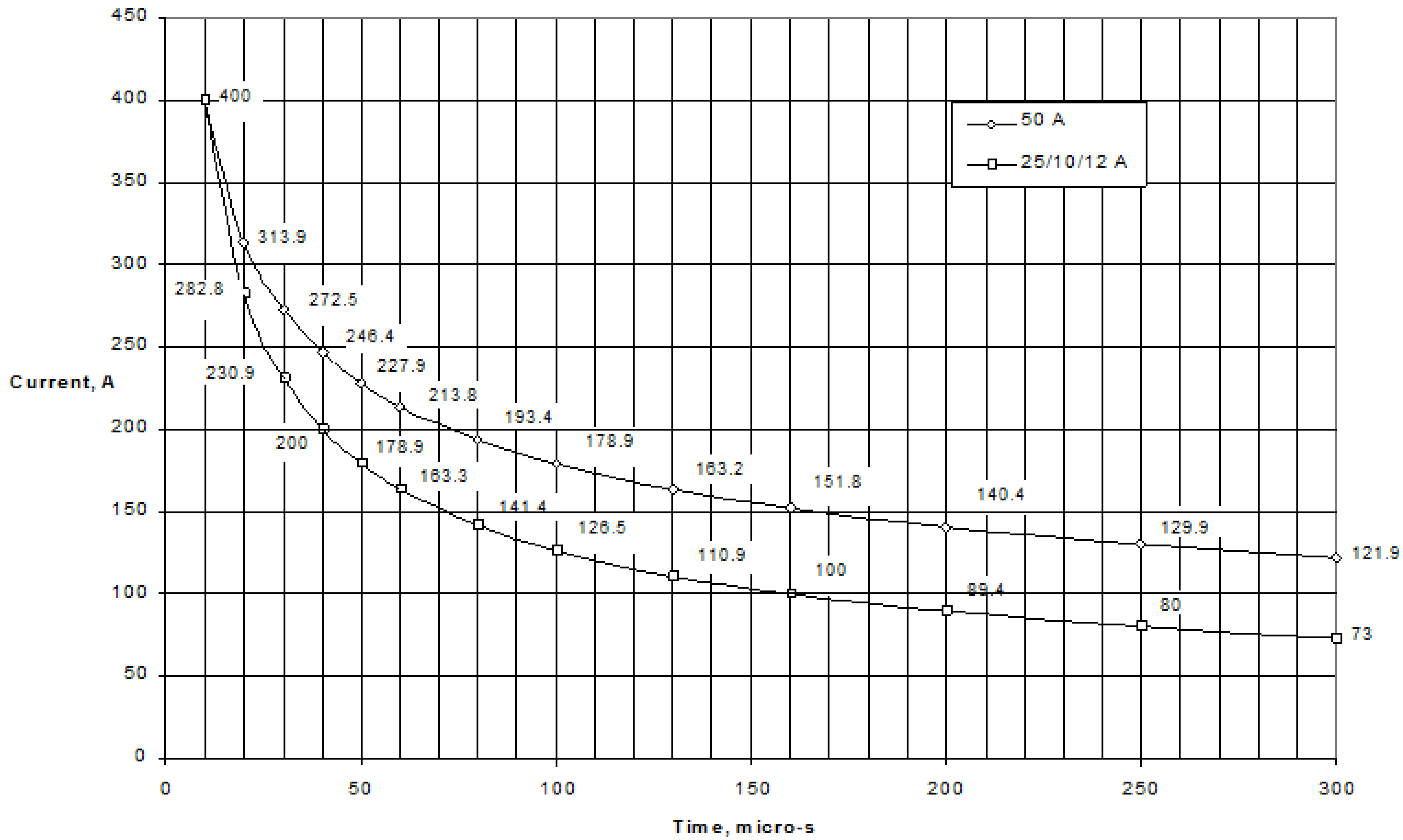


FIGURE G.3.2.2.2-1 REVERSE CURRENT ENVELOPES FOR TIME DURATION SHORTER THAN 300 MICROSECONDS

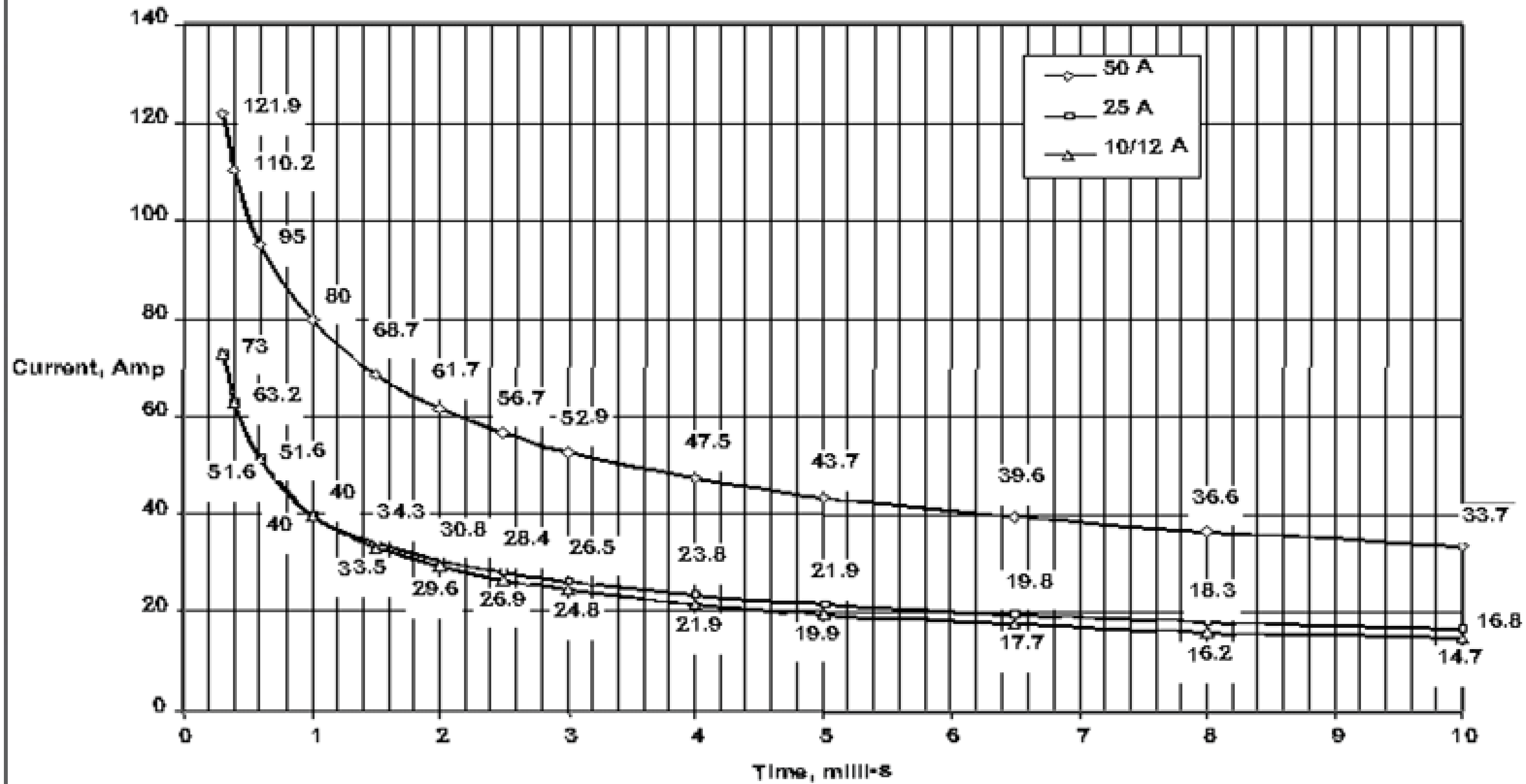


FIGURE G.3.2.2.2-2 REVERSE CURRENT ENVELOPES FOR TIME DURATION BETWEEN 300 MICROSECONDS AND 10 MILLISECONDS

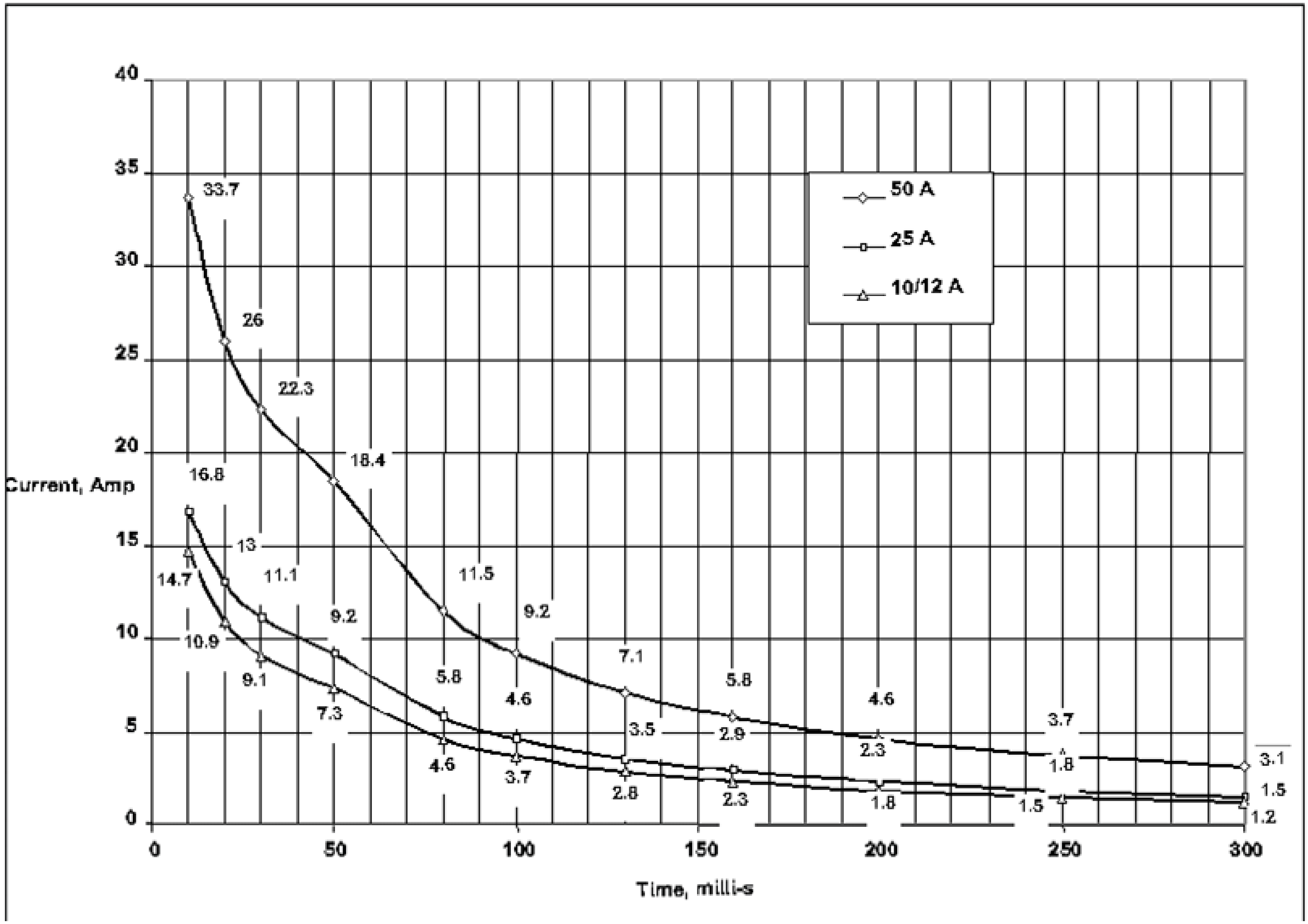


FIGURE G.3.2.2.2-3 REVERSE CURRENT ENVELOPES FOR TIME DURATION BETWEEN 10 AND 300 MILLISECONDS

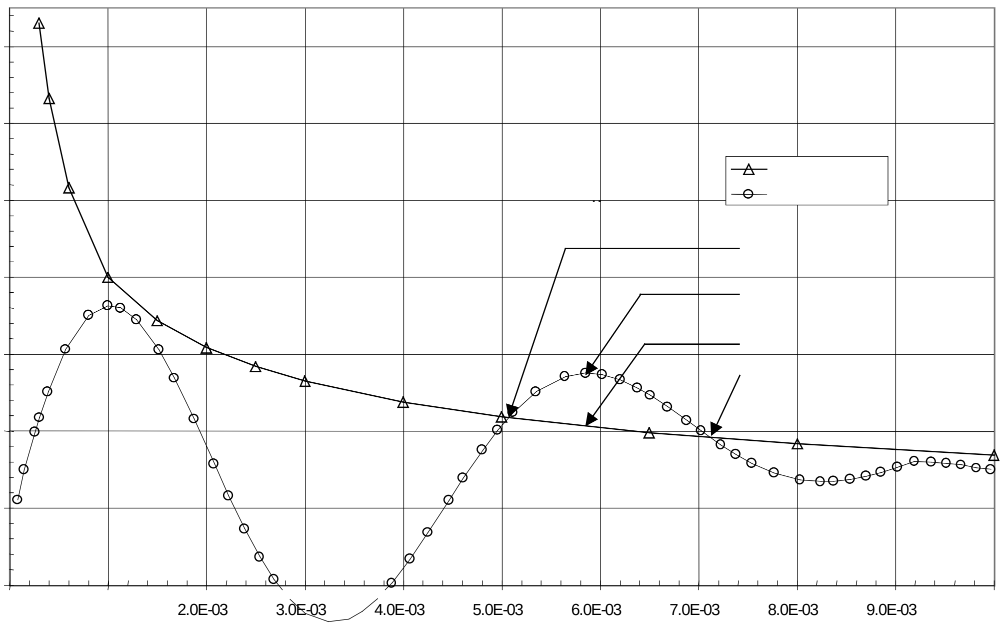


FIGURE G.3.2.2.2-4 AN EXAMPLE OF A LOAD PARTIALLY CONTAINED WITHIN THE ENVELOPE

G.3.2.2.3 CIRCUIT PROTECTION DEVICES

G.3.2.2.3.1 ISS EPS CIRCUIT PROTECTION CHARACTERISTICS

G.3.2.2.3.1.1 REMOTE POWER CONTROLLERS

The ISS power source will provide protection to the EPCE interface for overload conditions by means of a RPC. The overload limitation characteristics of the power feeders are defined in the figures in this paragraph. The shaded regions in the figures show the current limit regions from the time the protection devices start to control the current within the specified range, to the maximum time where the protection device trips and interrupts the current flow.

A. The EPCE connected to a UOP **shall** operate and be compatible with the characteristics in Figure G.3.2.2.3.1.1-1 for USL or Figure G.3.2.2.3.1.1-2 for JEM.

B. The EPCE connected to a SUP **shall** operate and be compatible with the characteristics in Figure G.3.2.2.3.1.1-3.

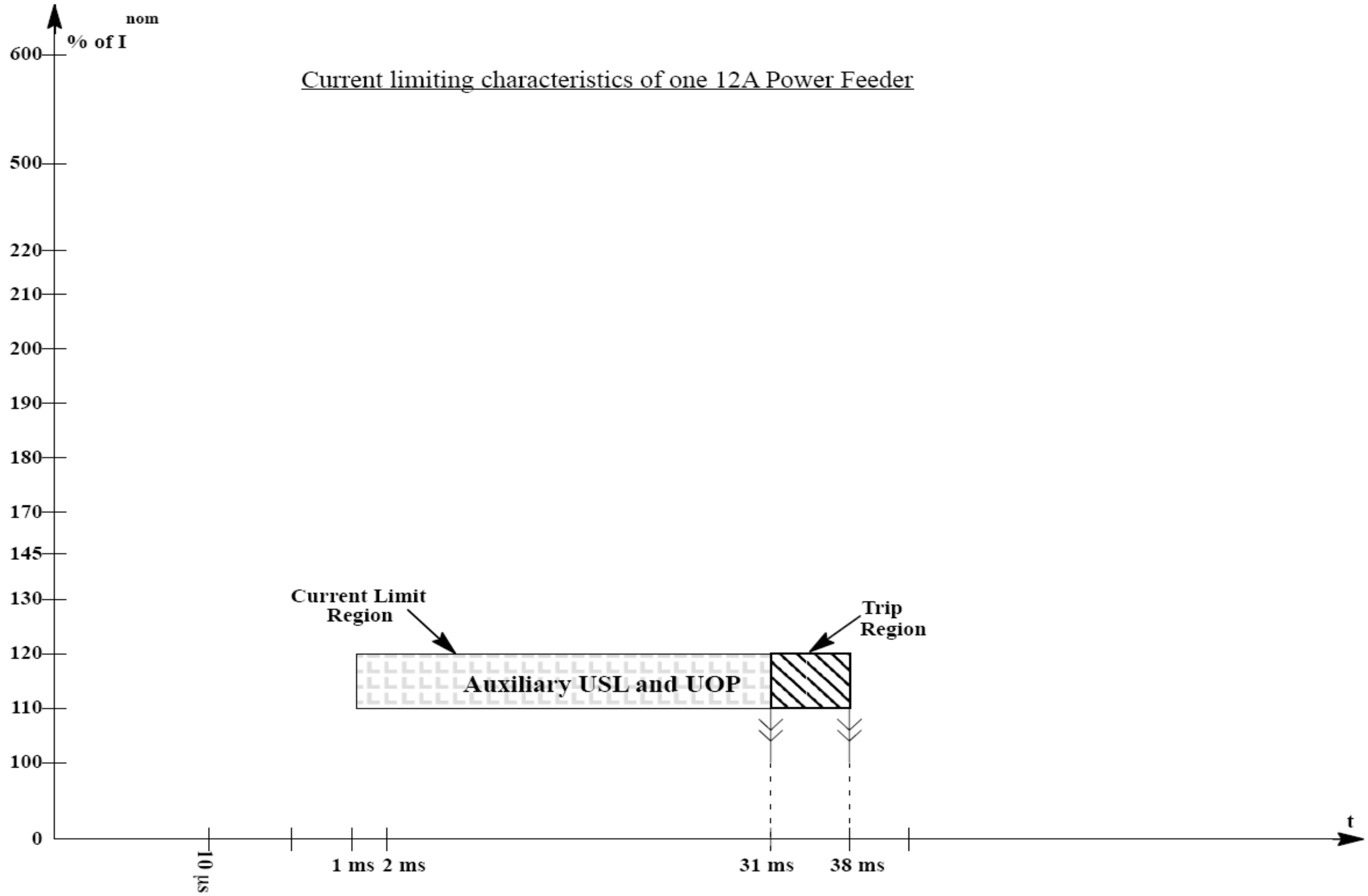
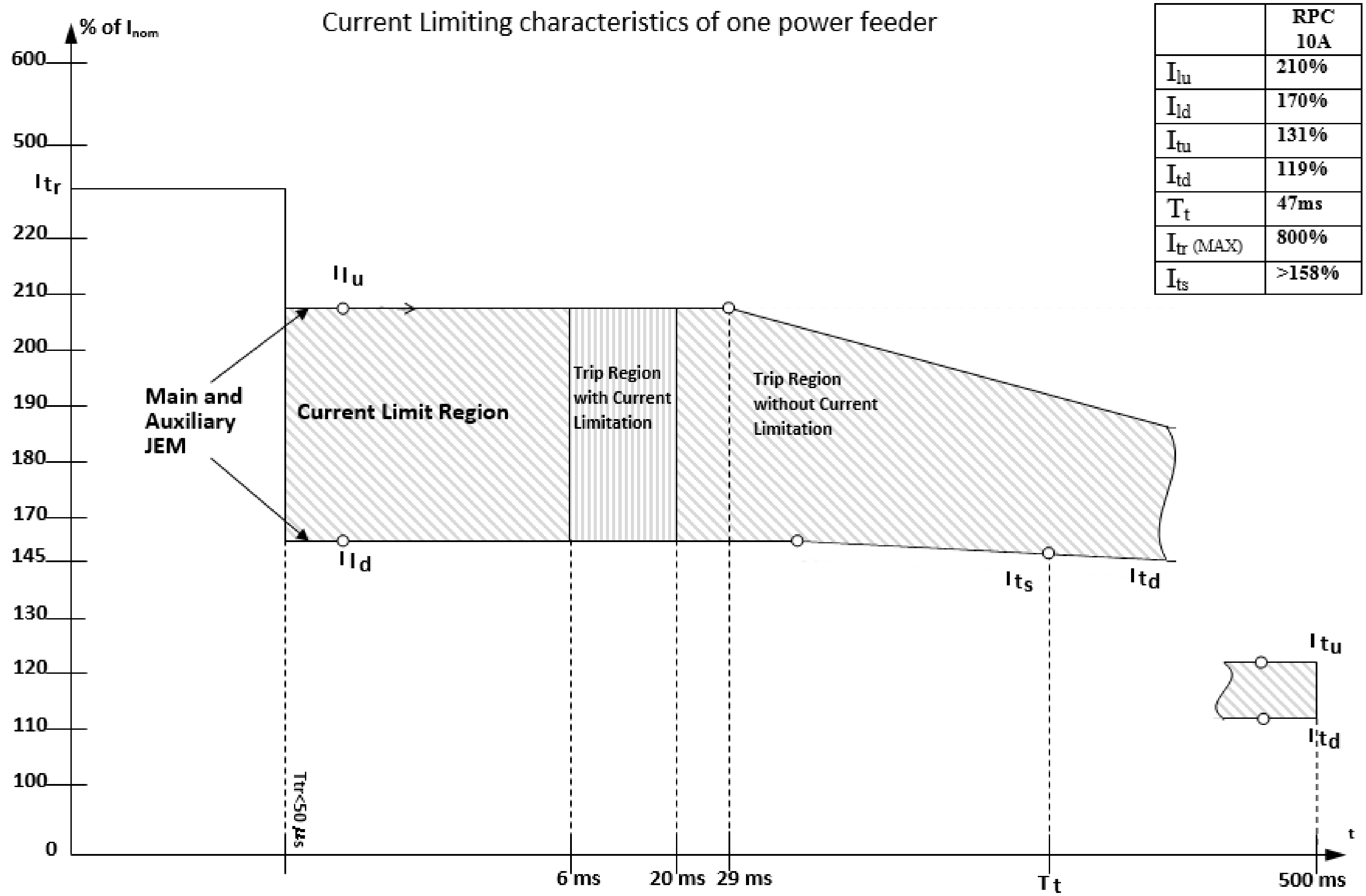


FIGURE G.3.2.2.3.1.1-1 USL UOP OVERLOAD PROTECTION CHARACTERISTICS



	RPC 10A
I_{lu}	210%
I_{ld}	170%
I_{tu}	131%
I_{td}	119%
T_t	47ms
I_{tr} (MAX)	800%
I_{ts}	>158%

FIGURE G.3.2.2.3.1.1-2 JEM UOP OVERLOAD PROTECTION CHARACTERISTICS

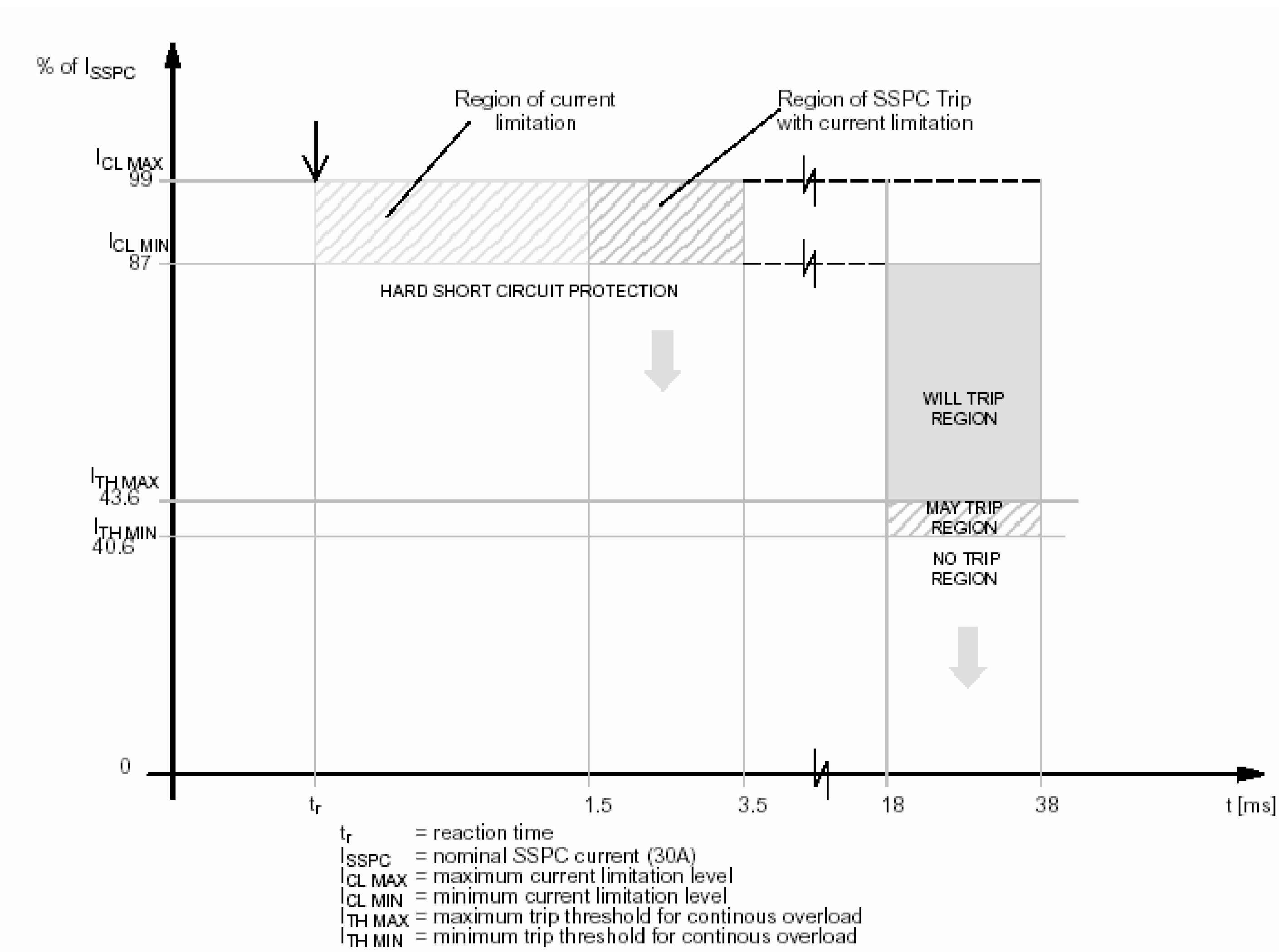
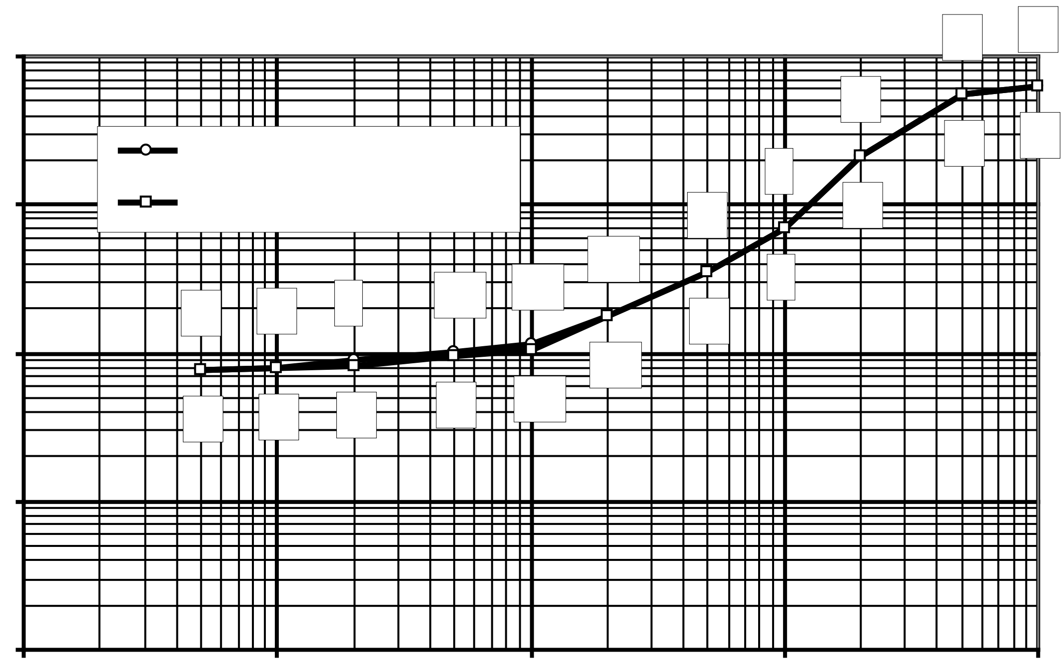
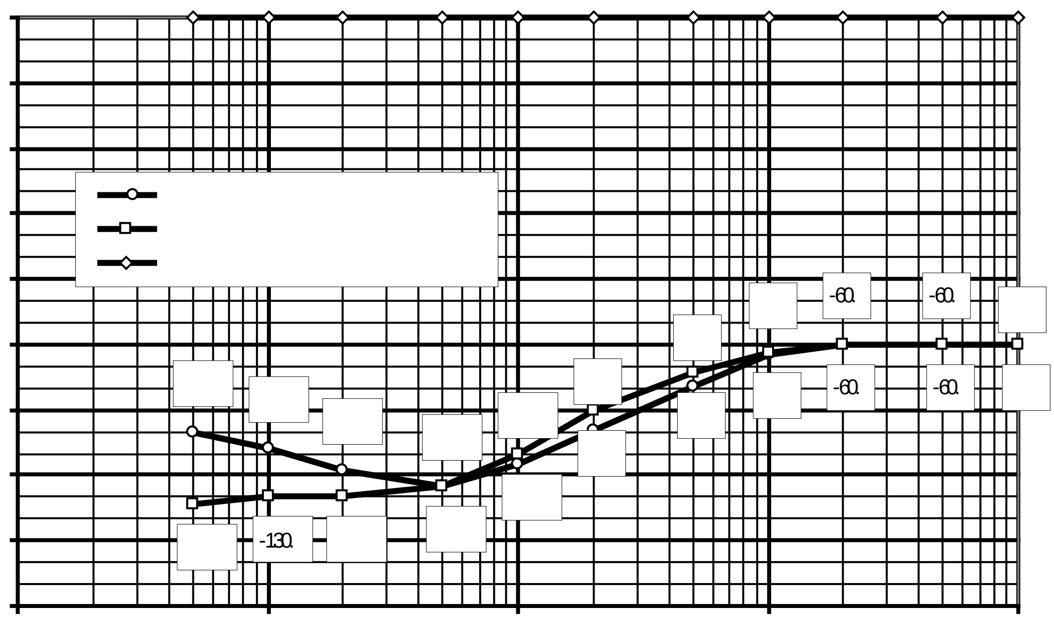


FIGURE G.3.2.2.3.1.1-3 SUP OVERLOAD PROTECTION CHARACTERISTICS

G.3.2.2.4 EPCE COMPLEX LOAD IMPEDANCES

The load impedance presented by the EPCE to Interface C **shall** not exceed the bounds defined by Figure G.3.2.2.4-1 for input over the frequency range of 50 Hz to 100 kHz. The magnitude component of the EPCE input impedance must not be less than the minimum defined in Figure G.3.2.2.4-1. At frequencies where the magnitude component of the EPCE input impedance is less than the defined minimum, the phase component of the input impedance must not exceed the bounds defined in this figure.





Figure

Notes:

FIGURE G.3.2.2.4-1 INTERFACE C LOAD IMPEDANCE LIMITS FOR 10 – 12 AMPERE CIRCUIT RATING

G.3.2.2.5 LARGE SIGNAL STABILITY

The EPCE connected to Interface C **shall** maintain stability with the ISS EPS interface by damping a transient response to 10 percent of the maximum response amplitude within 1.0 millisecond (ms), and remaining below 10 percent thereafter under the following conditions:

1. The rise time/fall time (between 10 and 90 percent of the amplitude) of the input voltage pulse is less than 10 microseconds (s).
2. The voltage pulse is to be varied from 100 to 150 ms in duration.

Note: Figure G.3.2.2.5-1 is used to clarify the above requirement.

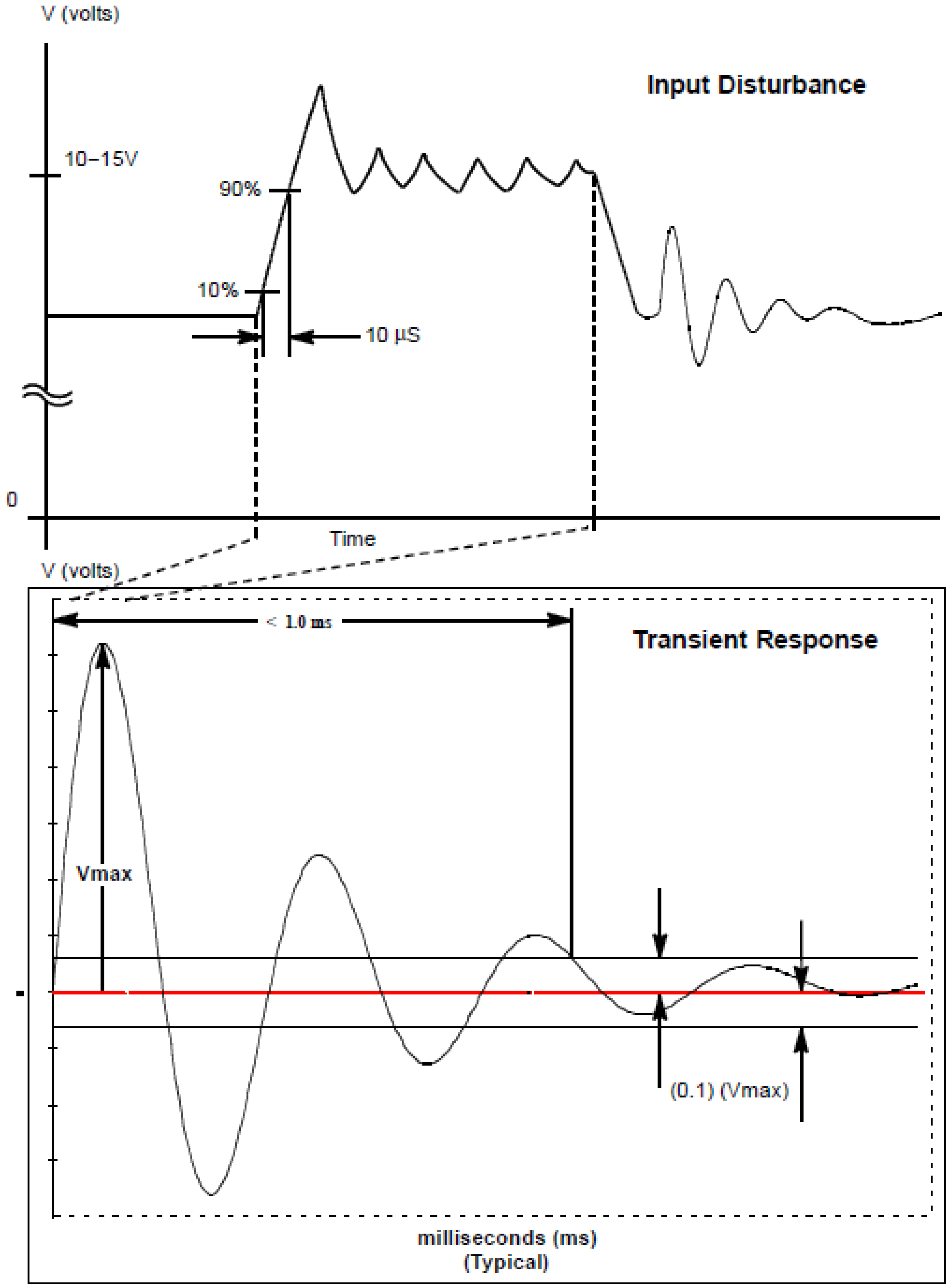


FIGURE G.3.2.2.5-1 PULSE APPLIED TO THE POWER INPUT OF THE EPCE

G.3.2.2.6 SUP GFI CHARACTERISTICS

This requirement applies to EPCE that will be connected to the ISS Secondary electric power system at the Columbus SUPs. All EPCE that can draw power from the SUPs are considered to be portable loads. To be compatible with SUP GFI (Ground Fault Interrupt) function, portable payloads must meet Common Mode Capacitance requirements or Leakage Current requirements.

G.3.2.2.6.1 COMMON MODE CAPACITANCE

The Portable load **shall** meet the existing EMI conducted emissions in paragraph 3.2.2.1 requirements up to 100 kHz, and the total common mode capacitance within the load is less than 200 nano-Farads.

G.3.2.2.6.2 LEAKAGE CURRENTS

The electric power connections to portable loads will include lines that carry the +120 volt (hot), nominal 0 volt (return line), and two independent grounds (“green wires”). Any difference between the currents that can flow in the hot and return lines, while connected to the SUP, are considered to be leakage (or common mode) currents. To be compatible with SUP GFI function, EPCE must meet the following requirements.

G.3.2.2.6.2.1 FREQUENCY DOMAIN LEAKAGE LIMITS

Spectral components of the common mode currents drawn by portable loads **shall** not exceed the limits defined by Figure G.3.2.2.6.2.1-1.

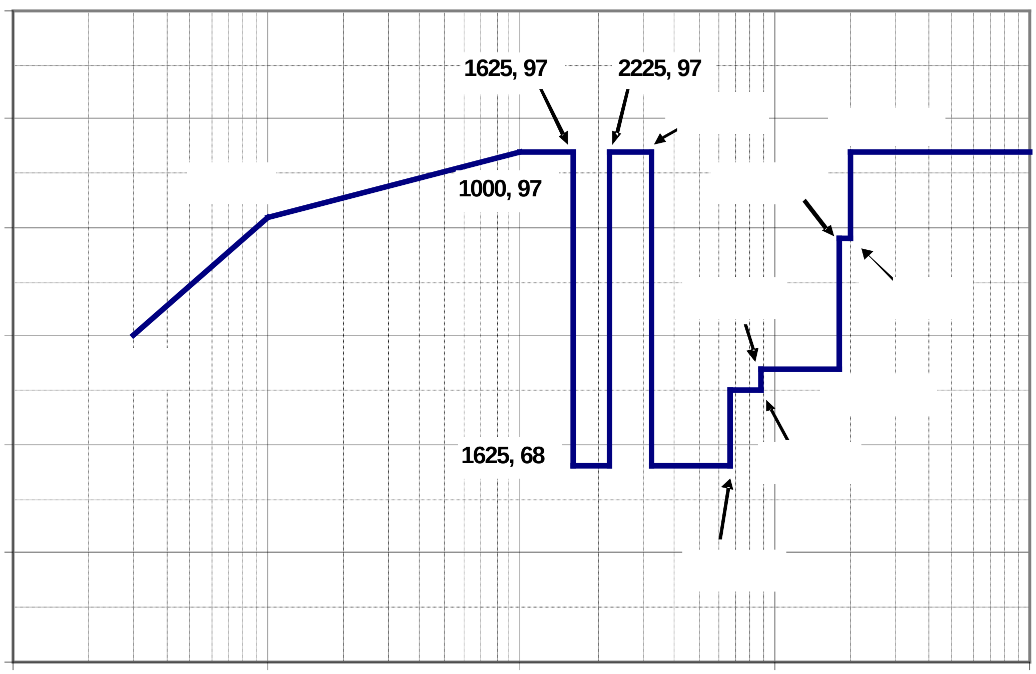


FIGURE G.3.2.2.6.2.1-1 SUP POWER OUTLET GFI CHARACTERISTICS

G.3.2.2.6.2.2 TIME DOMAIN LEAKAGE LIMITS

The sensitivity and time-to-trip of the SUP GFI function to common mode (step-function) currents will be as shown in Figure G.3.2.2.6.2.2-1. Inrush common mode currents drawn by portable loads **shall** not exceed Figure G.3.2.2.6.2.1-1.

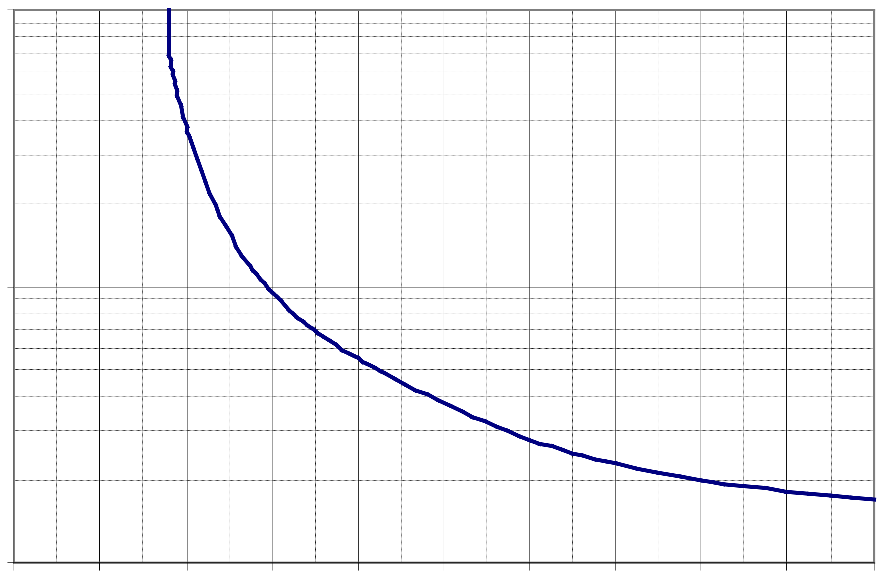


FIGURE G.3.2.2.6.2.2-1 SUP TIME DOMAIN LEAKAGE CURRENT

G.3.2.2.7 ELECTRICAL STANDALONE STABILITY

The EPCE connected to Interface C, **shall** provide local stability by meeting requirement N.3.2.2.10.

G.3.2.3 SAFETY REQUIREMENTS

G.3.2.3.1 PORTABLE EQUIPMENT/POWER CORDS

A. Non-battery powered portable equipment must comply with the Class H general requirement 3.2.2.8.1 in order to prevent shock hazards. A typical Class H bonding implementation is to incorporate a three-wire power cord. A three-wire power cord consists of a (+) supply lead, a (-) return lead and a safety (green) wire; one end of the safety (green) wire is connected to the portable equipment chassis (and all exposed conductive surfaces) and the other end is connected to structure of the utility outlet (Payload provided outlet, UOP, etc.). A system of double insulation or its equivalent, when approved by NASA, may be used without a ground wire.

B. Non-battery powered equipment must have a redundant ground path terminated at the connector back shell for output voltages exceeding 30 volts rms or DC nominal (32 volts rms or DC maximum) where the bonding methodology does not satisfy the DFMR criteria of MA2-99-142 (found in SSP 51700 Appendix E). When a redundant ground (which may be a fourth wire or the cable shield, provided that the shield is sized to carry the fault load) is necessary to satisfy the criteria of MA2-99-142 (found in SSP 51700 Appendix E), the redundant bond path must comply with the Class H requirement. Note: Non-battery powered equipment must provide 1 megohm DC isolation between power input to chassis and return to chassis invoked by paragraph 3.2.1.4.1.2.

G.3.3 COMMAND AND DATA HANDLING INTERFACE REQUIREMENTS

Command and Data Handling requirements for payloads are addressed in Appendix I.

G.3.4 PAYLOAD NTSC VIDEO INTERFACE REQUIREMENTS

Payload NTSC video interface requirements are addressed in section N.3.4.

G.3.5 THERMAL CONTROL INTERFACE REQUIREMENTS

Payload thermal control interface requirements are addressed in section 3.5.

G.3.6 VACUUM SYSTEM REQUIREMENTS

Payload vacuum system interface requirements and deliverables are addressed in section N.3.6.

G.3.7 PRESSURIZED GASES INTERFACE REQUIREMENTS

Payload pressurized nitrogen interface requirements are addressed in section N.3.7.

G.3.8 JEM PRESSURIZED REQUIREMENTS

Payload JEM pressurized gases (Ar, He, CO_2) interface requirements are addressed in section N.3.8.

G.3.9 ENVIRONMENT INTERFACE REQUIREMENTS

Payload environment interface requirements are addressed in section 3.9.

G.3.10 FIRE PROTECTION INTERFACE REQUIREMENTS

Payload fire protection interface requirements are addressed in section 3.10.

G.3.11 MATERIALS AND PROCESSES INTERFACE REQUIREMENTS

Payload materials and processes interface requirements are addressed in section 3.11.

G.3.12 HUMAN FACTORS INTERFACES

G.3.12.1 CONTINUOUS NOISE LIMITS

Non-rack payloads **shall** not exceed the limits specified in Table G.3.12.1-1 for all octave bands (NC-34 equivalent).

Note: This acoustic requirement does not apply during failure or maintenance operations, or in those cases when the payload meets the Intermittent Noise Source requirements specified in paragraph 3.12.3.2.

TABLE G.3.12.1-1 NOISE LIMITS FOR NON-RACK AND SUBRACK PAYLOADS

Noise Limit at 0.6 Meters Distance From Equipment (NC 34)	
Frequency Band (Hz)	**SPL (dB)**
63	59
125	52
250	45
500	39
1000	35
2000	33
4000	32
8000	31

G.4.0 VERIFICATION

G.4.1 RESPONSIBILITIES

The PD is responsible for providing verification for all applicable requirements in this appendix, as allocated to the payload through the payload unique ICD. The ISS Program is responsible for review and approval of the submitted verification.

G.4.2 VERIFICATION METHODS

Compliance with the requirements stated in Section G.3.0 are proven using one or more of the methods described in paragraph 4.2.

G.4.3 ISS TO NON-RACK PAYLOAD INTERFACE VERIFICATION REQUIREMENTS

G.4.3.1 PHYSICAL AND MECHANICAL INTERFACES

G.4.3.1.1 CONNECTOR PHYSICAL MATE

A. Verification that the non-rack payload connectors physically mate with the corresponding module connectors **shall** be by demonstration or inspection. The demonstration or inspection **shall** use module connectors with the part numbers specified in Table G.3.1.1-1 to verify that the connectors physically mate. The inspection **shall** be a review of non-rack payload connectors against Table G.3.1.1-1 and Table G.3.1.1.2-1. The verification **shall** be considered successful when the demonstration shows the non-rack payload connectors physically mate with their corresponding module connectors or when the inspection shows the non-rack payload connectors match the specifications.

Verification Submittal: CoC

B. Verification of the non-rack payload connectors with the requirements of SSQ 21635 **shall** be by inspection. The inspection **shall** be a review of non-rack payload connector design drawings. The inspection **shall** be considered successful when the review shows the drawings identify the SSQ 21635 or equivalent requirement for the non-rack payload connectors.

Verification Submittal: CoC

C. Verification that connectors provide protection to prevent damage when unmated **shall** be by inspection of drawings or flight hardware. Verification **shall** be considered successful with the inspection shows that protection for unmated connectors is provided.

Verification Submittal: CoC

G.4.3.1.1.1 UTILITY OUTLET PANEL

Verification of appropriate pin assignment **shall** be by inspection. The inspection **shall** be an inspection of payload drawings to verify that the connector pinouts match the corresponding J3 and J4 pinouts. The verification **shall** be considered successful when the inspection shows that the connector pinout is appropriate.

Verification Submittal: CoC

G.4.3.1.1.2 STANDARD UTILITY PANEL - COLUMBUS

Verification of pin assignment **shall** be by inspection. The inspection **shall** be an inspection of payload drawings to verify that the connector pinouts match the corresponding J1, J2 and J3 pinouts. The verification **shall** be considered successful when the inspection shows that the connector pinouts are compatible with J1, J2 and J3 pinouts.

Verification Submittal: CoC

G.4.3.1.2 MICROGRAVITY

NVR

G.4.3.1.2.1 QUASI-STEADY REQUIREMENTS

Verification *should* be by analysis. The analysis is considered successful when it is shown that no impulse is greater than 10 lb·s (44.5 N·s) over any 10 to 500 second interval.

Verification Submittal: Analysis Report

G.4.3.1.2.2 VIBRATORY REQUIREMENTS

Verification **shall** be accomplished by test or analysis. Verification **shall** be considered successful when it is shown force levels are below the values shown in Figure N.3.1.2.2-1 (Table N.3.1.2.2-1) or acceleration levels are below Figure N.3.1.2.2-2 (Table N.3.1.2.2-2).

Note: Guidance for verification of this requirement can be found in D684-13066-01, Payload Microgravity Verification Guidelines.

Verification Submittal: Analysis Report or Test Report

G.4.3.1.2.3 TRANSIENT REQUIREMENTS

Verification **shall** be by analysis or test. Verification **shall** be considered successful when the impulse delivered by the non-rack payload over any 10-second period is shown to be no greater than 10 lb·s (44.5 N·s)) and when the sum of the impulse and vibration resulting from the impulse do not exceed the vibratory limits of G.3.1.2.2 over any 100 second period. FEM time domain analysis is an acceptable verification method for this requirement. Acceleration or force response test data is acceptable if interface impedance considerations are included, including adjustment for possible modal frequency shift and interface structural amplification or attenuation.

Verification Submittal: Analysis Report or Test Report

G.4.3.2 ELECTRICAL INTERFACE REQUIREMENTS

G.4.3.2.1 ELECTRICAL POWER CHARACTERISTICS

NVR

G.4.3.2.1.1 INTERFACE C STEADY-STATE VOLTAGE CHARACTERISTICS

NVR

G.4.3.2.1.2 RIPPLE VOLTAGE CHARACTERISTICS

G.4.3.2.1.2.1 RIPPLE VOLTAGE AND NOISE

Verification of the Ripple Voltage and Noise requirements **shall** be by test and analysis. The verification **shall** be considered successful when analysis of the test data shows the EPCE connected to interface C operates and is compatible with the EPS time domain ripple voltage and noise level of at least 2.5 Vrms within the frequency range of 30 Hz to 1 MHz. Test results of CS01, if performed, may be used as input to the analysis.

Verification Submittal: Test and Analysis Report

G.4.3.2.1.2.2 RIPPLE VOLTAGE SPECTRUM

Verification of the Ripple Voltage Spectrum requirements **shall** be by test and analysis. The verification **shall** be considered successful when analysis of the test data shows the EPCE connected to interface C operates and is compatible with the ripple voltage spectrum in Figure G.3.2.1.2.2-1. Test results of CS01 and CS02, if performed, may be used as input to the analysis.

Verification Submittal: Analysis Report

G.4.3.2.1.3 TRANSIENT VOLTAGES

G.4.3.2.1.3.1 INTERFACE C

Verification of the Transient Voltage requirements **shall** be by test or analysis. Input voltage **shall** be 113 Vdc and 126 Vdc with the Interface C source impedance, as specified in Figure G.4.3.2.2.5-1, Stability Test Setup, Transient Responses. Verification of compatibility with the specified Transient Voltages **shall** be performed by test or analysis of EPCE operation across the transient envelope as specified in Figure G.3.2.1.3.1-1 in this document. The verification **shall** be considered successful when the test or analysis shows the EPCE is compatible with the EPS transient voltage characteristics as specified in Figure G.3.2.1.3.1-1.

Verification Submittal: Analysis Report

G.4.3.2.1.3.2 FAULT CLEARING AND PROTECTION

Fault Clearing and Protection *should* be verified by analysis. The verification *should* be considered successful when analysis shows that the EPCE at Interface C is not damaged by the transient voltages as specified in Figure G.3.2.1.3.2-1. Note: The transient shown in the expanded view is a composite of three possible transient conditions; consequently, the analysis may consist of separate examination of the 12 microsecond transient, the 150 microsecond transient and the 300 microsecond transient.

Verification Submittal: Analysis Report

G.4.3.2.1.3.3 NON-NORMAL VOLTAGE RANGE

Verification of compatibility with Non-Normal voltage range conditions *should* be performed by analysis. The analysis *should* ensure the EPCE is not damaged when parameters are as specified in paragraph G.3.2.1.3.3. The analysis *should* be performed with all converters directly downstream of Interface C. The verification *should* be considered successful when analysis shows the EPCE is not damaged when within ISS interface conditions as defined in paragraph G.3.2.1.3.3.

Verification Submittal: Analysis Report

G.4.3.2.2 ELECTRICAL POWER INTERFACE

G.4.3.2.2.1 SURGE CURRENT

Surge Current **shall** be verified by test. Input power to the EPCE must be representative of the ISS power environment. Verification of compatibility with Surge Current limits **shall** be performed by test at high and low input voltage values as specified. The power source used to perform the test **shall** be capable of providing a range of power between 0 kW to 1.44 kW at 113-126 Vdc for Interface C connected equipment. The EPCE **shall** be operated under worst-case loading conditions that envelope operational loading and voltage ranges. The test **shall** indicate operability and compatibility exists based on test data and the requirements specified in paragraph G.3.2.2.1. These requirements apply to all operating modes and changes including power-up and power-down. The verification **shall** be considered successful when test results show under high and low voltage conditions the EPCE can perform all functional capabilities and prove compatibility by operating within the specified limits of paragraph G.3.2.2.1.

Verification Submittal: Test Report

G.4.3.2.2.2 REVERSE CURRENT

Reverse current limits requirements **shall** be verified by analysis.

Verification of compatibility with reverse current limits **shall** be performed by analysis using the input voltages 113 V and 126 V prior to the occurrence of fault for the EPCE connected to Interface C, or 116 V and 126 V prior to the occurrence of fault for integrated racks connected to Interface B . The EPCE **shall** be analyzed under selected loading conditions that envelope operational loading.

The verification **shall** be considered successful when analysis shows that the EPCE complies with requirements defined in Paragraph G.3.2.2.2 for the reverse current into the upstream power source.

If the reverse current exceeds the envelope limits defined in Paragraph G.3.2.2.2 for one or more short time intervals, the requirement for reverse current transients partially contained within the envelope **shall** be verified by analysis.

The verification **shall** be considered successful when analysis shows that the EPCE complies with inequality for the reverse current exceeding the envelope limits defined in Paragraph G.3.2.2.2 for one or more short time intervals.

Verification Submittal: Analysis Report (Description of model, parameters and the results of the Analysis)

G.4.3.2.2.3 CIRCUIT PROTECTION DEVICES

G.4.3.2.2.3.1 ISS EPS CIRCUIT PROTECTION CHARACTERISTICS

G.4.3.2.2.3.1.1 REMOTE POWER CONTROLLERS

A. Analysis of the test data required by paragraph G.4.3.2.2.1 **shall** be performed to show the EPCE connected to a UOP location operates and is compatible with the characteristics shown and described in paragraph G.3.2.2.3.1.1.A. The analysis **shall** be performed at initiation of power to the EPCE and with load combinations for which the EPCE is designed. The verification **shall** be considered successful if the analysis results show the initial current flow, when powered ‘on’, to the EPCE and current flow during the EPCE operations with load combinations does not exceed the current magnitude and duration as defined and described in paragraph G.3.2.2.3.1.1.A.

Verification Submittal: Analysis of test data required by G.4.3.2.2.1.

B. Analysis of the test data **shall** be performed to show the EPCE connected to a SUP location operates and is compatible with the characteristics shown and described in paragraph G.3.2.2.3.1.1.B. The analysis **shall** be performed at initiation of power to the EPCE and with load combinations for which the EPCE is designed. The verification **shall** be considered successful if the analysis shows the initial current flow, when powered ‘on’, to the EPCE and current flow during the EPCE operations with load combinations does not exceed the current magnitude and duration as defined and described in paragraph G.3.2.2.3.1.1.B.

Verification Submittal: Test and Analysis Report

G.4.3.2.2.4 EPCE COMPLEX LOAD IMPEDANCES

EPCE complex load impedance(s) **shall** be verified by test.*

*Verification may be performed by the PRCU or equivalent only if the PRCU or equivalent meets source impedance requirements in Figure G.4.3.2.2.4-1. All active converters directly downstream of interface C **shall** be qualification or flight hardware. Loading of the downstream converter(s) can be simulated to provide full range of active converter loading. Load impedance **shall** be tested under conditions of high voltage, 126 volts, and low voltage, 113 volts to the EPCE and with these conditions for the active converters directly downstream **shall** be exercised through the complete range of their loading. Selected combinations of converters that can influence the measured load impedance at Interface C **shall** be tested.

The verification **shall** be considered successful when the test shows that all load impedances measured for high and low voltage remain within specified limits.

Note: The test report must include the following:

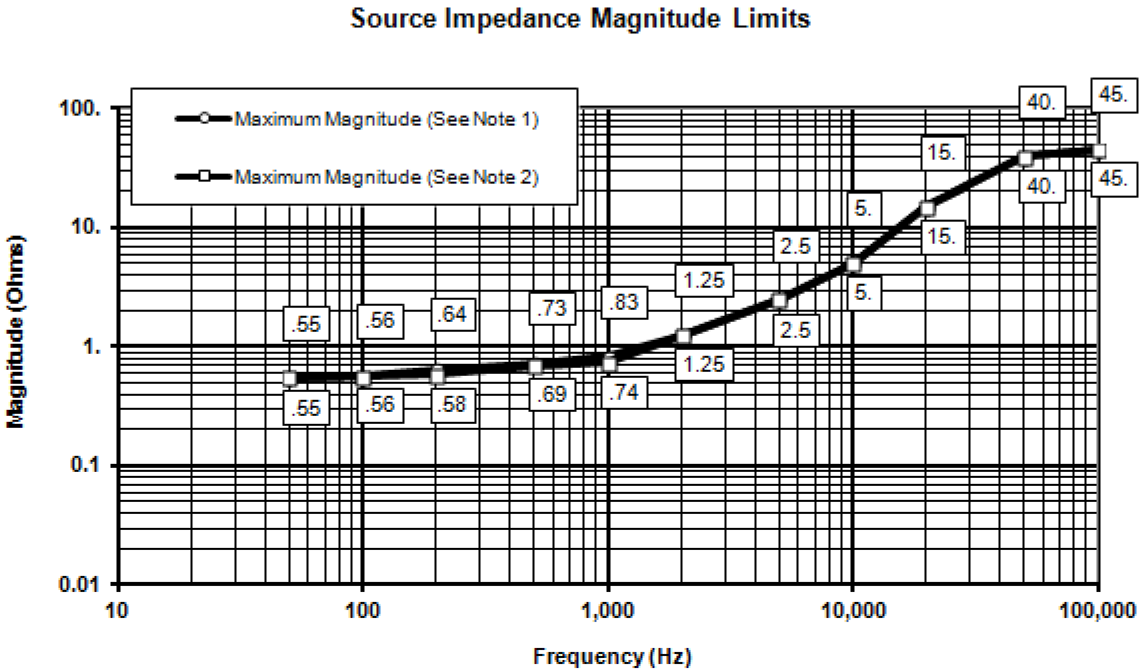
1. A brief description of the test setup and procedure.
2. Input impedances for each configuration tested, magnitude and phase between 100 Hz and 100 kHz, with a minimum of 20 points per decade being measured.

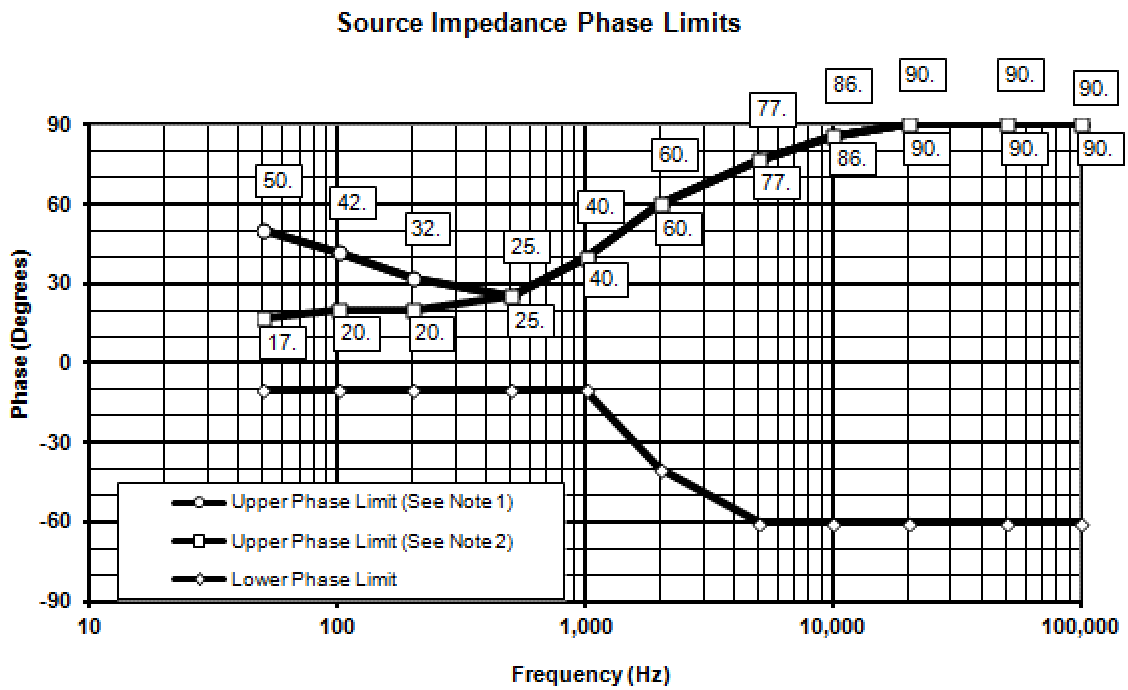
   Format: Graphical Data - plots of magnitude and phase versus frequency on a log scale. Identify with each plot:

   (a) The combination of RPCs and switches that are powered (closed).

   (b) Which electrical items are “on”, including items which have filters powered when the EPCE is “off”.

   (c) The operational state or mode of each powered EPCE.





Notes:
1. Limit when total load on the Secondary Power Source is less than 400 watts.
2. Limit when total load on the Secondary Power Source is at least 400 watts.

FIGURE G.4.3.2.2.4-1 STANDARD INTERFACE C SOURCE IMPEDANCE, 10 - 12 AMPERES CIRCUIT RATING

Verification Submittal: Test Report showing compliance with the Unique Payload Hardware ICD.

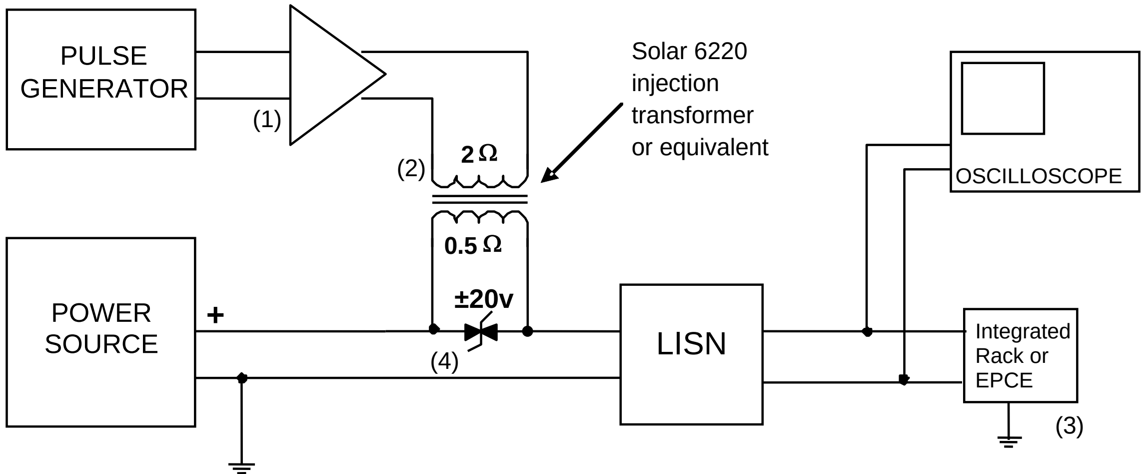
G.4.3.2.2.5 LARGE SIGNAL STABILITY

Large signal stability **shall** be verified by test and analysis. A large signal stability test **shall** be conducted for the EPCE connected to Interface C. An integrated analysis **shall** be provided by the payload developer for representative maximum and minimum case loads to demonstrate that impedance variations will not impact system stability. The input and transient response waveform for the EPCE **shall** be recorded from the start of the pulse through the time when the transient diminishes to and remains below 10 percent of the maximum amplitude of the response. The required test conditions may be produced using a programmable power source or the setup shown in Figure G.4.3.2.2.5-1. The 12 amp LISN or equivalent is to be used for EPCE connecting to Interface C as shown in Figure G.4.3.2.2.5-2. The pulse generator/amplifier must provide a source impedance of less than 0.2 ohms from 100 Hz to 10 kHz to the 2 ohm load of the primary side of the pulse transformer. Pulses of 100, 125 and 150 microsecond (±10 microsecond) duration **shall** be applied. The pulse amplitude at the secondary side of the injection transformer must be between 10 and 15 Volts. Pulse rise and fall times must not exceed 10 microseconds between 10 and 90 percent of the pulse amplitude. The resulting transient responses must remain within the EPS normal transient limits.

The following report data is to be provided:

1. Test configuration detail showing which EPCE was active for each test configuration.
2. Description of prototype, substitute, or missing flight EPCE items.
3. Current and voltage profiles for the input pulse and response.

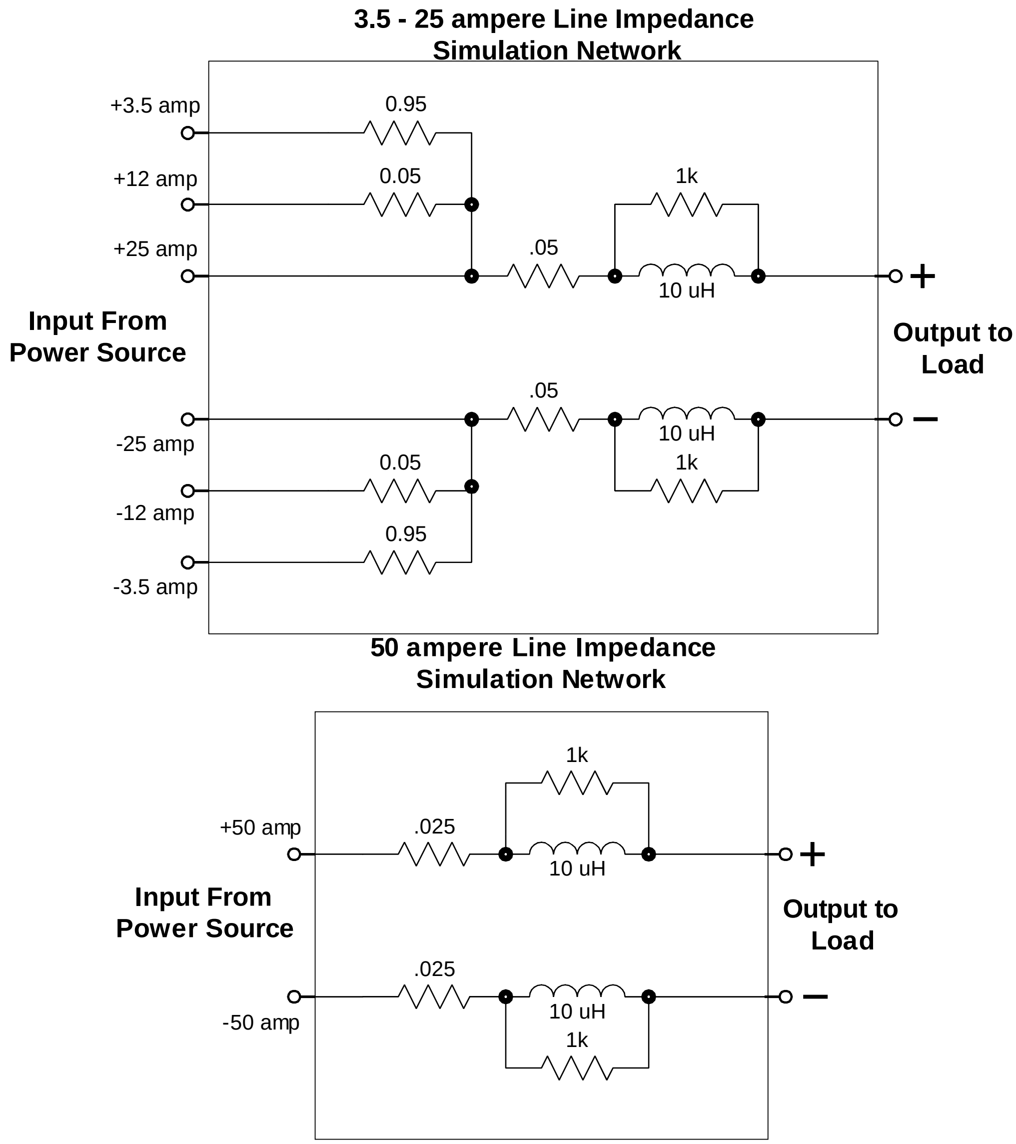
The test and analysis **shall** be considered successful when results show transient responses, measured at the input to the EPCE, diminish to 10 percent of the maximum amplitude within 1.0 milliseconds and remain below 10 percent thereafter.



Notes:

1. The output of the pulse generator must be applied to the transformer through a drive amplifier capable of providing an output impedance of 0.2 ohms, or less, from 100 Hz to 10 kHz.
2. The drive amplifier must be capable of delivering at least 75 watts rms into a 4 Ohm load and be suitable for EMC CS-01 tests.
3. Chassis of payload must be grounded. Portable equipment is not grounded. A differential probe is used if the scope is grounded.
4. Pulse generator, injection transformer and Zener diode may require adjustment to generate the test pulses and to protect the Integrated Rack or EPCE under test.

FIGURE G.4.3.2.2.5-1 STABILITY TEST SETUP, TRANSIENT RESPONSES



Note: Resistance is in Ohms

FIGURE G.4.3.2.2.5-2 ISS LINE IMPEDANCE SIMULATION NETWORK (LISN)

Verification Submittal: Test and Analysis Report

G.4.3.2.2.6 SUP GFI CHARACTERISTICS

NVR

G.4.3.2.2.6.1 COMMON MODE CAPACITANCE

Common mode capacitance **shall** be verified by analysis.

The verification **shall** be considered successful when analysis shows the portable loads meet the existing EMI requirements up to 100 kHz, and the total common mode capacitance within the load is less than 200 nano-Farads. This may be verified by review of the existing conducted emissions EMI test data and inspection of the electrical schematics or design documentation.

Verification Submittal: Analysis Report

G.4.3.2.2.6.2 LEAKAGE CURRENTS

NVR

G.4.3.2.2.6.2.1 FREQUENCY DOMAIN LEAKAGE LIMITS

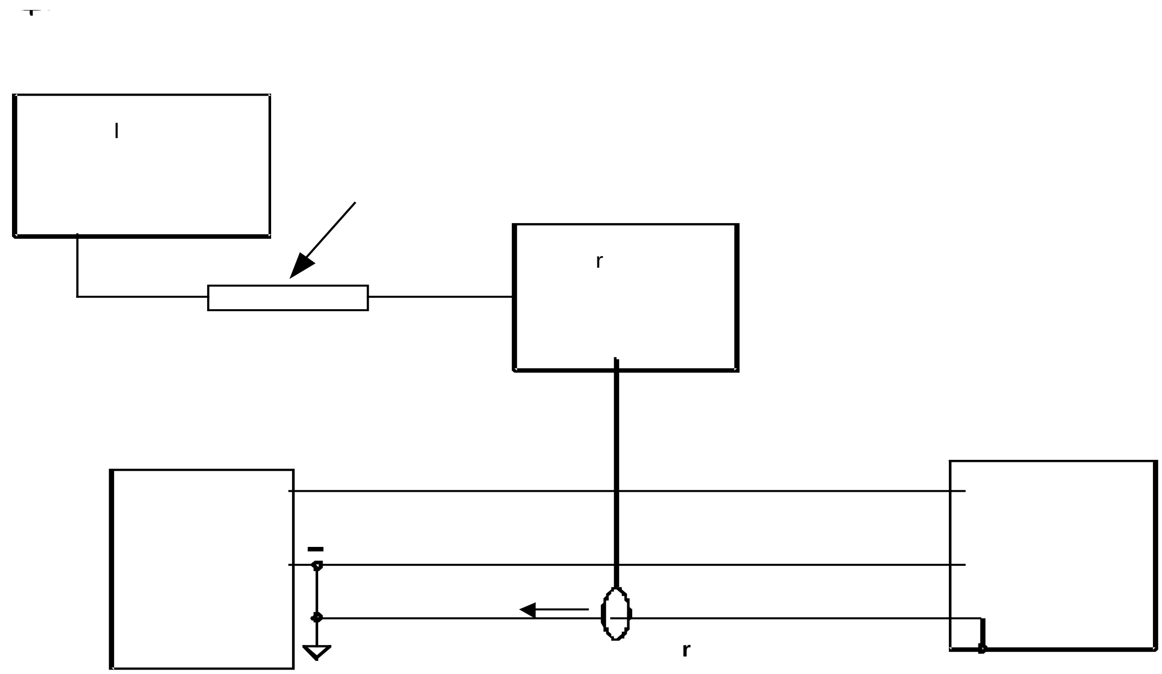
Frequency domain leakage **shall** be verified by test for all operational modes. The frequency domain conducted emission may be measured using the methods of SSP 30238, Space Station Electromagnetic Techniques, or COL-ESA-RQ-014 from 30 Hz to 50 kHz. The verification **shall** be considered successful when test data shows the portable loads conducted emissions measured on the positive and negative leads do not exceed the limits as defined in Figure G.3.2.2.6.2.1-1.

Verification Submittal: Test Report

G.4.3.2.2.6.2.2 TIME DOMAIN LEAKAGE LIMITS

Time domain leakage **shall** be verified by test for all operational modes. The verification **shall** be considered successful when test data shows the inrush common mode current does not exceed the time domain leakage current as defined in Figure G.3.2.2.6.2.2-1. In addition, the integrated transient current in the ground wire **shall** not exceed 0.1 mA-second over any 15 millisecond interval after the portable load is energized or turned ON, using the time domain methods below:

Note: The setup for measuring portable load leakage currents is shown in Figure G.4.3.2.2.6.2.2-1. (Figure to be revised to add a spectrum analyzer for the frequency domain measurements.)



Note: The power source may be a DDCU and RPCM, or a commercial power supply that provides an output within the Interface A, Figure G.4.3.2.2.6.2.2-2 impedance limits.

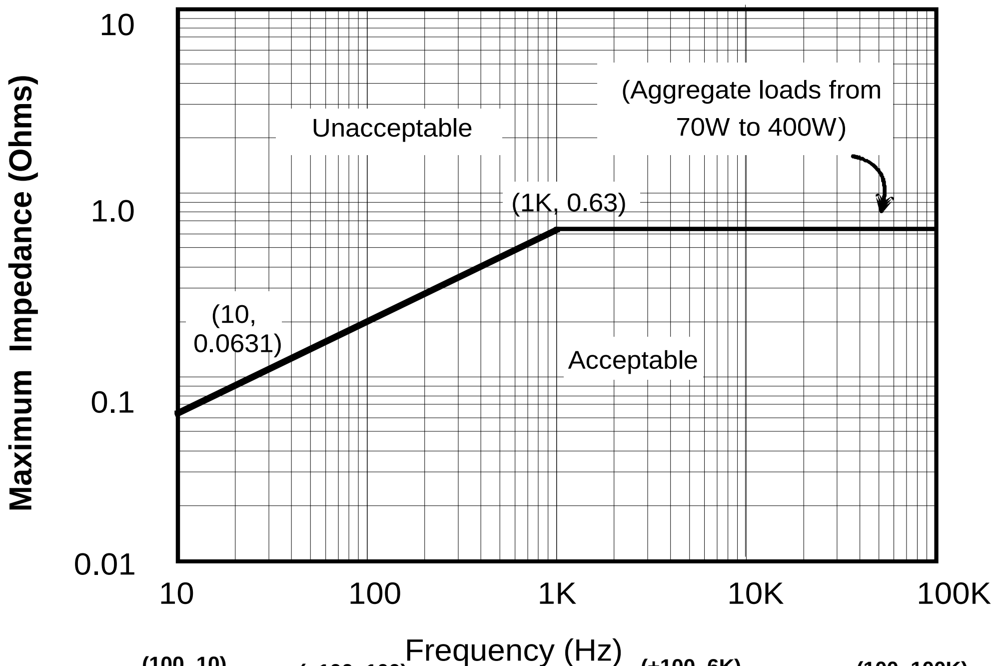
FIGURE G.4.3.2.2.6.2.2-1 MEASUREMENT OF PORTABLE LOAD LEAKAGE CURRENT

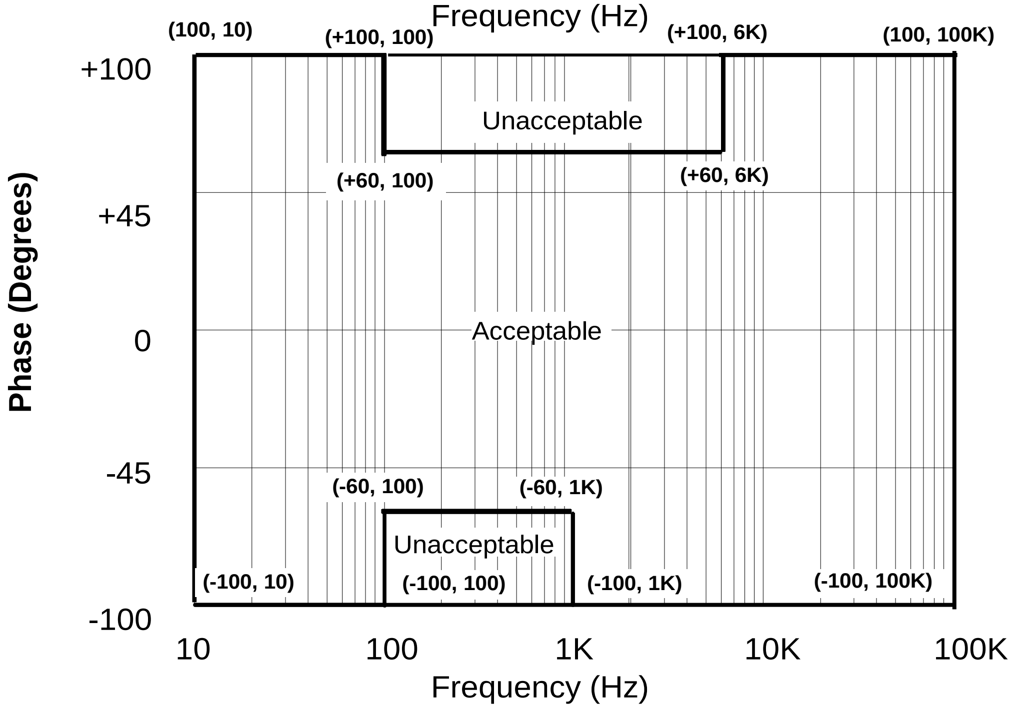
* The low pass filter must be a Butterworth design with at least 5 poles, and –3 dB frequency below 1 MHz, but not less than 50 kHz.

Notes:

Alternate instrumentation, equivalent to the ones shown, is acceptable.

All portable (SUP) loads must be grounded only by the “green wire” during this test. To ensure all ground currents are accounted for, the EPCE must not share a common chassis ground with the power supply other than the green wire. If the EPCE has any shielded data lines terminated at both ends, the shields will also need to be either removed on one end or included in the current probe for measuring.





Note: Available data shows that at frequencies below the DDCU internal control loop 0 dB cross-over frequency, the output impedance phase is greater than -60 degrees.

FIGURE G.4.3.2.2.6.2.2-2 INTERFACE A POWER SOURCE Z VERSUS FREQUENCY (AGGREGATE LOADS FROM 70 TO 400 WATTS)

Verification Submittal: Test Report

G.4.3.2.2.7 ELECTRICAL STANDALONE STABILITY

The EPCE connected to Interface C, **shall** meet the verification requirement N.4.3.2.2.10.

G.4.3.2.3 SAFETY REQUIREMENTS

G.4.3.2.3.1 PORTABLE EQUIPMENT/POWER CORDS

A. NVR

B. NVR

G.4.3.3 COMMAND AND DATA HANDLING INTERFACE REQUIREMENTS

Command and Data Handling requirements for payloads are addressed in Appendix I.

G.4.3.4 PAYLOAD NTSC VIDEO INTERFACE REQUIREMENTS

Payload NTSC video interface requirements are addressed in section N.3.4.

G.4.3.5 THERMAL CONTROL INTERFACE REQUIREMENTS

Payload thermal control interface requirements are addressed in section 3.5.

G.4.3.6 VACUUM SYSTEM REQUIREMENTS

Payload vacuum system interface requirements and data deliverables are addressed in section N.3.6.

G.4.3.7 PRESSURIZED GASES INTERFACE REQUIREMENTS

Payload pressurized nitrogen interface requirements are addressed in section N.3.7.

G.4.3.8 JEM PRESSURIZED REQUIREMENTS

Payload JEM pressurized gases (Ar, He, CO2) interface requirements are addressed in section N.3.8.

G.4.3.9 ENVIRONMENT INTERFACE REQUIREMENTS

Payload environment interface requirements are addressed in section 3.9.

G.4.3.10 FIRE PROTECTION INTERFACE REQUIREMENTS

Payload fire protection interface requirements are addressed in section 3.10.

G.4.3.11 MATERIALS AND PROCESSES INTERFACE REQUIREMENTS

Payload materials and processes interface requirements are addressed in section 3.11.

G.4.3.12 HUMAN FACTORS INTERFACES

G.4.3.12.1 CONTINUOUS NOISE LIMITS

Verification of Continuous Noise Sources (See Glossary of Terms) for non-rack payloads **shall** be performed by test.

SPL test measurements **shall** be obtained at 0.6 meters from all sides of the equipment. The SPL test **shall** use a Type 1 SLM in accordance with publication IEC 61672-1. The preferred instrument for acoustic verification is the Type 1 integrating-averaging sound level meter. This meter can either be of the handheld or component system variety.

The SPL **shall** be measured in each of eight octave bands: 63 Hz, 125 Hz, 250 Hz, 500 Hz, 1000 Hz, 2000 Hz, 4000 Hz, and 8000 Hz.

Octave band filters used for verification measurements will meet the Class 1 specifications in accordance with publication IEC 61260-1, over the frequency range required for verification.

SPL test measurements **shall** be made for each serialized payload flight hardware (or ancillary flight equipment operated outside the rack) until repeatability and acoustic level are demonstrated to produce acceptably low risk of exceeding the composite acoustic environment requirement with minimal operational constraints. The JSC Acoustics Office, with consultation of the Acoustics Working Group (AWG), **shall** determine, on a case-by-case basis, if serial number unit testing can be suspended for a particular payload design based on the following factors: 1) Repeatability of serial number unit test results of first flight units, 2) impact of exceedances (if any), 3) SPLs compared to requirement, 4) frequency bands where repeatability and exceedance issues reside, and 5) impact on composite acoustic environment.

The verification **shall** be considered successful when the test shows the non-rack SPL noise level on all sides are at or below the levels specified in Table G.3.12.1-1.

Verification Submittal: Test Report

APPENDIX H

COLD STOWAGE INTERFACE REQUIREMENTS

APPENDIX H – COLD STOWAGE INTERFACE REQUIREMENTS

H.1.0 INTRODUCTION

H.1.1 PURPOSE

This appendix provides requirements, guidelines and data deliverables for payload samples stowed in cold stowage assets.

H.1.2 SCOPE

This appendix provides requirements, guidelines and data deliverables for payload samples stowed in cold stowage assets on ISS and transportation vehicles.

H.1.3 USE

These requirements, guidelines and data deliverables are applied to payload cold stowage samples in addition to the general requirements, guidelines and data deliverables in Section 3.0 and are allocated to a payload through the payload unique ICD. The PD and the ISS Program must jointly agree on the interfaces and identify requirements as applicable if the interface exists, and not applicable if the interface does not exist for the payload configuration documented in the ICD.

H.2.0 DOCUMENTATION

See Section 5.0.

H.3.0 COLD STOWAGE INTERFACE REQUIREMENTS

H.3.1 STRUCTURAL/MECHANICAL INTERFACES

H.3.1.1 LAUNCH AND RETURN LOADS

Cold stowage samples or sample containers to be carried in an ISS Cold Stowage Facility **shall** withstand externally applied loads (ultimate) as listed in Table H.3.1.1-1, Launch and Return Loads, maintaining positive margins of safety, without any mechanical failure or breach of any levels of containment. It is recommended these loads be applied at the point of the thinnest wall thickness, weakest cross section or protrusion.

It is permissible to provide a secondary (external to the sample container) structural housing or support in order to satisfy this requirement.

TABLE H.3.1.1-1 LAUNCH AND RETURN LOADS

Type of Surface	Load
Flat surfaces	30.6 psi (2.15 kg/cm^2)
Cylindrical surfaces	30.6 pounds per linear inch (2.15 kg per linear cm)
Spherical surfaces or irregular shapes that would result in point loads	30.6 pounds (2.15 kg) applied to a single point normal to the surface of the sphere or to the protruding point or points

H.3.2 TEMPERATURE CERTIFICATION

Payload Cold Stowage samples accommodated by Cold Stowage fleet hardware may be transported and/or stowed on the ISS in any number of different freezers or refrigerators. To allow flexibility and maximize the use of launch/return mass and volume, the samples are to be certified to the lowest possible freezer or refrigerator temperature.

Note: While the Cold Stowage assets can experience single event failures that can cause the freezers to experience runaway conditions, there are numerous mitigation factors in place that make these conditions not credible:

- 24/7 monitoring of powered lockers with commanding capability while on ISS
- Timeliner bundles are in place to prevent Minus Eighty-Degree Laboratory Freezer for ISS (MELFI) +4 dewar from experiencing a run-away drop in temperature
- Even if the freezers experience a runaway condition, the sample temperatures will not drop instantaneously, they will lag, thus allowing the previous two mitigation factors to be executed.

H.3.2.1 FREEZER TEMPERATURE RANGE

Payload cold stowage sample containers for samples requiring frozen temperature **shall** withstand the temperature range of +0 °C (+32 °F) to -100 °C (-148 °F) without breaking.

H.3.2.2 REFRIGERATED TEMPERATURE RANGE

Payload cold stowage sample containers for Samples requiring refrigeration **shall** withstand the temperature range of +0 °C (+32 °F) to +6 °C (+42.8 °F) without breaking.

H.3.2.3 INCUBATED TEMPERATURE RANGE

Payload cold stowage sample containers for samples requiring warming or incubation *should* withstand the temperature range of +6 °C (+42.8 °F) to +49 °C (+120 °F) without breaking.

H.3.2.4 CRYOGENIC FREEZER TEMPERATURE RANGE

Payload Cold Stowage sample containers for samples requiring cryogenic temperatures **shall** withstand temperatures from ambient to -150 °C (-238 °F) without breaking. Ambient temperature is considered to be 22 °C (72 °F) ± - 2.8°C (5 °F).

H.3.3 BATTERIES

A. The payload Cold Stowage sample batteries accommodated by the Cold Stowage Facilities **shall** not leak after three temperature cycles from ambient to the temperatures defined in paragraphs H.3.2.1, H.3.2.2, H.3.2.3 and/or H.3.2.4.

B. SSP 51700, paragraph 3.14.2 addresses Batteries.

Note: Battery performance may be reduced due to effects of cold temperatures on battery electrochemistry.

H.3.4 CONTAINMENT

SSP 51700, paragraphs 3.10.1, 3.10.1.1, 3.10.1.2, and 3.10.1.3 address Containment.

Notes:

1. Any system flown in a habitable module and containing liquids, gasses, or powders will be assessed for toxicological level, and appropriate levels of containment will be provided. The provider of the equipment will furnish a list of the materials and their quantities to the JSC Toxicologist as per JSC 27472, Requirements for Submission of Data Needed for Toxicological Assessment of Chemicals to be Flown on Manned Spacecraft. Levels of containment are directly related to the toxicology level of the material.
2. Cold Stowage Facilities will not provide any levels of containment for the samples.

H.4.0 VERIFICATION

H.4.1 RESPONSIBILITIES

The PD is responsible for providing verification for all applicable requirements in this appendix, as allocated to the payload through the payload unique ICD. The ISS Program is responsible for review and approval of the submitted verification.

H.4.2 VERIFICATION METHODS

Compliance with the requirements stated in Section H.3.0 are proven using one or more of the methods described in paragraph 4.2.

H.4.3 COLD STOWAGE INTERFACE VERIFICATION REQUIREMENTS

H.4.3.1 STRUCTURAL/MECHANICAL INTERFACES

H.4.3.1.1 LAUNCH AND RETURN LOADS

Verification that cold stowage samples or sample containers can withstand externally applied launch and return loads **shall** be by analysis or test. If test is selected, a simple static load test may be used to apply the specified load to the samples or sample containers. The test **shall** be performed on one sample in each lot. Verification **shall** be considered successful when the Analysis Report or Test Report confirms that the samples or sample containers can withstand the loads specified.

Verification Submittal: CoC

H.4.3.2 TEMPERATURE CERTIFICATION

NVR

H.4.3.2.1 FREEZER TEMPERATURE RANGE

Verification of the payload Cold Stowage sample compatibility with the Cold Stowage System freezer temperature range **shall** be by test. The test **shall** be performed with the sample container and representative materials to a maximum expected fill level. This is to ensure that the container is not broken or otherwise destroyed after cycling a minimum of two times to the temperature range from ambient to -100 °C (-148 °F), at an environment heating/cooling rate of no less than 1 °C (1.8 °F)/minute. The sample container **shall** be held at the minimum temperature for at least 60 minutes for each cycle. Verification **shall** be successful upon inspection of container and sample during and after exposure to these temperatures with no evidence of damage or leakage being noted.

Verification Submittal: Test Report

H.4.3.2.2 REFRIGERATED TEMPERATURE RANGE

Verification of the payload Cold Stowage sample compatibility with the Cold Stowage System refrigerated temperature range **shall** be by test. The test **shall** be performed with the sample container and representative materials to a maximum expected fill level. This is to ensure that the container is not broken or otherwise destroyed after cycling a minimum of two times to the temperature range from ambient to -10 °C (+14 °F), at an environment heating/cooling rate of no less than 1 °C (1.8 °F)/minute. (Going to -10 °C ensures a phase change occurs). The sample container **shall** be held at the minimum temperature for at least 60 minutes for each cycle. Verification **shall** be successful upon inspection of container and sample during and after exposure to these temperatures with no evidence of damage or leakage being noted.

Verification Submittal: Test Report

H.4.3.2.3 INCUBATED TEMPERATURE RANGE

Verification of the payload Cold Stowage sample compatibility with the Cold Stowage System incubated temperature range *should* be by test. The test *should* be performed with the sample container and representative materials to a maximum expected fill level. This is to ensure that the container is not broken or otherwise destroyed after cycling a minimum of two times to the temperature range from +6 °C (+42.8 °F) to +49 °C (+120 °F) , at an environment heating/cooling rate of no less than 1 °C (1.8 °F)/minute. The sample container *should* be held at the minimum and maximum temperature for at least 60 minutes for each cycle. Verification *should* be successful upon inspection of container and sample during and after exposure to these temperatures with no evidence of damage or leakage being noted.

Verification Submittal: Test Report

H.4.3.2.4 CRYOGENIC FREEZER TEMPERATURE RANGE

Verification of the payload Cold Stowage sample compatibility with the Cold Stowage System cryogenic temperature range **shall** be by test. The test **shall** be performed with the sample container and representative materials to a maximum expected fill level. This is to ensure that the container is not broken or otherwise destroyed after cycling a minimum of two times to the temperature range from ambient to -150 °C (-238 °F), at an environment heating/cooling rate of no less than 1 °C (1.8 °F)/minute. The sample container **shall** be held at the minimum temperature for at least 60 minutes for each cycle. Verification **shall** be successful upon inspection of container and sample during and after exposure to these temperatures with no evidence of damage or leakage being noted.

Verification Submittal: Test Report

H.4.3.3 BATTERIES

A. Verification that payload Cold Stowage sample batteries accommodated by the Cold Stowage Facilities do not leak after three temperature cycles from ambient to the temperatures defined in H.3.2.1, H.3.2.2, H.3.2.3 and/or H.3.2.4 **shall** be by test. Verification **shall** be considered successful when inspection of battery during and after exposure to these temperatures shows no evidence of leakage.

Verification Submittal: Test Report

B. This requirement is verified through the Safety process.

H.4.3.4 CONTAINMENT

This requirement is verified through the Safety process.

H.5.0 COLD STOWAGE RESOURCES (INFORMATION ONLY)

H.5.1 DOUBLE COLDBAG (DCB) AND MINI COLDBAG (MCB)

The DCB and MCB are passive low temperature storage resources for the transportation of science samples to and from orbit. Ice Bricks provide cold conditioning for the contents. Temperature hold time depends on the Ice Brick temperature and quantities, sample requirements, and environment. Ice Bricks are described in more detail in paragraph H.3.0 of this appendix. Icepacs, an older version of Ice Bricks, may be used in place of Ice Bricks.

One DCB is equivalent to one Middeck locker insert in size and weighs approximately 8.2 kg (18.1 lbs). Each DCB can support up to 10.9 liters (665 cubic inches) of contents including the 12 Ice Brick assemblies, with a maximum mass including Ice Bricks and samples together of 27.21 kg (60.0 lbs). The weight of each Ice Brick depends on its temperature class.

The external dimensions of one MCB are 20.32 × 17.15 × 21.30 cm (8.0 × 6.75 × 8.38 in) and it weighs 1.27 kg (2.80 lb). The MCB can hold 4.23 Liters of contents and Ice Bricks.

The DCB and MCB are certified to fly on the ISS, Progress, Soyuz, SpaceX Dragon, Orbital ATK Cygnus and HTV. The DCB and MCB do not contain payload samples when flown on

Progress and HTV but are prepositioned on-orbit for return. Coldbags can be stowed in a locker or soft stowed. The MCB was designed for a Soyuz return. If soft stowed, heavy items must not be stowed on top of the Coldbag. Listed below is the nominal Dragon timeline.

H.5.1.1 NOMINAL DRAGON TIMELINE FOR CONDITIONED SAMPLE TRANSPORT

- Coldbag - Ascent
  - The science samples and Ice Bricks are inserted in the DCB in an offline laboratory at the launch site (at approximately L-72 hrs). Then, the integrated Coldbag containing science is turned over for late vehicle stowage.
  - For frozen stowage, the Coldbag hold time is approximately 5 days depending on the number of Ice Bricks and type of samples. For refrigerated stowage (+4 °C/39.2 °F) and incubation (+37 °C/98.6 °F), the Coldbag hold time is much greater.
- Coldbag - Descent
  - The Coldbag with conditioned samples is returned from orbit in Dragon. The Coldbags will be turned over to the Cold Stowage group at the dock. The Cold Stowage group will transfer the conditioned samples to carriers for the trip from the landing site to JSC. The samples will be maintained in powered, portable refrigerator/freezers, or in passive system with dry ice during transportation. At JSC, the conditioned samples will be turned over to the PDs. The duration from splash down to turnover at JSC is estimated to be ~splash down +60 to 72 hours. The duration from packing to splash down is no greater than 54 hours per flight rule G2-147 Payload Timeline Constraints for Cold Stowage Return on SpaceX Dragon.

The DCB and MCB have operating temperature ranges as listed below, depending on accompanying Ice Bricks (the MCB cannot maintain frozen temperatures for anything but Ice Bricks at +4 °C/39.2 °F and above):

- -26 °C/-14.8 °F
- -32 °C/-25.6 °F
- +4 °C/39.2 °F
- +12 °C/53.6 °C
- +16 °C/60.8 °C
- +22 °C/71.6 °F
- +25 °C/77 °F
- +27 °C/80.6 °F
- +37 °C/98.6 °F

Note: Other temperature requirements may be requested for evaluation.

H.5.1.2 DCB AND MCB STORAGE DIMENSIONS

The DCB in a 12-Ice Brick configuration, has an internal payload storage capacity (not including the Ice Bricks) of 34.9 cm × 22.2 cm × 17.1 cm (13.8 in × 8.8 in × 6.8 in). A payload container cannot exceed this size. A diagram of the DCB in the 12 Ice Brick configuration is shown in Figure H.5.1.2-1, Cut Away of Double Coldbag Pack with 12 Ice Bricks and Science Samples. A photograph of an open DCB is shown in Figure H.5.1.2-2. The MCB has an internal payload storage capacity for Ice Bricks and science of 17.02 × 13.97 × 17.78 cm (6.7 × 5.5 × 7.0 in). A photograph of an open MCB is shown in Figure H.5.1.2-3. Depending on the temperature required, and the vehicle timeline, the number of Ice Brick Assemblies can be increased or decreased to adjust hold times and volumes for the payload.

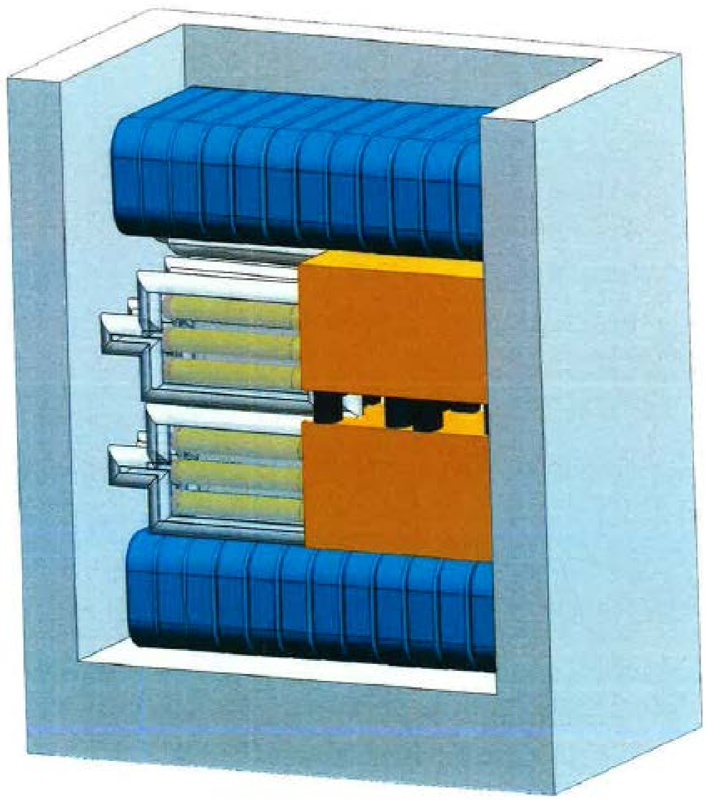


FIGURE H.5.1.2-1 CUT AWAY OF DOUBLE COLDBAG PACK WITH 12 ICE BRICKS AND SCIENCE SAMPLES

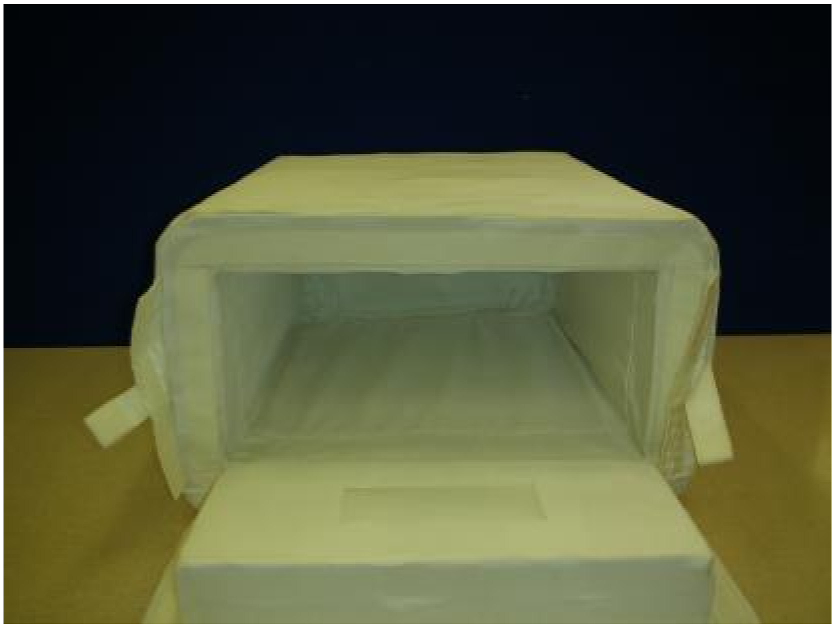


FIGURE H.5.1.2-2 OPEN DOUBLE COLDBAG

FIGURE H.5.1.2-3 OPEN MINI COLDBAG

H.5.2 ICE BRICK

The Ice Brick is designed to provide cooling to scientific specimens stored at low temperatures to and from the ISS. The Ice Bricks are designed to work with other insulated transporters (e.g. Coldbag) and to be refrozen using freezers such as MELFI, General Laboratory Active Cryogenic ISS Experiment Refrigerator (GLACIER) or Polar. The +37 °C/98.6 °F, +22 °C/71.6 °F and +27 °C/ 80.6 °F Ice Bricks can be conditioned in MERLIN.

The Ice Brick consists of various phase change materials that are encapsulated in a high-density polyethylene capsule and bound into pairs by Nomex belts. The Ice Bricks store latent heat energy, which is absorbed or released during a phase change (between liquid and solid state). The currently available Ice Brick operating temperatures are +4 °C/39.2 °F, -26 °C/-14.8 °F, -32 °C/-25.6 °F, +12 °C/53.6 °F, +22 °C/ 71.6 °F , +25 °C/77 °F, +27 °C/80.6 °F and +37 °C/98.6 °F.

+17 °C/62.6 °F Ice Bricks are in development.

The Ice Brick is designed to fit into a variety of existing and planned cold stowage systems. Different quantities of the Ice Bricks will be used depending on system and mission requirements. A sketch of an Ice Brick is shown in Figure H.5.2-1, Ice Brick Belt Assembly.

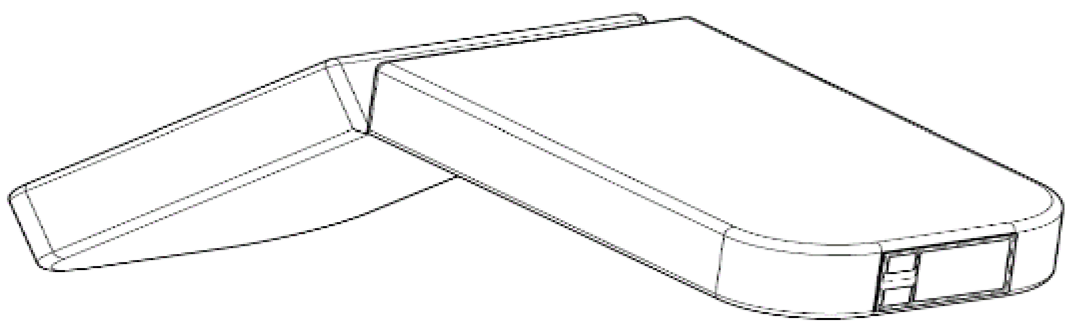


FIGURE H.5.2-1 ICE BRICK BELT ASSEMBLY

H.5.3 GLACIER

GLACIER serves as a double-middeck locker-sized, on-orbit, low temperature science storage facility, as well as cold stowage transportation to and from orbit. It is designed for active ascent/descent in Dragon or passive ascent in Cygnus and was tested for ATV loads. It has not yet been certified for HTV. GLACIER is capable of supporting 16.3 kg (36.0 lbs) of experiment samples in Dragon. A photograph of a GLACIER unit is shown in Figure H.5.3-1. A photograph of an open GLACIER unit is shown in Figure H.5.3-2.

FIGURE H.5.3-1 GLACIER UNIT

FIGURE H.5.3-2 OPEN VIEW OF GLACIER UNIT

H.5.3.1 ACTIVE GLACIER - DRAGON ASCENT

- Launched at cold temperatures with samples installed prior to turnover
- Late installation at Pad – L-24 hrs
- GLACIER is mounted in a late load location in the Dragon allowing the latest possible turnover prior to launch
- Requires power during transport to pad (supplied by ground battery unit) if the unit is to be powered off in excess of 30 minutes

H.5.3.2 ACTIVE GLACIER - DRAGON DESCENT

- Dragon capsule retrieved from splashdown in Pacific Ocean.
- After side hatch removal, all early retrieval powered payload are powered down and removed from Dragon. GLACIER is installed in transport fixture and connected to power pack for transport to port.
- At the port, GLACIER is transferred to Cold Stowage team.
- Cold Stowage Team will transport GLACIER and other Cold Stowage equipment to JSC for PI turnover. The samples will be maintained in powered, portable refrigerator/freezers, or in passive system with dry ice during transportation.

H.5.3.3 GLACIER TEMPERATURE RANGE

GLACIER supports an operational temperature range of +4 °C/39.2 °F to -160 °C/-256 °F

- Dragon or EXPRESS Rack air cooling mode: +4 °C to -95 °C/-139 °F
  - GLACIER can reach a minimum of -95 °C in the Dragon due to power limitations of the vehicle

- EXPRESS MTL water cooling mode: +4 °C/39.2 °F to -160 °C/-256 °F

  - However, to achieve a temperature colder than -130 °C/-202 °F, GLACIER would require a minimum of 360 W of power. Any temperature colder than -95 °C/-139 °F is outside of the nominal usage plans for GLACIER and will require coordination among Cold Stowage Team, PI, and ISS resources.

H.5.3.4 POWER OFF GLACIER HOLD TIMES

With a -100 °C/-148 °F set point, GLACIER can maintain samples below -68 °C/-90.4 °F for a maximum of 6 hours (assuming a 75% full volume).

H.5.3.5 COOL DOWN CURVES

Figures H.5.3.5-1 thru H.5.3.5-3 show the Cool-down curves for GLACIER. EXPRESS MTL water cooling mode is +4 °C/39.2 °F to -160 °C/-256 °F; however, can only achieve -130 °C/-202 °F when restricted to 220W.

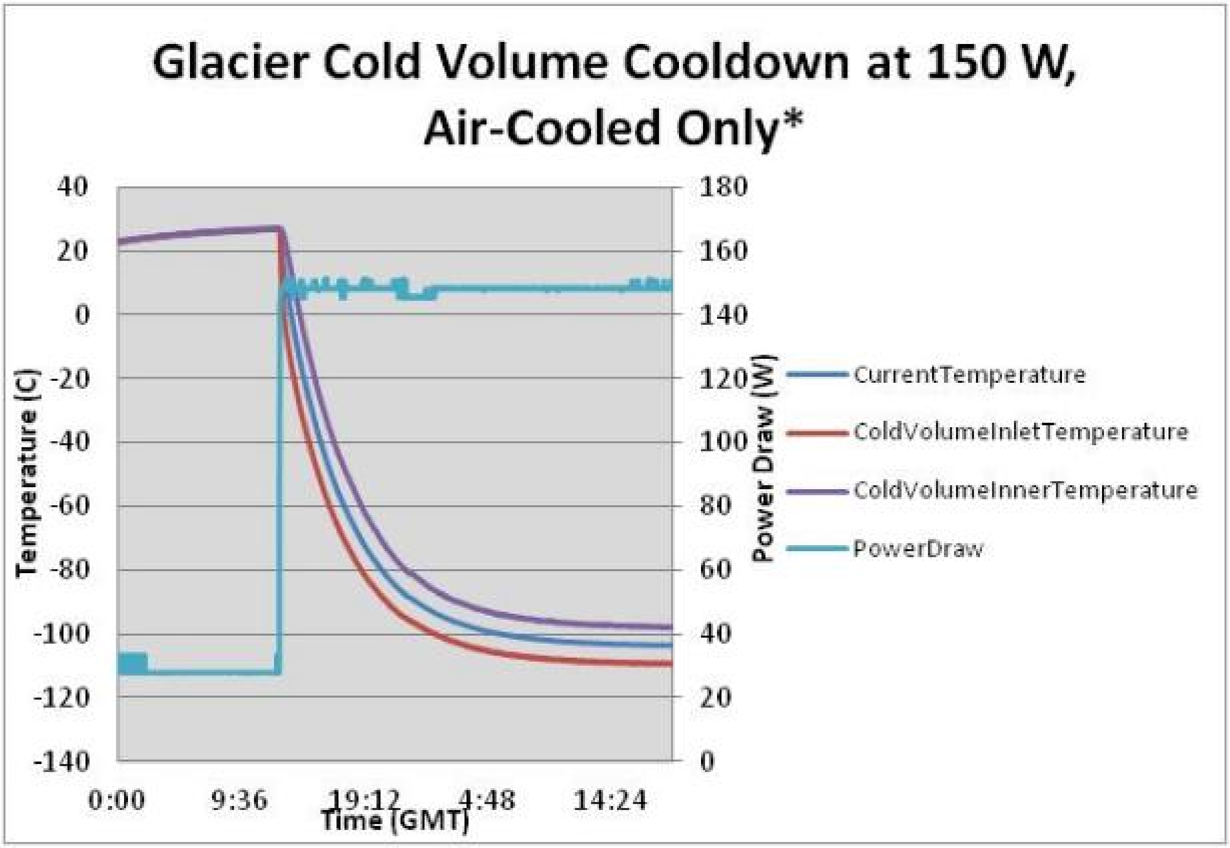


FIGURE H.5.3.5-1 GLACIER PERFORMANCE AT 150W, AIR-COOLED

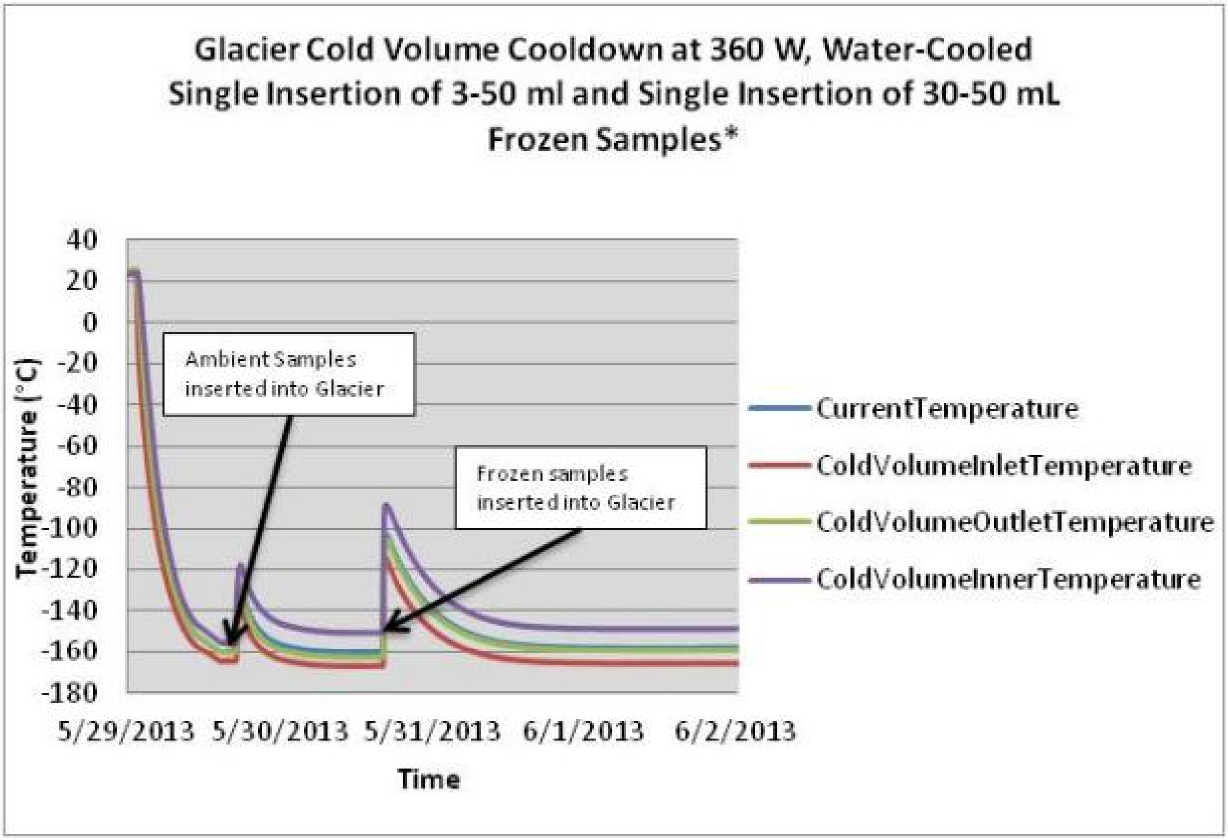


FIGURE H.5.3.5-2 GLACIER PERFORMANCE AT 360W, WATER-COOLED

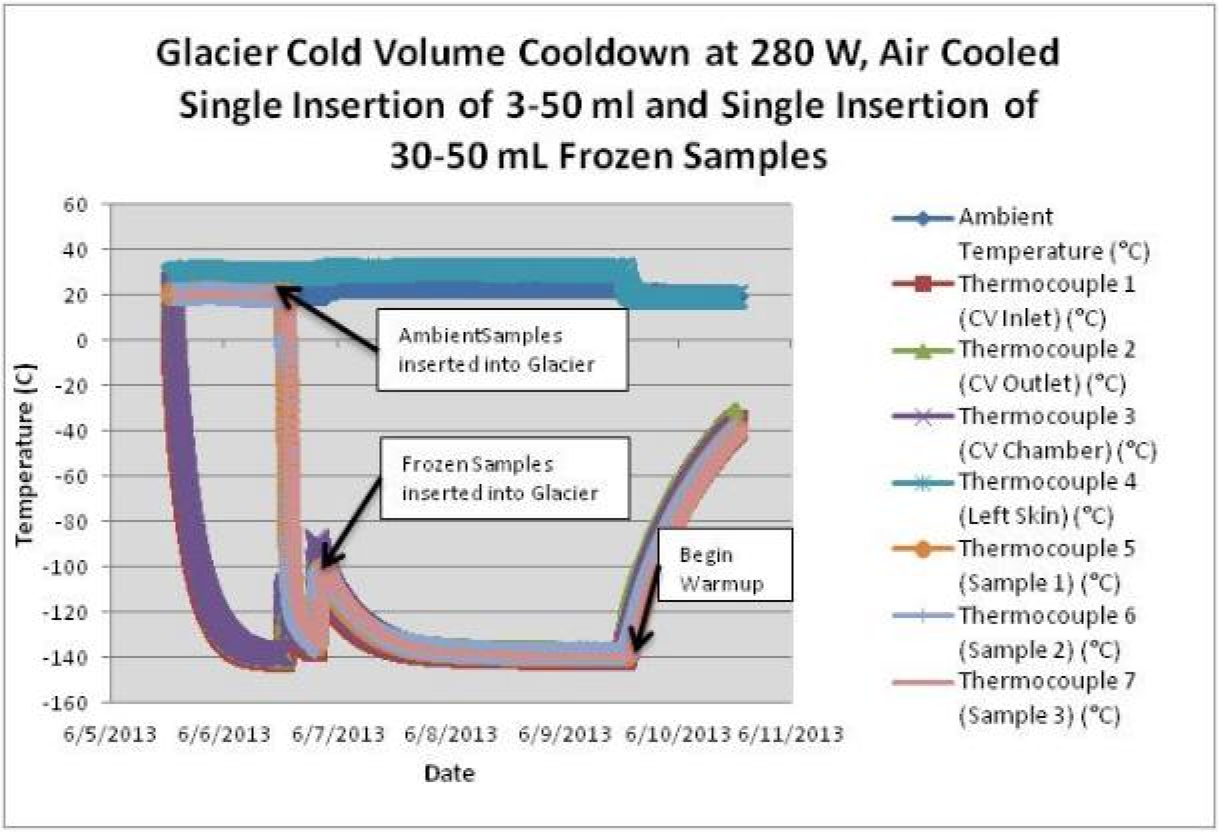


FIGURE H.5.3.5-3 GLACIER PERFORMANCE AT 280W, AIR-COOLED

H.5.3.6 GLACIER STORAGE DIMENSIONS

The GLACIER unit contains four separate stowage compartments that contain two Type X trays positioned vertically within the unit. Each tray contains Velcro straps to secure samples. Figures H.5.3.6-1 and H.5.3.6-2 depict the configurations along with the dimensions of the Type X tray. Internal dimensions of the Type X tray are 18.5 cm × 19.7 cm × 26.7 cm (7.3 in × 7.7 in × 10.5 in).

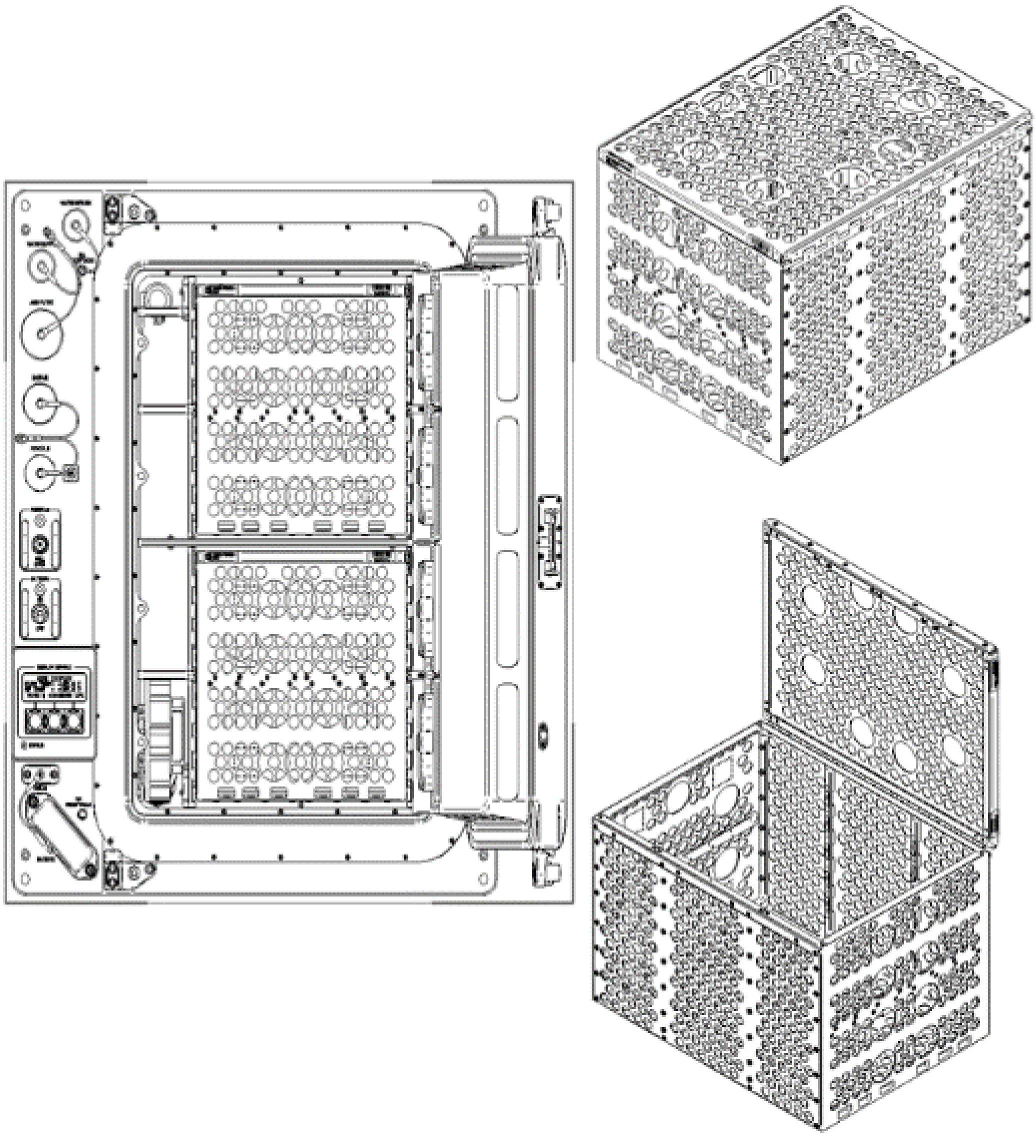


FIGURE H.5.3.6-1 CONFIGURATION 1 - TYPE X GLACIER TRAY

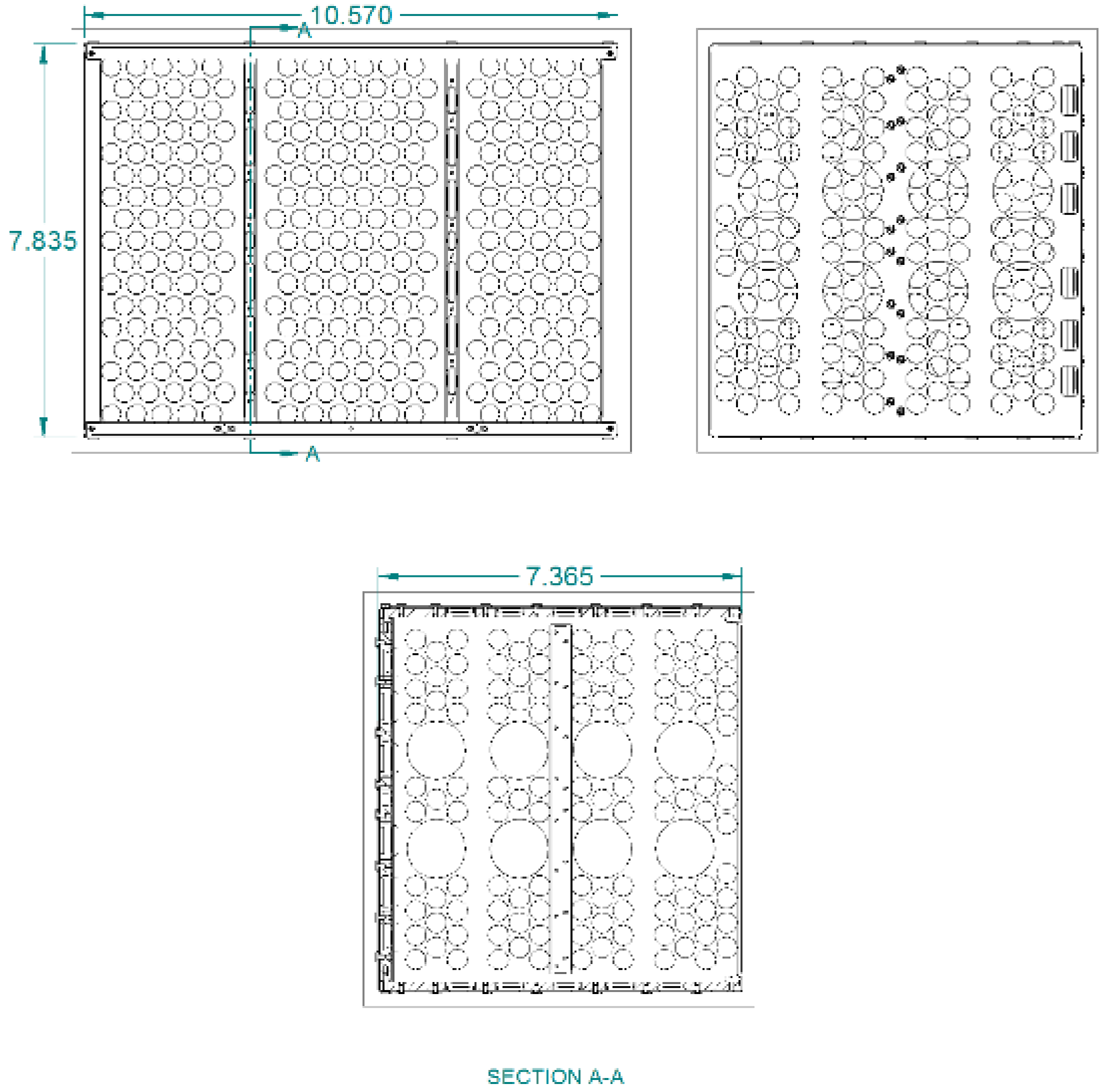


FIGURE H.5.3.6-2 TYPE X GLACIER TRAY DIMENSIONS

H.5.3.7 GLACIER-SPECIFIC HARDWARE REGULATIONS

A. While operating within the EXPRESS Rack, the preferred nominal configuration is to have the GLACIER's power consumption limited to 220 W and the AUX bit set. If the GLACIER unit is not powered, the AUX bit will not be set.

Rationale: If the EXPRESS rack fails from main to aux, and GLACIER power consumption is not limited to 220W or below, then testing has shown that the SSPC channel is likely to trip. For this reason GLACIER power consumption must be limited when the aux bit is set. This will minimize the time GLACIER is powered down during a main-to-aux failover.

B. The GLACIER door must not be open to ambient air for more than 60 seconds.

H.5.4 POLAR

Polar serves as a single-middeck locker equivalent, on-orbit, low temperature science storage facility, as well as cold stowage transportation to and from orbit. It is designed for active ascent/descent in SpaceX Dragon and Orbital ATK Cygnus powered ascent as well as soft stow in Dragon, Cygnus and HTV. Polar has a usable volume of 12.7L and is capable of supporting up to 6.76 kg (14.9 lbs) of experiment samples (limited by volume). The Polar engineering unit is shown in Figure H.5.4-1 and H.5.4-2 (open).

FIGURE H.5.4-1 POLAR UNIT

FIGURE H.5.4-2 POLAR UNIT (DOOR OPEN, TRAY INSTALLED)

H.5.4.1 ACTIVE POLAR – DRAGON/CYGNUS ASCENT

- Launched at cold temperatures with samples installed prior to turnover
- Late installation at Pad – L-24 hrs for Dragon, L-72 hours for Cygnus.
- Polar is mounted in a late load location in the vehicle allowing the latest possible turnover prior to launch
- Requires power during transport to pad (supplied by ground battery unit) if the unit is to be powered off in excess of 30 minutes

H.5.4.2 ACTIVE POLAR – DRAGON DESCENT

- Dragon capsule retrieved from splashdown in Pacific Ocean.
- After side hatch removal, all early retrieval powered payloads are powered down and removed from Dragon. Polar is installed in transport fixture and connected to power pack for transport to port.
- At the port, Polar is transferred to Cold Stowage team.
- Cold Stowage Team will transport Polar and other Cold Stowage equipment to JSC for PI turnover. The samples will be maintained in powered, portable refrigerator/freezers, or in passive system with dry ice during transportation.

H.5.4.3 POLAR TEMPERATURE RANGE

Polar supports a nominal operational temperature of -80 °C ±5 °C (-112 °F)

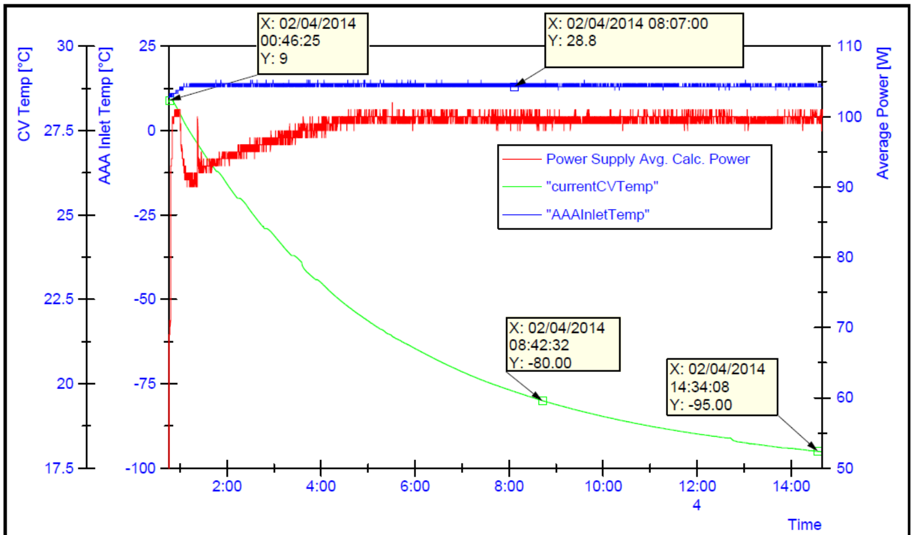
- Dragon or EXPRESS Rack mode: +4 °C to -95 °C/-139 °F
  - Polar can maintain -95 °C/-139 °F if additional power is provided to the powered locker location (less than 100 W)

H.5.4.4 POLAR POWER OFF HOLD TIMES

With a -80 °C/-112 °F set point, Polar can maintain samples below -68 °C/-90.4 °F for a maximum of three hours (assuming a 75% full volume).

H.5.4.5 POLAR COOLDOWN CURVES

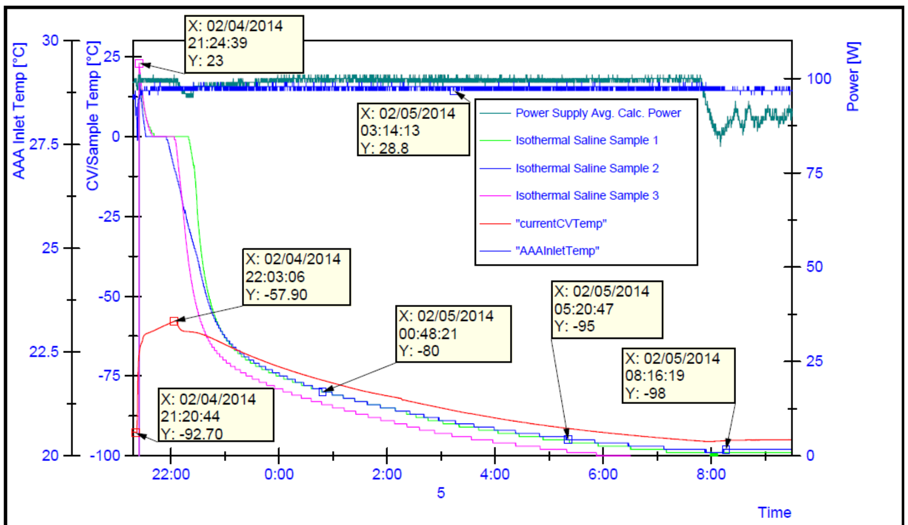
The following curves, H.5.4.5-1 through H.5.4.5-5, are taken from the Polar S/N 002 Qualification Thermal Performance as documented on CBSE-TPS-223. The test was performed in a calibrated thermal chamber using inlet temperatures near the maximum for the SpaceX Dragon and Orbital ATK Cygnus vehicles and above those documented on previous GLACIER ISS and Dragon flights. The Cold Volume Rear and Cold Volume Right RTDs were used as the controlling RTDs for this test.



100W Cooldown

Polar, with tray inserted and empty, was at 9°C internally, and the ambient temperature was ~28.8. Polar was then set to a Maximum Power Draw of 100W, and the set point was changed to -95°C. After 07:54, Polar reached -80°C, and after 13:44, Polar reached -95°C.

FIGURE H.5.4.5-1 POLAR UNIT 100W COOLDOWN



Ambient Sample Insertion

Polar, with tray and no samples, was at -92.7°C (Set Point of -95°C) internally, with an ambient temp of ~28.8. Three 50mL instrumented samples at 23°C, were then inserted into Polar. The cold volume warmed to a maximum of -57.9°C before beginning to cool again. The last of the 3 samples to reach -80°C took 3:23, and it reached -95° in 7:56, and then stabilized at -98° after 10:51.

FIGURE H.5.4.5-2 POLAR UNIT 100W SAMPLE INSERTION

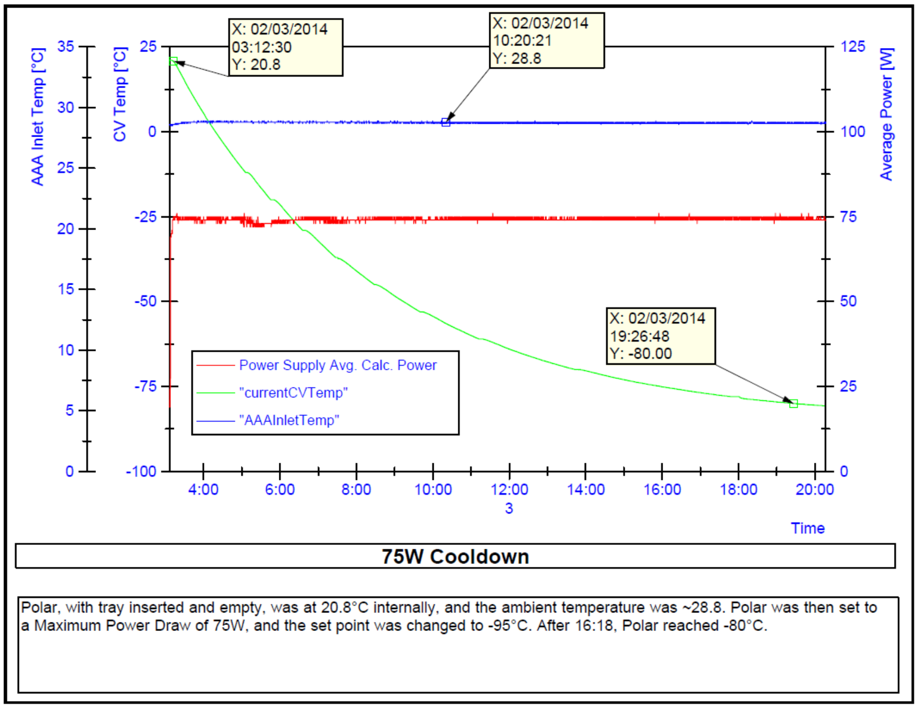


FIGURE H.5.4.5-3 POLAR UNIT 75W COOLDOWN

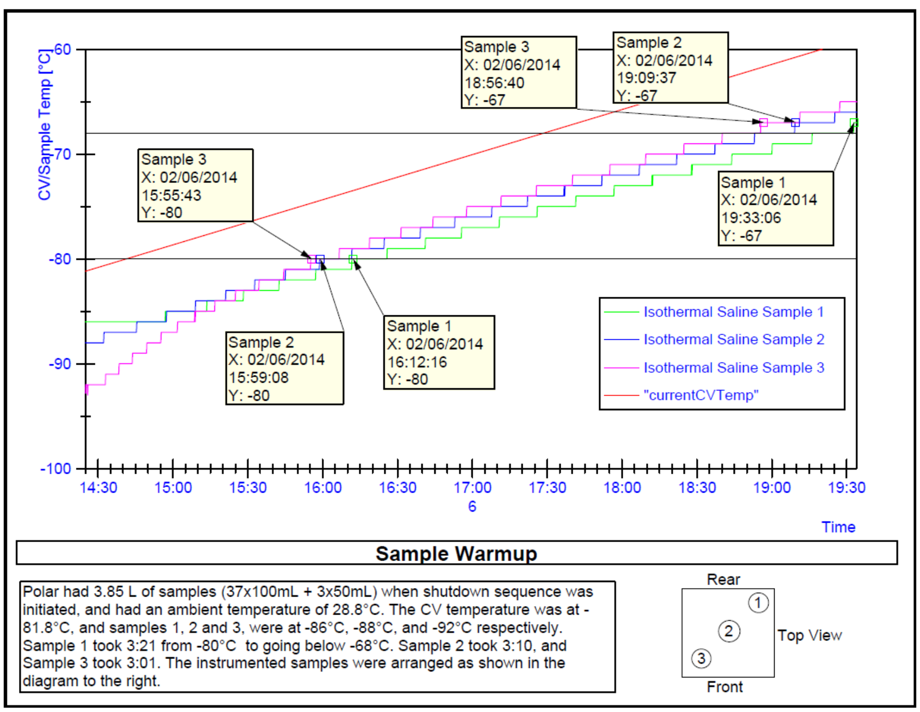


FIGURE H.5.4.5-4 POLAR UNIT SAMPLE WARMUP

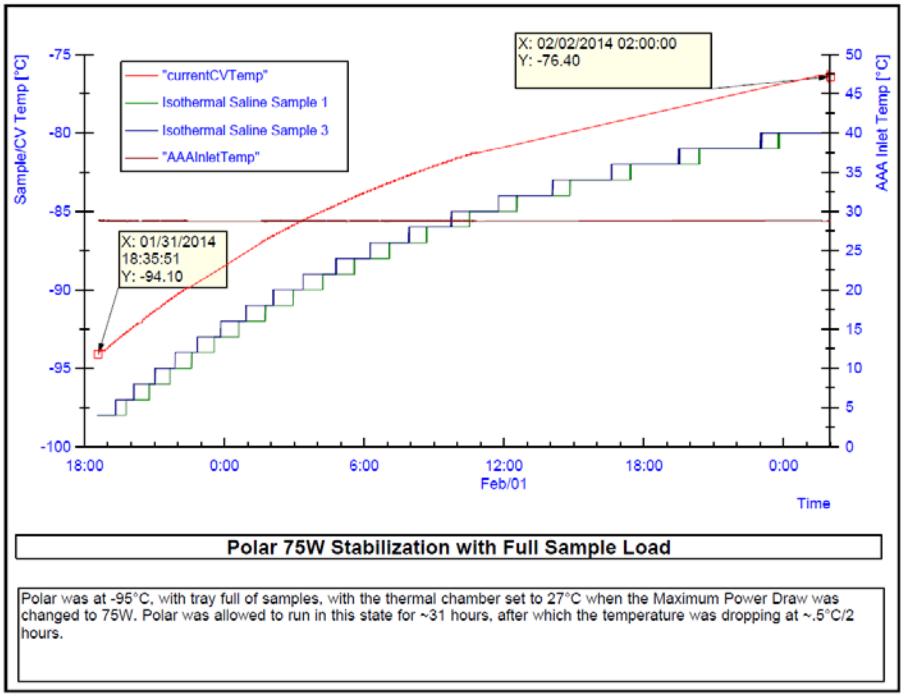


FIGURE H.5.4.5-5 POLAR UNIT 75W SAMPLE STABILIZATION

H.5.4.6 POLAR STORAGE DIMENSIONS

The Polar unit contains a separate stowage compartment that contains one tray positioned vertically within the unit. Each tray contains Velcro straps to secure samples and is configurable per flight. Figure H.5.4.6-1 and H.5.4.6-2 depict the configurations along with the dimensions of the Polar tray. Internal dimensions of the tray are H=6.524”, W=8.776”, D=13.610”. User must also be aware of stiffeners located on inside of tray which can reduce usable volume depending on sample geometry.

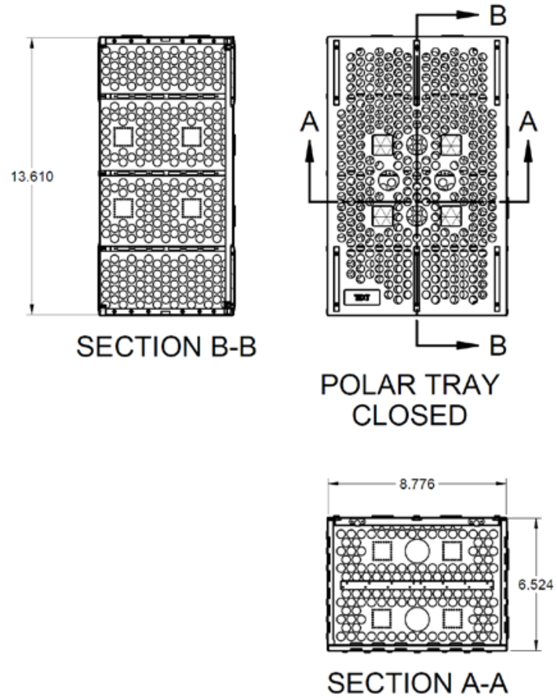


FIGURE H.5.4.6-1 POLAR TRAY INTERNAL DIMENSIONS

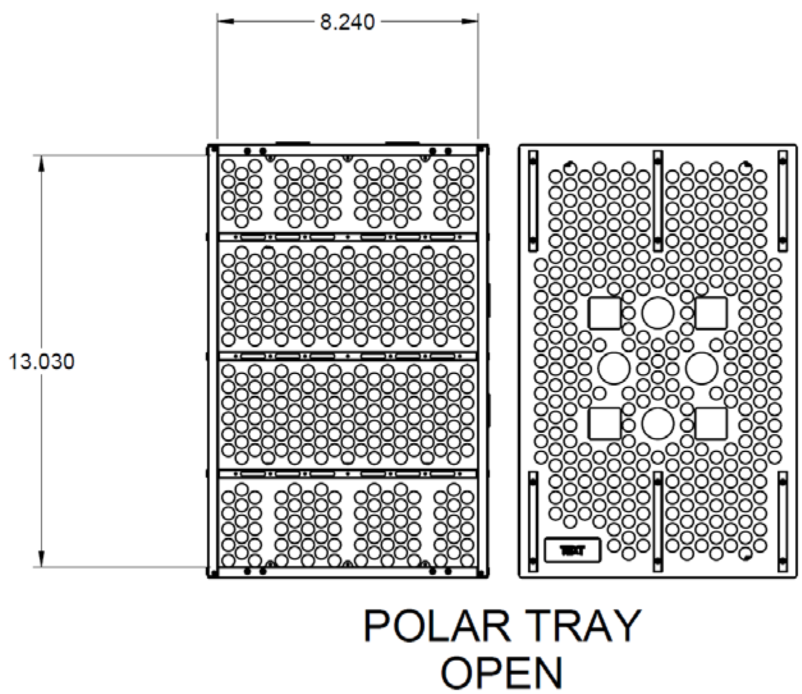


FIGURE H.5.4.6-2 POLAR TRAY LID REMOVED DIMENSIONS TO INSIDE OF LIP

H.5.4.7 POLAR-SPECIFIC HARDWARE REGULATIONS

Access events must be limited to a maximum of two minutes.

H.5.5 MERLIN

MERLIN serves as an on-orbit low temperature and incubation science storage facility, as well as cold/incubation stowage transportation to and from orbit. It is a single MLE size payload.

H.5.5.1 ACTIVE MERLIN - DRAGON ASCENT

- Launched at cold or warm temperatures with samples installed prior to turnover
- Late installation at Pad- L-24 hr
- MERLIN mounted in a late load location in the Dragon allowing for late load turnover
- Requires power during transport to pad (supplied by ground battery unit) if power interrupts exceed 10 minutes

H.5.5.2 ACTIVE MERLIN - DRAGON DESCENT

- Dragon capsule retrieved from splashdown in Pacific Ocean.
- After side hatch removal, all powered lockers are powered down and removed from Dragon. MERLIN is installed in transport fixture and connected to power pack for transport to port.
- At the port, MERLIN is transferred to Cold Stowage team.
- Cold Stowage Team will transport MERLIN and other Cold Stowage equipment to JSC for PI turnover.

H.5.5.3 MERLIN TEMPERATURE RANGE

MERLIN supports the following temperature ranges:

- Approximately +4 °C/39.2 °F to +48.5 °C/119.3 °F in air cooling mode (Dragon). (Air cooling operations may be colder based on payload configuration.)
- Approximately -20 °C/-4 °F to + 46 °C/114.8 °F in water cooling mode (EXPRESS).

Cooling and Heating performance curves are shown in Figures H.5.5.3-1 through H.5.5.3-4.

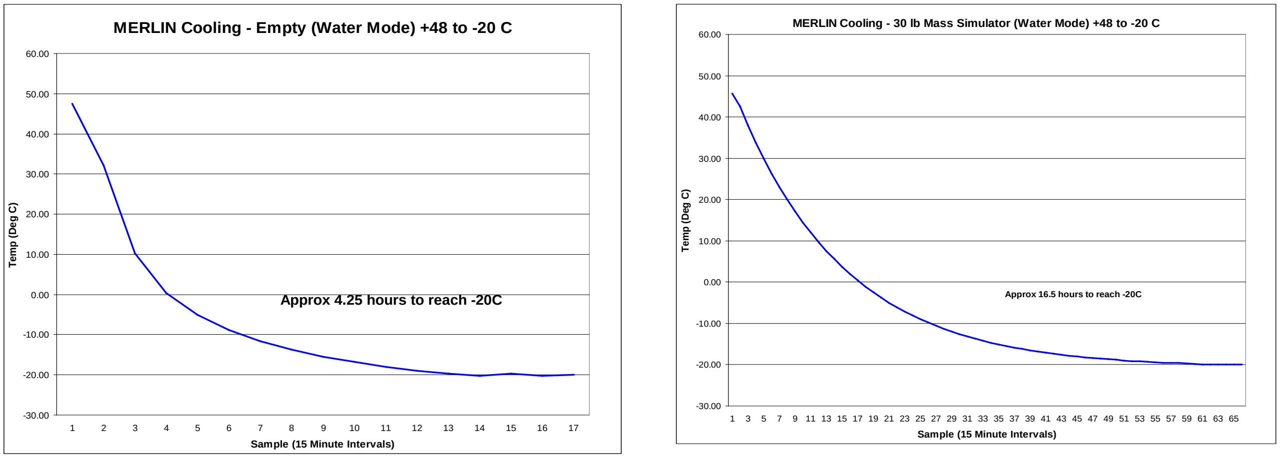


FIGURE H.5.5.3-1 MERLIN COOLING PERFORMANCE – WATER MODE

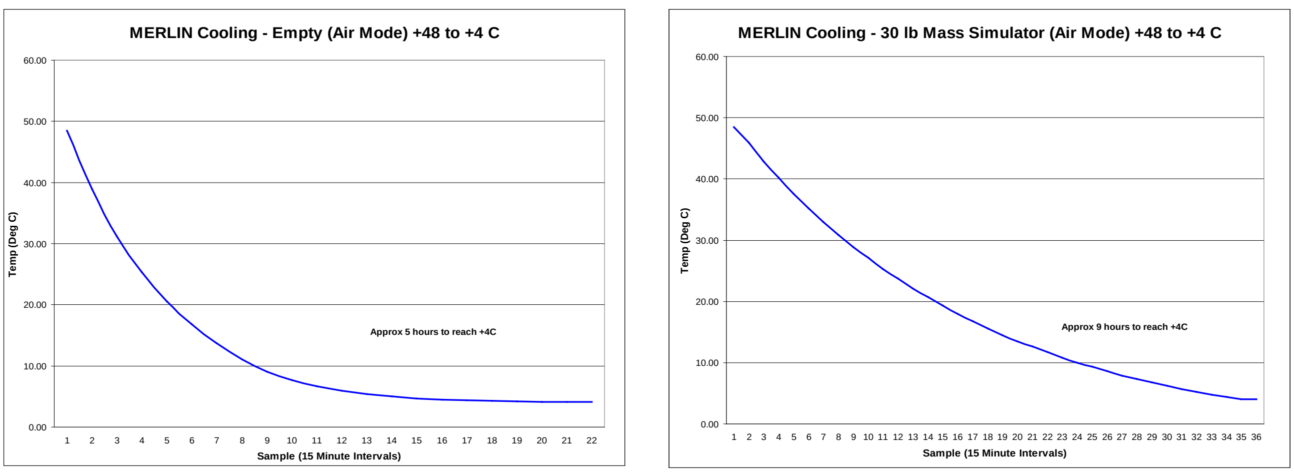


FIGURE H.5.5.3-2 MERLIN COOLING PERFORMANCE - AIR

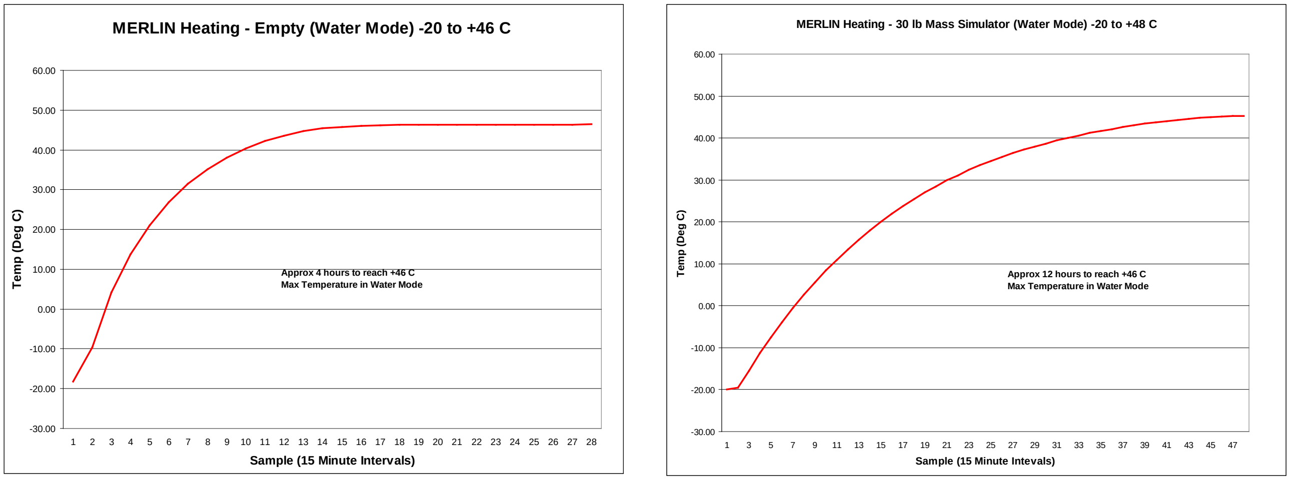


FIGURE H.5.5.3-3 MERLIN HEATING PERFORMANCE - WATER

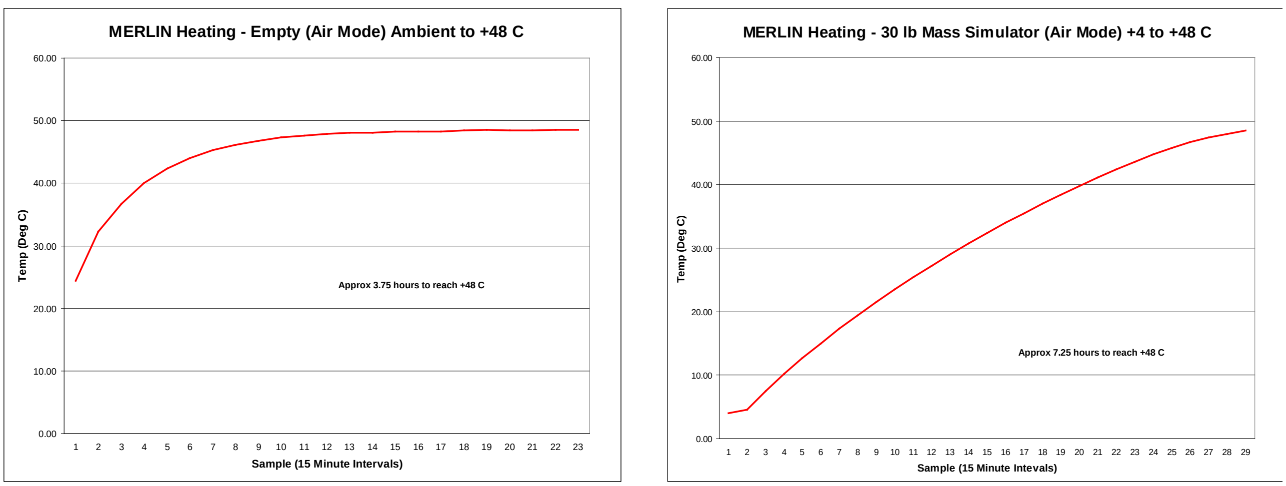


FIGURE H.5.5.3-4 MERLIN HEATING PERFORMANCE - AIR

H.5.5.4 POWER OFF HOLD TIMES

Hold times are dependent upon payload size and MERLIN set point. Hold times for a 30 pound mass simulator for various set points are shown in Figure H.5.5.4-1.

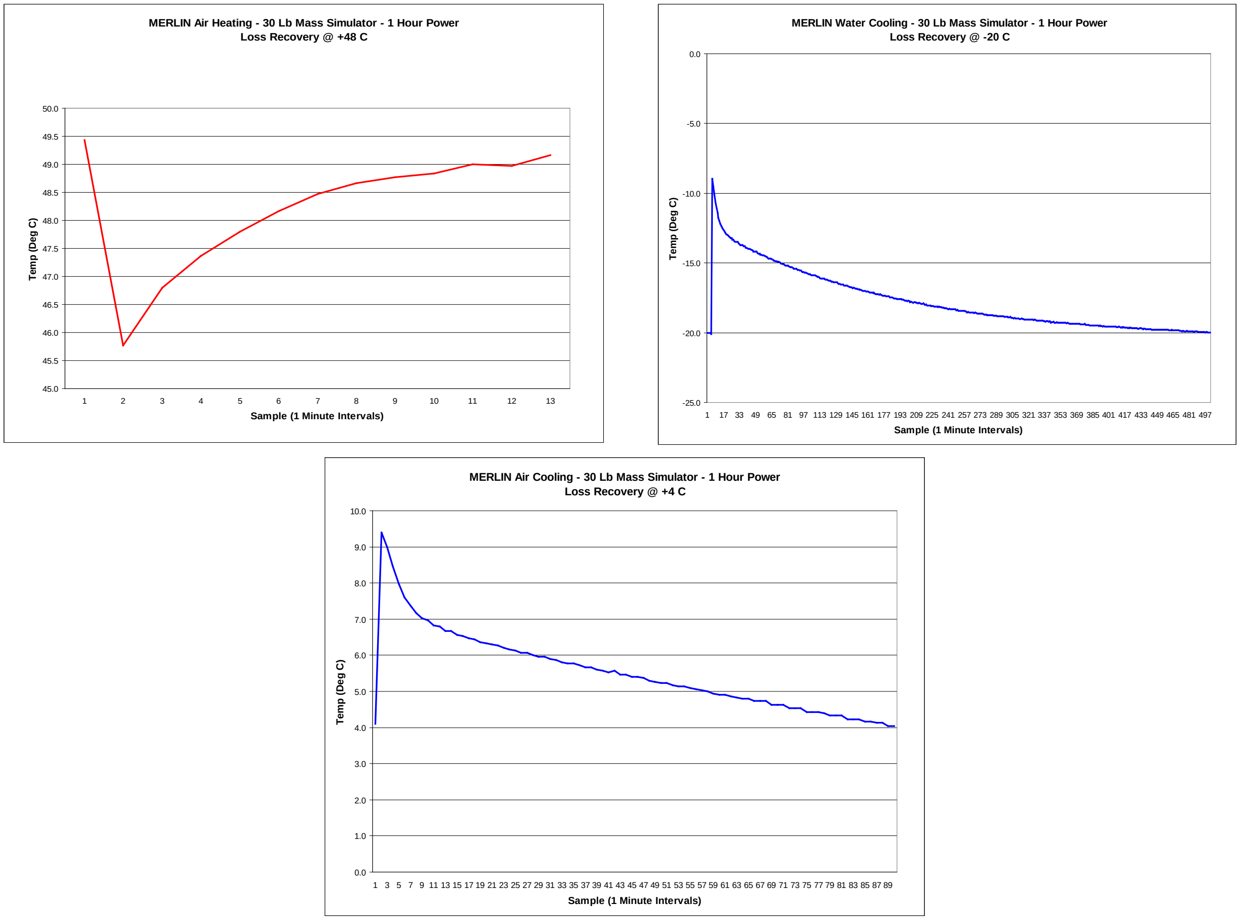


FIGURE H.5.5.4-1 HOLD TIMES

H.5.5.5 STORAGE DIMENSIONS (NOMINAL)

MERLIN supports a maximum single payload size of 17.25 cm × 25.87 cm × 41.9 cm (6.79 in × 10.184 in × 16.50 in) (18.7 liters/1141 cu in). Payloads using the entire internal volume must design a support structure that is compatible with the internal rail system so that internal hardware can be contained during launch and landing. Photographs of the interior and exterior of MERLIN are shown in Figure H.5.5.5-1.

FIGURE H.5.5.5-1 MERLIN EXTERIOR AND INTERIOR

H.5.5.6 STORAGE DIMENSIONS (ALTERNATIVE)

Cold Stowage GFE Hardware can provide a Transportation Storage Device (Pouch Assembly) which can support payload size of 7.62 cm × 17.53 cm × 31.24 cm (6.9in × 3in × 12.3in) (4.2 liters/255 cu in). The Pouch Assembly is shown in Figure H.5.5.6-1. This Tray and Pouch provides the necessary interface to the MERLIN internal volume.

FIGURE H.5.5.6-1 MERLIN POUCH ASSEMBLY

H.5.6 MELFI

The MELFI rack is a European Space Agency (ESA)-provided rack that was built and developed as a result of barter agreements between ESA, NASA and JAXA. It is operated to store and preserve life science and biological samples at a temperature set point ranging from +10 °C/50 °F to -99 °C/-146 °F inside Dewar-type containers. (There are four independent thermally insulated Dewars.) While MELFI is capable of operating anywhere within this range of temperatures, the performance of the rack has been tailored to 3 specific modes based on input from the science community. These modes are described in Table H.5.6-1, MELFI Temperature Range Modes.

TABLE H.5.6-1 MELFI TEMPERATURE RANGE MODES

Mode	Sample Temperature	Setpoint
-80 °C (-112 °F)	<-68 °C (<-90.4 °F)	-95 °C (-139 °F)
-26 °C (-14.8 °F)	<-23 °C; >-37 °C (<-9.4 °F; >-34.6 °F)	-35 °C (-31 °F)
4 °C (39.2 °F)	<+6 °C; >+0.5 °C (<42.8 °F; >32.9 °F)	2 °C (35.6 °F)

MELFI provides multiple freezer configurations to best meet individual experiment needs and PD science objectives. Although MELFI is designed for storage and cooling of samples, it does not provide any containment of samples. Sample containment is the responsibility of the PD.

H.5.6.1 HOLD TIMES

MELFI is designed to maintain a -95 °C/-139 °F setpoint Dewar below -68 °C/-90.4 °F for up to 8 hours (with sufficient thermal mass) after being powered off once the Dewars have cooled down to their respective set points. **MELFI does not guarantee hold times for the -35 °C/ -31 °F or +2 °C/35.6 °F Dewars.**

H.5.6.2 STORAGE DIMENSIONS

H.5.6.2.1 TRAYS

The function of the trays are to safely and efficiently store the sample box modules, while allowing easy access to the scientific samples during crew operations. An empty tray is shown in Figure H.5.6.2.1-1. There are four trays per Dewar and each tray is removable. The crew can access any box module stored in a tray when the tray is withdrawn from the Dewar. A tray may be retrieved (partly or fully) from the Dewar by pulling on the handle.

FIGURE H.5.6.2.1-1 EMPTY MELFI TRAY

H.5.6.2.2 BOX MODULES

Each tray contains box modules, which in turn hold the samples themselves. Box modules come in two different sizes: ½ box module and ¼ box module, indicating the amount of the tray volume taken up by the box module. Two ½ box modules or four ¼ box modules will fit on one tray, or a combination of ½ and ¼ box modules. The ¼ box modules are being phased out but are shown here as reference. There are currently no ¼ box modules in any of the ISS MELFI units. Box modules may be interchanged between trays within the same Dewar or in different Dewars. The box modules are shown in Figure H.5.6.2.2-1.

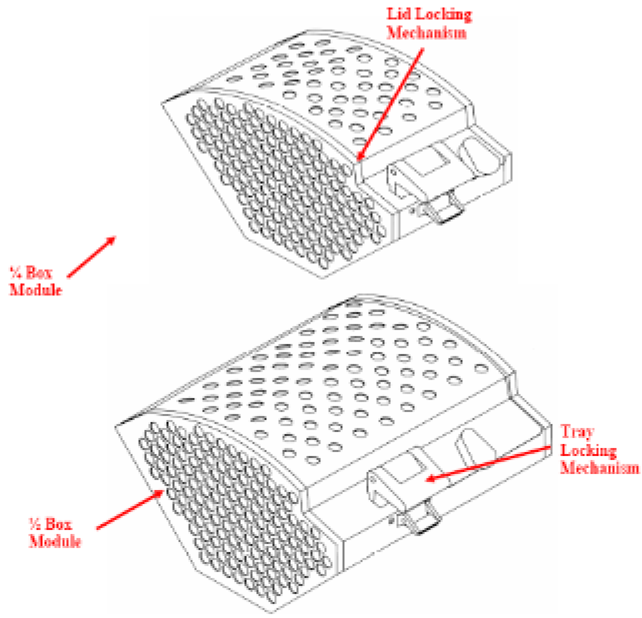


FIGURE H.5.6.2.2-1 STANDARD ¼ AND ½ BOX MODULES

The box modules have two strips of Velcro loops on the inside, at the bottom plate, for fixation of payload items, if desired. Opposite, on the outside of the bottom plate, the box module will have two strips of Velcro hooks which will allow box modules to attach to any surface when removed from the tray. The box modules have individual locking mechanisms and are also locked into place in the trays.

The box module can be used to store a large variety of samples. It is designed to allow samples to be added for storage while the module is locked in position to the tray, regardless of the location of other sample modules in the tray. Perforated plates are used in the construction to reduce the mass of the box module as shown. Box module dimensions are shown in Figure H.5.6.2.2-2 and Table H.5.6.2.2-1.

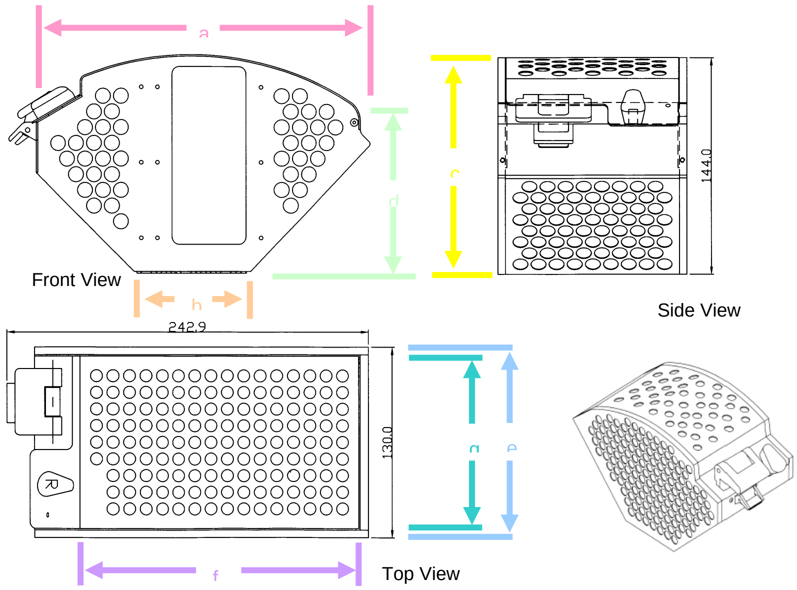


FIGURE H.5.6.2.2-2 BOX MODULE DIMENSIONS

The 3x5 Mesh Bag was developed by NASA Cold Stowage to contain experiment vials in MELFI or other Cold Stowage resources and is capable of accommodating a wide range of vials and sample types. The bag measures 3 inches by 5 inches and is not considered a level of containment. The 3x5 Mesh Bag has two compartments separated by a layer of chemglass. The top of the bag has a Velcro seal that closes both compartments. The mesh bag is shown in Figure H.5.6.2.2-3.

PDs can choose to design their own sample containers; however, they must conform to the size and shape restrictions of the box modules.

FIGURE H.5.6.2.2-3 3 × 5 MESH BAG

TABLE H.5.6.2.2-1 MELFI EXTERIOR* DIMENSIONS

	Code ->	a	b	c	d	e	f	g	
	Internal Volume	**Max width**	**Min width**	**Max width**	**Min width**	**Length/ Depth**	**Door Width**	**Door Length**	**Max per tray**
½ Box Module	5.79 L (353 cu in)	22 cm (8.66 in)	7.5 cm (2.95 in)	14.3 cm (5.6 in)	10.5 cm (4.1 in)	27 cm (10.6 in)	18.5 cm (7.28 in)	26 cm (10.2 in)	2
¼ Box Module	2.67 L (162.9 cu in)	22 cm (8.66 in)	7.5 cm (2.95 in)	14.3 cm (5.6 in)	10.5 cm (4.1 in)	13 cm (5.1 in)	18.5 cm (7.28 in)	11.9 cm (4.68 in)	4

* Wall is approximately 1 mm (0.039 in) in thickness

H.5.6.3 MELFI DEWAR ACCESS CONSTRAINTS

A. The Dewar tray must not be open to ambient air for more than 60 seconds.

B. The minimum time between door openings of any given Dewar is 45 minutes for that same Dewar.

C. A Dewar in support of cold science must not be accessed while the Brayton Machine is powered off except for removal of samples/Ice Bricks for packing in a DCB.

D. For Ice Brick insertions into an active Dewar, the minimum time between door openings of all active Dewars is 24 hours.

MELFI stabilization requires a minimum door opening time. In addition, MELFI requires time to recover from the heat leak associated with exposing a Dewar tray and exposing samples to ambient temperatures. The 45 minute constraint between door openings may increase/decrease according to thermal mass, Brayton Machine Speed, LTL coolant temperature and flow rate. Accessing a Dewar while the Brayton Machine is unpowered will affect the science stowed in that Dewar. Without the Brayton Machine running, MELFI will not be able to provide a timely recovery from such access. If too much warm mass is inserted into an active Dewar that supports cold science, the temperature will become too warm to support the science.

H.5.7 SUMMARY

Tables H.5.7-1 and H.5.7-2 summarize capabilities of all Cold Stowage fleet assets.

TABLE H.5.7-1 SUMMARY SPECIFICATIONS FOR ACTIVE AND PASSIVE COLD STOWAGE ASSETS (2 PAGES)

	Temperature Set Points	Cool Down Rate	Hold Times	Volume		Max Payload Mass & Size
				Internal Useable (L)	External	
MELFI	+2 °C -35 °C -95 °C	2mL sample from ambient to -68 °C in 30 Minutes	*Minimum of 8 hour hold time from -95 °C to -68 °C *Minimum of 8 hour hold time from +2 °C to +6 °C *assumes adequate thermal mass in MELFI dewars at the time of power off	175	Rack Facility	Payload must fit into ½ box module. See Table H.5.6.2.2-1
GLACIER	+4 °C to -95 °C on air cooling +4 °C to -160 °C on water cooling	0.25 °C per minute from ambient to -95 °C	-160 °C to -68 °C is 20hrs -100 °C to -68 °C is 6 hrs. Both hold times assume a 75% full volume	19.5*	Double MLE	Maximum of 16.3 kg* for commercial vehicles Single Type X Tray: 18.5 cm × 19.7 cm × 26.7 cm
POLAR	+4 °C to -95 °C	150mL of sample from Ambient to -80 °C in 6 hours	-80 °C to -68 °C in 3 hours with 75% occupied sample volume	12.68	Single MLE	6.76 kg Tray Dimensions inside stiffeners: 15.7 cm × 21.03 cm × 33.76 cm

TABLE H.5.7-1 SUMMARY SPECIFICATIONS FOR ACTIVE AND PASSIVE COLD STOWAGE ASSETS (2 PAGES)

	Temperature Set Points	Cool Down Rate	Hold Times	Volume		Max Payload Mass & Size
				Internal Useable (L)	External	
MERLIN	+48.5 °C to +4 °C on air cooling. +48.5 °C to -20 °C On-Orbit ISS	0.15 °C per minute from +48 °C to +4 °C on air cool mode 1.3 °C per minute from +48 °C to -20 °C on water cool mode 0.12 °C per minute from +22 °C to +48 °C on air cool mode	0.09 °C per minute from +4 to +8C (at +25 °C ambient)	18.7 empty volume 4.17 with the pouch Internal Volume dependent on support structure for payload	Single MLE	10kg; 17.25 cm × 25.87 cm × 41.9 cm emote volume 7.62 cm × 17.53 cm × 31.24 cm internal pouch dimensions
Double Coldbag	N/A	N/A	See Table H.5.7-2	13.3L	Single MLE	34.9 cm × 22.2 cm × 17.1 cm

*Volume and Mass shown for two (2) Type X Trays.

TABLE H.5.7-2 SUMMARY HOLD TIMES FOR DOUBLE COLDBAG

Ice Brick Temperature (°C)	Ice Brick Quantity	Hold Time in Coldbag (hours)
+37	14	+120
+22	12	+164 from +23 to +25 °C (ambient temp of ~30 °C)
+27	12	+270 from +23 to +29 °C
+4	12	+232
-26	14	+120*
-32	14	+120*
-32	12	+102*

*Hold time is from -95 °C to -19.99 °C

Note: All hold times are based on an ambient environment of 21-23 ºC (70-74 ºF)

APPENDIX I

COMMAND AND DATA HANDLING INTERFACE REQUIREMENTS

APPENDIX I – COMMAND AND DATA HANDLING INTERFACE REQUIREMENTS

I.1.0 INTRODUCTION

I.1.1 PURPOSE

This appendix provides requirements, guidelines and data deliverables for payloads interfacing with ISS C&DH systems.

I.1.2 SCOPE

This appendix addresses all payloads utilizing ISS C&DH systems including Low Rate Data Link (LRDL), Medium Rate Data Link (MRDL), High Rate Data Link (HRDL), EXPRESS Ethernet and RS-422, Ku-band IP Services (KuIP), and JSL. See Table I.1.2-1 for a description of the available interfaces.

Note: This appendix will refer to both Medium Rate Data Link (MRDL) and Joint Station LAN (JSL) as Ethernet. Originally the ISS Ethernet architecture was divided into two networks, one for mission operations and one for Payloads. The Payloads network was referred to as MRDL reflective of the initial 10 Mbps half duplex rate that was higher than the MIL-STD-1553B (LRDL), but lower than the Fiber (HRDL) rate. The payload network has since been expanded to include wired 10/100 Mbps Full duplex and wireless capabilities and is now integrated with the JSL. Thus, the MRDL terminology is no longer indicative of the actual Ethernet rates on ISS. The second Ethernet network was used for mission operations and was originally called Integrated Station LAN (ISL). It has since been allocated as part of the JSL allowing one Ethernet Network to encompass the entire Space Station providing both wireless and 10/100 Mbps wired capabilities to US modules, International Partner modules and payloads.

TABLE I.1.2-1 AVAILABLE ISS C&DH INTERFACES (2 PAGES)

INTERFACE	DESCRIPTION	SERVICE	CAPABILITY	INTERFACE LOCATION
LRDL	Payload MIL-STD-1553B Local Bus Remote Terminal connection to the Payload Multiplexer Demultiplexer (PL MDM)	H&S Low Rate Telemetry Command File Transfer	1280 words per RT 102.4 kbps maximum per bus shared by all connected RTs (640 words/pkt, 10 pkts/sec) 10.24 kbps per RT (10 64-word commands/sec) 8 Mbyte file size maximum	Rack, UOP, JEM UOP, COL SUP
HRDL	TAXI Fiber optic network connected to a central Automated Payload Switch for routing to other locations and/or multiplexing telemetry into the Ku Communications Unit	Two-way point-to-point	100 Mbps	Rack
EXPRESS RS-422				EXPRESS Connector Panel

TABLE I.1.2-1 AVAILABLE ISS C&DH INTERFACES (2 PAGES)

INTERFACE	DESCRIPTION	SERVICE	CAPABILITY	INTERFACE LOCATION
Ethernet	802.3 Ethernet switches and hubs 802.11 Wireless Access Points (WAPs)	Telemetry via iPEHG Gateway Telemetry via Wireless Payload-to-Payload wired Payload-to-Payload wireless Two-way KuIP File Transfer (via Two-Way KuIP) File Transfer (via SWORDFISH)	100 Mbps maximum via HRDL gateway 802.11 b – 11 Mbps 802.11 g – 54 Mbps 802.11 n – 135 Mbps Rate varies on RF Environment and number of users 10/100 Mbps 802.11 b – 11 Mbps 802.11 g – 54 Mbps 802.11 n – 135 Mbps Rate varies on RF Environment and number of users 10/100 Mbps via CCSDS internet Protocol Encapsulation 4.3 Gbyte file size (File size depends on protocol and operational constraints) 50 Gbyte file size (File size depends on protocol and operational constraints)	Rack Utility Interface Panel (UIP) Utility Outlet Panel (UOP) JEM Utility Outlet Panel (UOP) COL Standard Utility Panel (SUP) iPEHG User Interface Panel Edge Router User Interface Panel Hirschmann Switch Laptop WAPs within pressurized volume
EXPRESS Ethernet	802.3 Ethernet network within EXPRESS Rack and derivatives	H&S Telemetry (via Rack Interface Controller) Telemetry (via RIC bypass) Telemetry (Laptop)	95 words per Subrack via TCP/IP 1.8 Mbps via TCP/IP 6 Mbps via CCSDS space packet 3 Mbps via TCP/IP	EXPRESS Connector Panel or any Ethernet interface Laptop

I.1.3 USE

These requirements, guidelines and data deliverables are applied to payloads interfacing with ISS C&DH systems in addition to the general requirements, guidelines and data deliverables in Section 3.0 and are allocated to a payload through the payload unique ICD. The PD and the ISS Program must jointly agree on the interfaces and identify requirements as applicable if the interface exists, and not applicable if the interface does not exist for the payload configuration documented in the ICD.

I.2.0 DOCUMENTATION

See Section 5.0.

I.3.0 COMMAND AND DATA HANDLING INTERFACE REQUIREMENTS

I.3.1 C&DH GENERAL REQUIREMENTS

I.3.1.1 SCHEMATIC DATA REQUIREMENTS

Data Deliverable: Provide a general C&DH schematic showing all C&DH interfaces.

I.3.1.2 DISPLAYS

All laptop and portable computing device displays for use by payloads **shall** be in accordance with SSP 50313, Display and Graphics Commonality Standard.

Note: When a COTS software product is not modified and is used “as is”, compliance with the DGCS is not required, per SSP 50313, paragraph 1.2.3.C. However, the IDAGS panel will review the product under consideration to assess its on-orbit use acceptability.

Note: A streamlined set of display requirements is being developed and will be added to this document in a new Appendix.

I.3.2 WORD/BYTE NOTATIONS, TYPES AND DATA TRANSMISSIONS

This section applies to all payload commands and data on the LRDL, all header/trailer data on the MRDL, and HRDL.

I.3.2.1 WORD/BYTE NOTATIONS

Payloads **shall** use the word/byte notations as specified in SSP 52050, International Standard Payload Rack to International Space Station, Software Interface Control Document Part 1, Paragraph 3.1.1.

I.3.2.2 DATA TYPES

Payloads **shall** use the data types as specified in SSP 52050, Paragraph 3.2.1 and subsections.

I.3.2.3 DATA TRANSMISSIONS

A. Payload data transmissions on MRDL *should* use the data transmission order in accordance with SSP 52050, paragraph 3.3.4.1.

B. Payload data transmissions on HRDL *should* use the data transmission order in accordance with CCSDS 701.0-B-3, Advanced Orbiting Systems, Networks and Data Links: Architectural Specification, paragraph 1.6.

C. The payload *should* be designed to accept commands resulting in a variable downlink rate.

I.3.3 CONSULTATIVE COMMITTEE FOR SPACE DATA SYSTEMS

Payloads must use the Consultative Committee for Space Data Systems (CCSDS) standards for Space to Ground and Ground to Space data and time requirements as specified in this section. This section applies to all payload commands and data on the LRDL, MRDL, and HRDL.

I.3.3.1 CCSDS DATA

A. Payload data that is space to ground **shall** be either CCSDS Data Packets or CCSDS Bitstream.

B. Payload data that is S-band ground to space **shall** be CCSDS Data Packets. Ku-band IP service data will be formatted from the payload's perspective in IP messages.

C. Payload to Payload MDM data **shall** be CCSDS Data Packets.

I.3.3.1.1 CCSDS DATA PACKETS

Payload data packets downlinked via the KuIP return link **shall** contain an even number of octets. Payload CCSDS data packets consist of a primary header and a secondary header followed by the data field.

I.3.3.1.1.1 CCSDS PRIMARY HEADER

Payloads **shall** develop a CCSDS primary header in accordance with SSP 52050, Paragraph 3.1.3.1.

I.3.3.1.1.2 CCSDS SECONDARY HEADER

Payloads **shall** develop a CCSDS secondary header in accordance with SSP 52050, Paragraph 3.1.3.2.

I.3.3.1.2 CCSDS DATA FIELD

Payload CCSDS data fields **shall** contain the payload data from the transmitting application to the receiving application, and the CCSDS checksum in accordance with SSP 52050, Paragraph 3.1 and subparagraphs.

I.3.3.1.3 CCSDS DATA BITSTREAM

Payloads with HRDL *should* be developed in accordance with CCSDS 701.0-B-3, Paragraph 2.3.2.3.

I.3.3.1.4 CCSDS APPLICATION PROCESS IDENTIFICATION FIELD

The CCSDS Application Process Identifier (APID) will be used for routing data packets as described in SSP 41175-02, Software Interface Control Document Station Management and Control to International Space Station Book 2, General Software Interface Requirements, Paragraph 3.3.2.1.3. The format of APIDs is shown in SSP 41175-02, Table 3.3.2.1.1-1. Telemetry APIDs for a payload or subrack payload will be requested from the Systems Engineering and Integration (SE&I) – Payload Software Integration (PSI) function, and will be recorded in the payload unique software ICD.

I.3.3.1.5 COMMAND PACKET CHECKSUM

Payloads **shall** verify the command packet checksum, calculated from the first word of the CCSDS header to the last word of the command data word, prior to use.

I.3.3.2 CCSDS TIME CODES

I.3.3.2.1 CCSDS UNSEGMENTED TIME

Payloads **shall** use CCSDS unsegmented time code (CUC) in the secondary header as specified in CCSDS 301.0-B-2, Time Code Formats, Paragraph 2.2, as tailored by SSP 52050 formats.

I.3.3.2.2 CCSDS SEGMENTED TIME

Segmented time code will be sent to the payload by a broadcast message on the Payload MIL-STD-1553B. Segmented time code formats is specified in CCSDS 301.0-B-2, Paragraph 2.4.

The broadcast time will be received at subaddress #29 on each Payload MIL-STD-1553B bus. The broadcast time signal will be updated once a second and is accurate to ±2.5 ms with respect to the Space Station Global Positioning System (GPS) receiver.

I.3.4 MIL-STD-1553B LOW RATE DATA LINK (LRDL)

Payloads with low rate data **shall** implement a single MIL-STD-1553B Remote Terminal (RT) to the payload unique MIL-STD-1553B bus in accordance with SSP 52050, Paragraph 3.2.

I.3.4.1 MIL-STD-1553B PROTOCOL

I.3.4.1.1 STANDARD MESSAGES

A. Payloads **shall** develop standard messages for the Payload MIL-STD-1553B in accordance with SSP 52050, Paragraph 3.2.3.3.

B. MIL-STD-1553 subaddress assignments **shall** be per SSP 52050, Table 3.2.3.2.1.4-1.

I.3.4.1.2 COMMANDING

Payloads **shall** receive and process commands from the Payload MDM that originate from the Ground, Timeliner, Payload MDM and PCS in accordance with SSP 52050, Paragraph 3.2.3.4.

I.3.4.1.3 HEALTH AND STATUS DATA

A. The format for the H&S data provided by the payload **shall** be as given in Figure I.3.4.1.3-1, Single Subset ID Health and Status Format, for an RT with a single Subset ID or as given in Figure I.3.4.1.3-2, Integrated ISPR or Non-Rack End Item Health and Status Format, for an RT containing multiple Subset IDs.

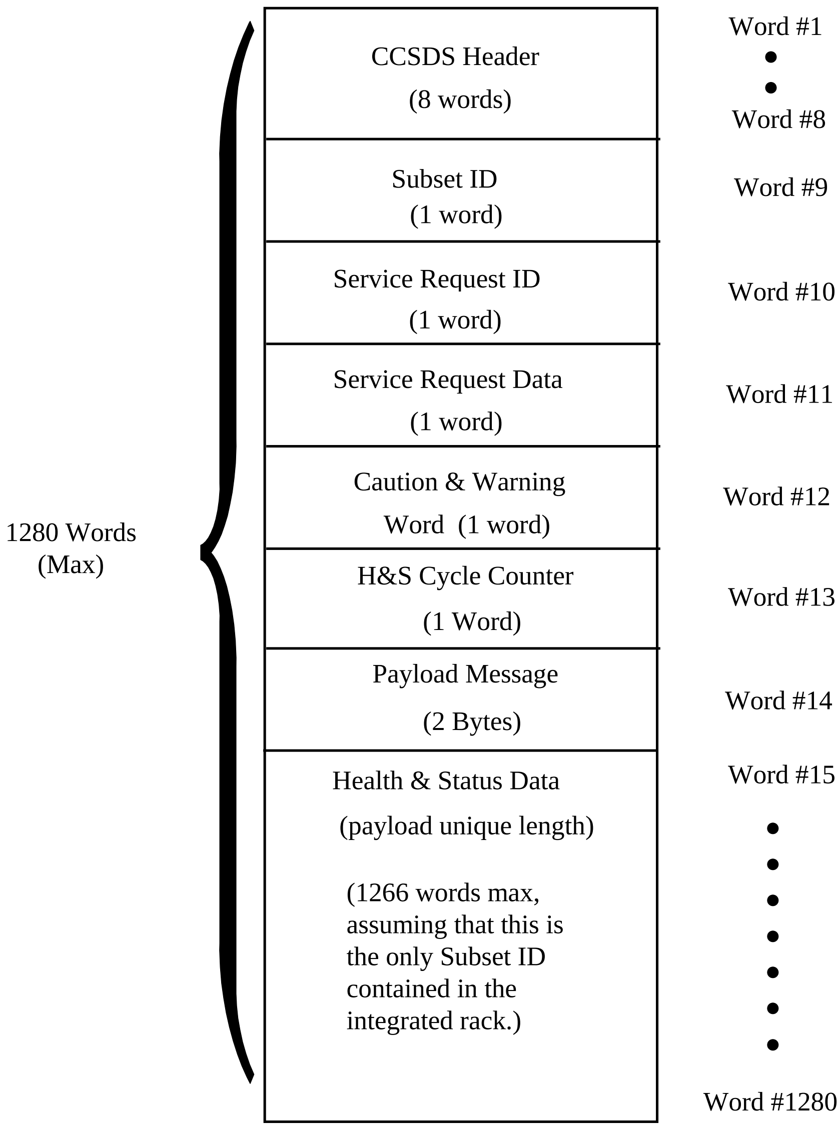


FIGURE I.3.4.1.3-1 SINGLE SUBSET ID HEALTH AND STATUS FORMAT

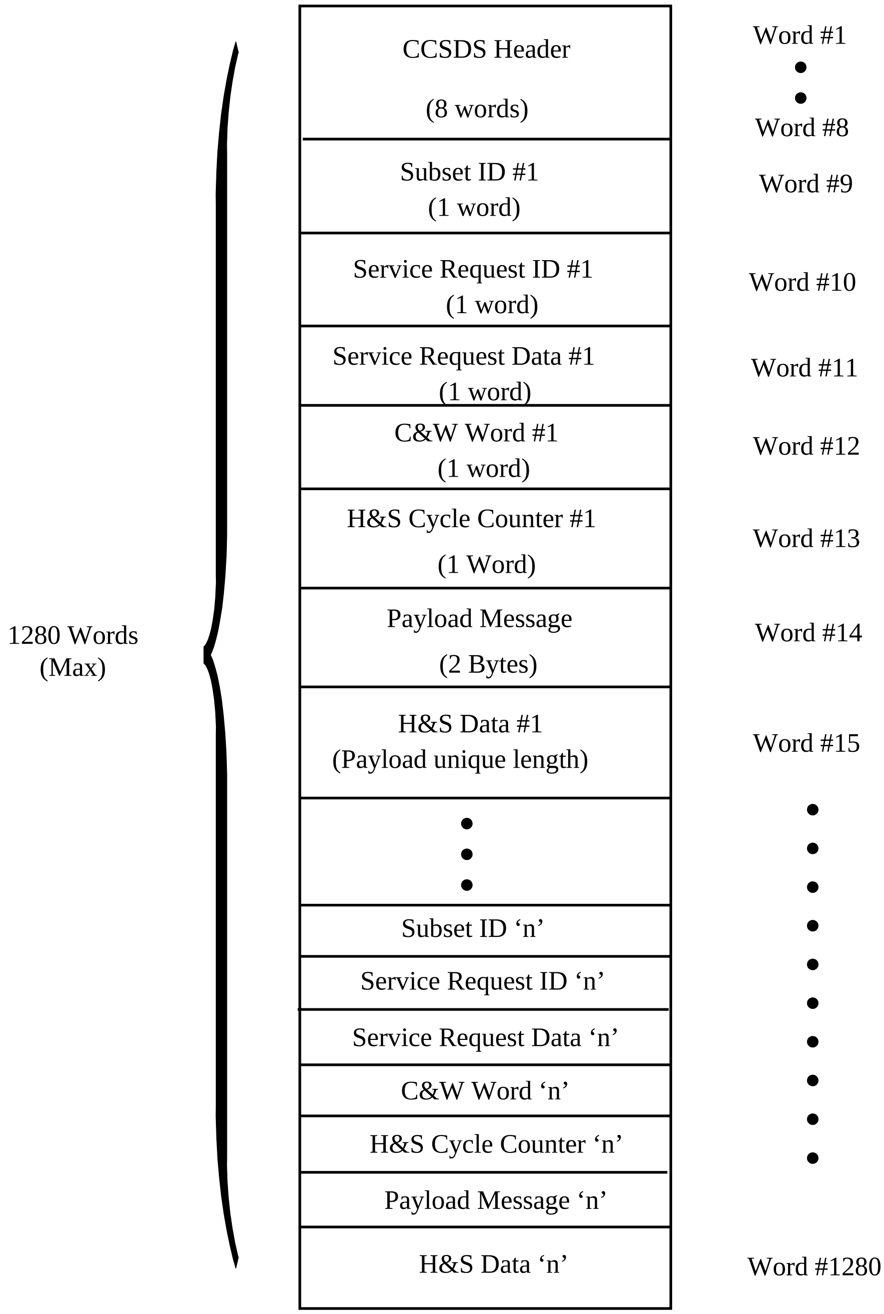


FIGURE I.3.4.1.3-2 INTEGRATED ISPR OR NON-RACK END ITEM HEALTH AND STATUS FORMAT

B. The Payload Multiplexer/Demultiplexer (PL MDM) collects the H&S CCSDS packages from the RTs at a predefined rate of 1.0 Hz or 0.1 Hz. The data rate at which the H&S data is collected will be determined by the Payload Developer (PD)/Payload Integrator (PI) in conjunction with the ISRP, and their own analysis and associated safety reviews. The PL MDM collects up to 1280 words of H&S data from each ISPR and non-rack end item RT location. The 1280 words will include the CCSDS header. The PL MDM collects H&S Data from ISPR or non-rack end item RTs as four 32-word messages in the first 100 millisecond processing frame of the 1 second minor frame collection cycle. During subsequent 100 millisecond processing frames of the 1 second minor frame, the PL MDM collects up to four 32 word messages, but only enough 32 word messages to complete the collection of the H&S data. The PL MDM collects H&S data during the first half of the 100 millisecond processing frames as shown in SSP 52050, Appendix D.

C. Payloads **shall** respond to their respective PL MDM polls for health and status data with updated data at a 1 Hz or 0.1 Hz rate.

D. Payload RTs **shall** update H&S data such that the data is ready to be read at the appropriate time within the 100 millisecond processing frame as the 32 word messages are requested.

E. Payload request data embedded in the H&S data provided by a Subset ID **shall** only be set for a single collection cycle for each request.

F. The Request ID for payload Request Data **shall** be as given in Table I.3.4.1.3-1, Service Requests.

TABLE I.3.4.1.3-1 SERVICE REQUESTS (2 PAGES)

Service Request Type	Structure	Binary Definition
Low Rate Telemetry Start	1 Word (Request ID) 1 Word Number of Packets	‘00000000 00000011’ b (or ’3’ or ’ 0x0003’) Range {1-100}
Low Rate Telemetry Stop	1 Word (Request ID)	‘00000000 00000100’ b (or ’4’ or ’ 0x0004’)
Procedure Execution Start	1 Word (Request ID) 1 Word (Sequence ID)	‘00000000 00010010’ b (or ’18’ or ’ 0x0012’) Payload Dependent
Procedure Execution Stop	1 Word (Request ID) 1 Word (Sequence ID)	‘00000000 00010011’ b (or ’19’ or ’ 0x0013’) Payload Dependent
Procedure Execution Resume	1 Word (Request ID) 1 Word (Sequence ID)	‘00000000 00010100’ b (or ’20’ or ’ 0x0014’H) Payload Dependent
Start File Read	1 Word (Request ID) 1 Word (File ID)	‘00000000 00010000’ b (or ’16’ or ’ 0x0010’H) Payload Dependent
Start File Write	1 Word (Request ID) 1 Word (File ID)	‘00000000 00010001’ b (or ’17’ or ’ 0x0011’) Payload Dependent
Stop File Read	1 Word (Request ID) 1 Word (File ID)	‘00000000 00011000’ b (or ’24’ or ’ 0x0018’) Payload Dependent

TABLE I.3.4.1.3-1 SERVICE REQUESTS (2 PAGES)

Service Request Type	Structure	Binary Definition
Stop File Write	1 Word (Request ID) 1 Word (File ID)	‘00000000 00011001’ b (or ’25’ or ’ 0x0019’) Payload Dependent
Restart File Read	1 Word (Request ID) 1 Word (Block #)	‘00000000 00011010’ b (or ’26’ or ’ 0x001A’) Payload Dependent
Ancillary Data Start	1 Word (Request ID) 1 byte (Data Set ID) 1 byte (Cyclic/Aperiodic)	‘00000000 00000001’ b (or ’1’ or ’ 0x0001’) Data Set Dependent; Range {1-100} ’1’ (Cyclic) (See Note 1 below) ’0’ (Aperiodic)
Ancillary Data Stop	1 Word (Request ID) 1 byte (Data Set ID)	‘00000000 00000010’ b (or ’2’ or ’ 0x0002’) Data Set Dependent (See Note 2 below)
Install Bundle	1 Word (Request ID) 1 Word (Bundle ID Parameter)	‘00000000 00010101’ b (or ’21’ or ’ 0x0015’) Payload Dependent
Halt Bundle	1 Word (Request ID) 1 Word (Bundle ID Parameter)	‘00000000 00010110’ b (or ’22’ or ’ 0x0016’) Payload Dependent
Remove Bundle	1 Word (Request ID) 1 Word (Bundle ID Parameter)	‘00000000 00010111’ b (or ’23’ or ’ 0x0017’) Payload Dependent
’null’	1 Word (No Request)	‘00000000 00000000’ b (or ’0’ or ’ 0x0000’)

Note 1: For ‘Ancillary Data Start’ request:
Most Significant Byte (Bits 0-7) contains the Rate (i.e., Cyclic vs. Aperiodic)
Least Significant Byte (Bits 8-15) contains the Data Set ID

Note 2: For ‘Ancillary Data Stop’ request:
Most Significant Byte (Bits 0-7) is not used
Least Significant Byte (Bits 8-15) contains the Data Set ID

G. The Caution and Warning (C&W) word embedded in each Subset ID’s H&S data is provided so that the rack controller or the Payload Executive Processor (PEP) can monitor for out-of-bounds safety related conditions. Availability of the C&W word to the PEP and the ISS C&W system will facilitate the isolation of problems or malfunctions to the subrack level for racks which have multiple payloads. Payloads which the ISRP have determined cannot cause such a condition **shall** zero fill the C&W word.

H. Subset IDs which have multiple C&W events occurring simultaneously **shall** set their C&W word to the value representing the most severe event occurring at that time.

I. The C&W word **shall** be placed as word #4 of H&S data for each Subset ID as shown in Figure I.3.4.1.3-1 and Figure I.3.4.1.3-2.

J. For each Subset ID that is reporting H&S Data, an H&S Cycle Counter **shall** be provided with the characteristics listed below. This H&S Cycle Counter will be used by Payload Operations personnel to determine whether H&S data being received is stale or not.

-format as shown in Figure I.3.4.1.3-1 and Figure I.3.4.1.3-2
-an unsigned 16 bit integer in the range 0 to 65,535
-set to ‘0’ for the first H&S packet that the Subset ID transmits
-incremented by a value of ‘1’ for each H&S packet transmitted
- reset to a value of ‘0’ once a value of ‘65,535’ is reached, and then the Subset ID will continue incrementing the H&S Cycle Counter as noted above

K. Payloads which require messages to be displayed on a PCS onboard the ISS or displayed by Payload Operations personnel on the ground **shall** include those messages in their H&S Data as shown in Figure I.3.4.1.3-1 and Figure I.3.4.1.3-2.

L. Payload messages **shall** be formatted as shown in Figure I.3.4.1.3-3.

Message Counter	**Message Identifier**
Most Significant Byte	Least Significant Byte

FIGURE I.3.4.1.3-3 PAYLOAD MESSAGE FORMAT

M. The Message Counter **shall** have the following characteristics:

-be an unsigned eight-bit integer in the range of zero to 255
-initially contain a value of ‘0’
-be incremented by a value of ‘1’ with each message issued by the payload
-be reset to a value of ‘0’ once a value of 255 is reached, and then the payload will continue incrementing the Message Counter as noted above

N. The Message Identifier **shall** be an 8-bit unsigned integer in the range 0 to 255. The value of the message identifier and the associated text to be displayed will be captured during the development of the payload PDL C&DH Data Set.

I.3.4.1.4 SAFETY DATA

A. Payload safety data **shall** be included in the Health and Status data CCSDS packets provided by payload remote terminals. Safety data is the set of payload generated C&W related parameters that are required to be monitored for C&W events. Determination of the safety-related parameters that are required is the responsibility of the PD/payload integrator in conjunction with the ISRP and associated safety reviews. Examples of safety-related data include: 1) A parameter (including the Health & Status C&W word itself) that is limit checked onboard by the Payload MDM based on ISRP requirements or ISS requirements/flight rules; 2) A parameter that is monitored on the ground based on ISRP requirements or payloads analyses; 3) A parameter that is monitored internally by the payload to determine if the Health & Status Caution or Warning bit needs to be set.

Note: Safety parameters such as current or temperature measurements that are being monitored onboard for a situation that could lead to a fire or overheating are not downlinked via S-band; however, resultant rack-level Emergency, Caution, and Warning (ECW) bits that are set based on the Payload MDM limit check function are automatically included in the S-band downlink.)

B. Payloads or subrack payloads which are required to report such a condition **shall** set their summary C&W word to the following values as long as condition persists:

0 — No Problem
1 — Advisory
2 — Caution
3 — Warning
4 — Emergency (Toxic) - (Scar)

I.3.4.1.4.1 CAUTION AND WARNING

For the purpose of C&W classifications, the sensors are the payload's means of detecting events that were deemed necessary by the ISRP during the Phased Safety Reviews. The sensors used to produce Caution and Warning Events are determined by the PD. Advisories may be set if the PD identifies a situation that meets the classification of an advisory.

I.3.4.1.4.1.1 CLASS 1 – EMERGENCY

All of the defined ISS Emergency conditions are reported only by ISS systems or integrated racks with a rack smoke detector.

- The emergency condition rapid cabin depressurization will be detected by the ISS module sensors.
- The emergency condition of toxic atmosphere is set as a scar.
- Payload Fire emergencies can only be declared as a confirmed fire event by the ISS rack smoke detector or equivalent, which can detect 96% of the smoke detector failures.

When an emergency event is detected, the format of the data will identify the event type (fire, toxic atmosphere, or depressurization). Emergency conditions require all onboard crew to respond immediately.

I.3.4.1.4.1.2 CLASS 2 - WARNING

Payloads **shall** format the caution and warning word in accordance with SSP 52050, Paragraph 3.2.3.5 as a warning when the payload sensors detect the following conditions:

(1) A potential fire event, (detected by a sensor other than an ISS rack smoke detector or equivalent)

(2) A precursor event that could manifest to an emergency condition (toxic atmosphere, rapid cabin depressurization or fire) and

(a) automatic safing has failed to safe the event or

(b) the system is not automatically safed (i.e. requires manual intervention)

(3) An event that results in the loss of a hazard control and

(a) automatic safing has failed to safe the event or

(b) the system is not automatically safed (i.e. requires manual intervention)

Note: A Warning requires someone to take action immediately. Warnings are used for events that require manual intervention and for notification when automatic safing fails.

I.3.4.1.4.1.3 CLASS 3 - CAUTION

Payloads **shall** format the caution and warning word in accordance with SSP 52050, Paragraph 3.2.3.5 as a caution when the payload sensors detect the following conditions:

(1) A precursor event that could manifest to an emergency condition (toxic atmosphere, rapid cabin depressurization or fire) and automatic safing has safed the event (i.e. the system does not require manual intervention)

(2) An event that results in the loss of a hazard control and automatic safing has safed the event (i.e., the system does not require manual intervention)

Note: A Caution requires no immediate action by the crew. Automatic safing has controlled the event.

I.3.4.1.4.1.4 CLASS 4 - ADVISORY

Payloads that require an advisory **shall** format the caution and warning word in accordance with paragraph 3.2.3.5, Health and Status Data, of SSP 52050 as an advisory. Advisories are set for the following conditions:

(1) Advisories are set primarily for ground monitoring purposes (advantageous due to limited comm. coverage and data recording).

(2) Data item that most likely will not exist permanently in Telemetry List but are desired to be time tagged and logged for failure isolation, trending, sustaining engineering, etc.

I.3.4.1.5 SERVICE REQUESTS

Payloads that require service requests *should* be in accordance with SSP 52050, Paragraph 3.2.3.7.

I.3.4.1.6 ANCILLARY DATA

A. The payload *should* receive Unique Ancillary Data (UAD) according to SSP 52050, Paragraph 3.2.3.8.2.

B. The payload *should* receive Broadcast Ancillary Data (BAD) according to SSP 52050, Paragraph 3.2.3.8.1.

I.3.4.1.7 FILE TRANSFER

Payloads requiring file transfer *should* develop their file transfer in accordance with SSP 52050, Paragraph 3.2.3.9.

I.3.4.1.8 LOW RATE TELEMETRY

Payloads requiring low rate telemetry *should* develop low rate telemetry (i.e. science data) in accordance with SSP 52050, Paragraph 3.2.3.10.

I.3.4.1.9 DEFINED MODE CODES

I.3.4.1.9.1 IMPLEMENTED MODE CODES

Payloads **shall** implement MIL-STD-1553B mode codes in accordance with SSP 52050, Paragraph 3.2.3.2.1.5 and Table 3.2.3.2.1.5-1.

I.3.4.1.9.2 UNIMPLEMENTED/UNDEFINED MODE CODES

The payload MIL-STD-1553B RT may be designed to recognize both unimplemented and undefined mode codes as illegal commands. If the RT designer does decide to monitor for unimplemented/undefined code modes, the RT *should* respond by setting the message error bit in the status word.

I.3.4.1.10 ILLEGAL COMMANDS

The payload MIL-STD-1553B RTs are not required to respond to illegal commands. If a RT designed with this option detects an illegal command, it *should* respond to the illegal command by setting the message error bit in the status word.

I.3.4.2 MIL-STD-1553B LOW RATE DATA LINK (LRDL) INTERFACE CHARACTERISTICS

I.3.4.2.1 LRDL REMOTE TERMINAL ASSIGNMENT

I.3.4.2.1.1 LRDL CONNECTOR/PIN ASSIGNMENTS

I.3.4.2.1.2 MIL-STD-1553B BUS A AND B CONNECTOR/PIN ASSIGNMENT

A. Payload connectors P3 and P4 mating requirements to the UIP connector J3 and J4 are shown in paragraphs N.3.1.1.7.A and N.3.1.1.7.B.

B. Payload connectors P3 and P4 **shall** meet the pin out interfaces of the UIP J3 and J4 connectors as shown respectively in Figure N.3.1.1.8-2 and Figure N.3.1.1.8-3.

C. Payload connectors P3 and P4 mating requirements to the UOP connectors J3 and J4 are shown in paragraphs G.3.1.1.A and G.3.1.1.B.

D. Payload connectors P3 and P4 **shall** meet the pin out interfaces of the UOP connectors J3 and J4 as shown respectively in Figure G.3.1.1.1-1 and Figure G.3.1.1.1-2.

E. Payload connector P2 mating requirements to the SUP connector J2 are specified in paragraphs G.3.1.1.A and G.3.1.1.B.

F. Payload connector P2 **shall** meet the pin out interfaces of the SUP connector J2 as shown in Figure G.3.1.1.2-6.

I.3.4.2.1.3 REMOTE TERMINAL ADDRESS CODING

A. Payloads **shall** be designed to read and respond to the hardware remote terminal address coding scheme for the Standard Payload Bus, for all locations defined in Table I.3.4.2.1.3-1. Details of the implementation of an ISPR remote terminal address coding example are illustrated in Figure I.3.4.2.1.3-1.

B. Payload decimal values **shall** be mapped in 5 bit representation with bit 0 = Least Significant Bit (LSB) as shown in Figure I.3.4.2.1.3-1.

C. Payloads **shall** use odd-parity.

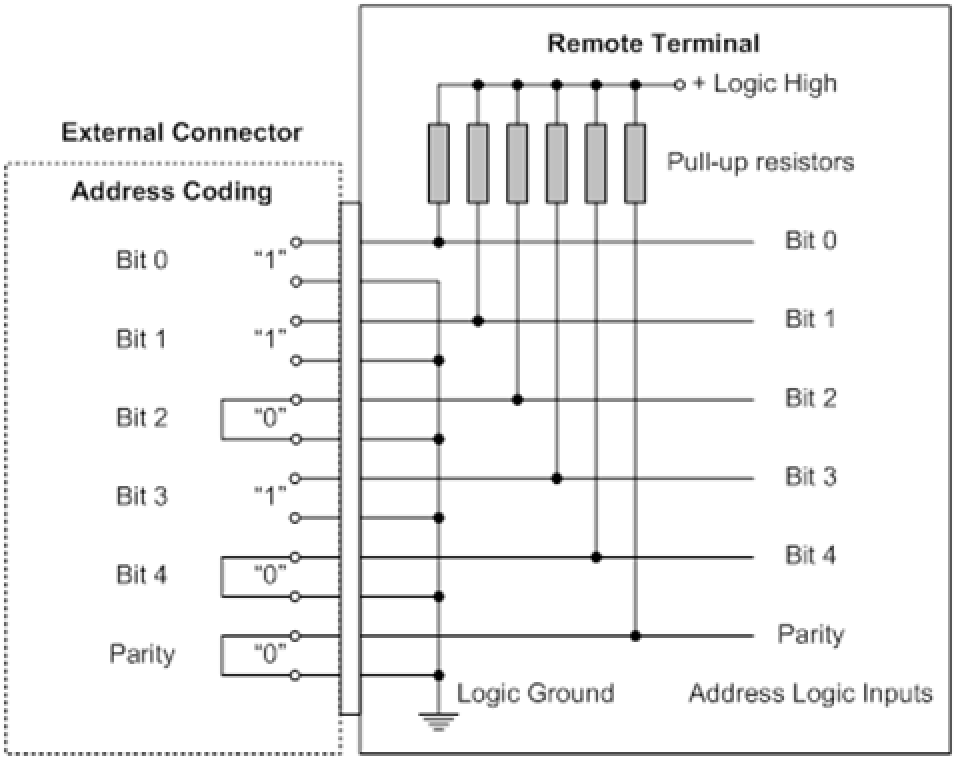
D. Payload jumpering address line to ground **shall** be logic 0.

E. Non-rack payload **shall** provide their own RT address coding in accordance with UOP/SUP locations defined in Table I.3.4.2.1.3-1.

TABLE I.3.4.2.1.3-1 REMOTE TERMINAL ADDRESS CODING FOR STANDARD PAYLOAD BUS

COL			JEM			USL		
Location	Payload Bus	RT Address	Location	Payload Bus	RT Address	Location	Payload Bus	RT Address
SUP#2 and SUP#3	LB PL-APM	5	UOP#b1	LB PL-JEM	5	UOP#1	LB PL-1	5
COL1F1	LB PLAPM	15	JPM1D4	LB PLJEM	6	UOP#3	LB PL-2	5
COL1F2	LB PLAPM	16	JPM1F1	LB PL–JEM	15	LAB1O1	LB PL2	8
COL1F3	LB PLAPM	17	JPM1F2	LB PL–JEM	16	LAB1O2	LB PL3	9
COL1F4	LB PLAPM	18	JPM1F3	LB PL–JEM	17	LAB1O3	LB PL3	10
COL1A1	LB PLAPM	19	JPM1F5	LB PL–JEM	18	LAB1O4	LB PL3	11
COL1A2	LB PLAPM	20	JPM1F6	LB PL–JEM	19	LAB1O5	LB PL3	12
COL1A3	LB PLAPM	21	JPM1A1	LB PL–JEM	20	LAB1S1	LB PL4	8
COL1A4	LB PLAPM	22	JPM1A2	LB PL–JEM	21	LAB1S2	LB PL4	9
COL1O1	LB PLAPM	23	JPM1A3	LB PL–JEM	22	LAB1S3	LB PL4	10
COL1O2	LB PLAPM	24	JPM1A4	LB PL–JEM	23	LAB1S4	LB PL4	11
			JPM1A5	LB PL–JEM	24	LAB1D3	LB PL4	14
						LAB1P1	LB PL1	12
						LAB1P2	LB PL2	15
						LAB1P4	LB PL3	17

Note: Although APM is globally changed to COL throughout this document, for specific C&DH references APM is not being changed.



Note: Example RT address = 11 in decimal representation.

- All address and parity lines have pull-up resistors so that "0" on those lines is achieved by connecting the lines to the Remote Terminal Logic Ground.
- The parity is odd.
- Bit 0 is LSB.

FIGURE I.3.4.2.1.3-1 ISPR REMOTE TERMINAL HARDWIRED ADDRESS CODING (EXAMPLE)

I.3.4.2.2 LRDL SIGNAL CHARACTERISTICS

The payload MIL-STD-1553B terminal characteristics **shall** be in accordance with MIL-STD-1553B, Notice 2, section 4.5.2.

I.3.4.2.3 LRDL CABLING

A. The payload MIL-STD-1553B internal wiring characteristics **shall** be according to SSQ 21655, Cable, Electrical, MIL-STD-1553 DataBus, Space Quality, General Specifications for 75 ohms.

B. The payload MIL-STD-1553B internal wiring stub length **shall** not exceed 12 feet, (3.65 meters), when measured from the internal MIL-STD-1553B Remote Terminal to the UIP.

I.3.4.2.4 MULTI-BUS ISOLATION

For Payloads utilizing multiple ISS Payload MIL-STD-1553B data buses, the signal isolation between the buses **shall** be no less than 58 dB. A data bus consists of a redundant pair, channel A and channel B. It matters not that the data buses exit the payload on the same or different connectors, or that the data buses are connected to the same or different buses. This requirement does not apply to payload unique buses.

I.3.5 ETHERNET

Payloads with Ethernet interfaces can be either "user devices" or "infrastructure devices". User devices must apply the applicable requirements from Table I.3.5.2-1. Payloads with more than one network interface (such as a bridge or router or switch) are considered "infrastructure devices". Infrastructure device requirements are not included in this document.

Note: A payload may fall in the infrastructure category if it incorporates an internal Ethernet switch, hub or repeater that can affect network operation. In this case, the payload will be assessed to determine if additional infrastructure requirements are applicable per SSP 50892.

The ISS Ethernet architecture provides both IEEE 802.3 10/100 Mbps wired connectivity and IEEE 802.11 b/g/n wireless connectivity. Payloads with wired or wireless Ethernet interfaces have access to the resources listed in Table I.3.5-1.

TABLE I.3.5-1 C&DH RESOURCES AVAILABLE FROM ETHERNET

Resource	Capability
Traditional Downlink via PEHG Gateway	Telemetry, Unidirectional Downlink
Ku-band IP Services	Standard Internet Protocols, Bi-Directional File Transfers, Telemetry, Video, Remote Desktop Access
Network Time Protocol Server	Time Synchronization with ISS 1553 Time via PEHG NTP Time Servers
Disruption Tolerant Network (DTN)	Bi-Directional Store-and Forward File Transfers, CFDP
Network Attached Storage (NAS)	File Storage
Network Monitoring System (NMS)	SNMP reports
ISS Operations	SSC File Server, Antivirus, File Storage, User Authentication

Payloads may be connected directly to Ethernet infrastructure devices, to racks, or internal to EXPRESS Racks (subrack payloads). Payloads will be evaluated to assure compatibility with infrastructure devices. Primary infrastructure devices related to payload operations include the improved Payload Ethernet Hub Gateway (PEHG) and the Layer 2 Ethernet Hub Multiplexer (LEHX) provided by JAXA for use by U.S. payloads in the JEM or attached to the JEM Exposed Facility. All subsequent PEHG references herein apply to the improved PEHG by implication. Payloads may also connect to other Infrastructure devices such as the Edge Routers, Hirschmann Switches and Wireless Access Points (WAPs) as shown in Figure I.3.5-1.

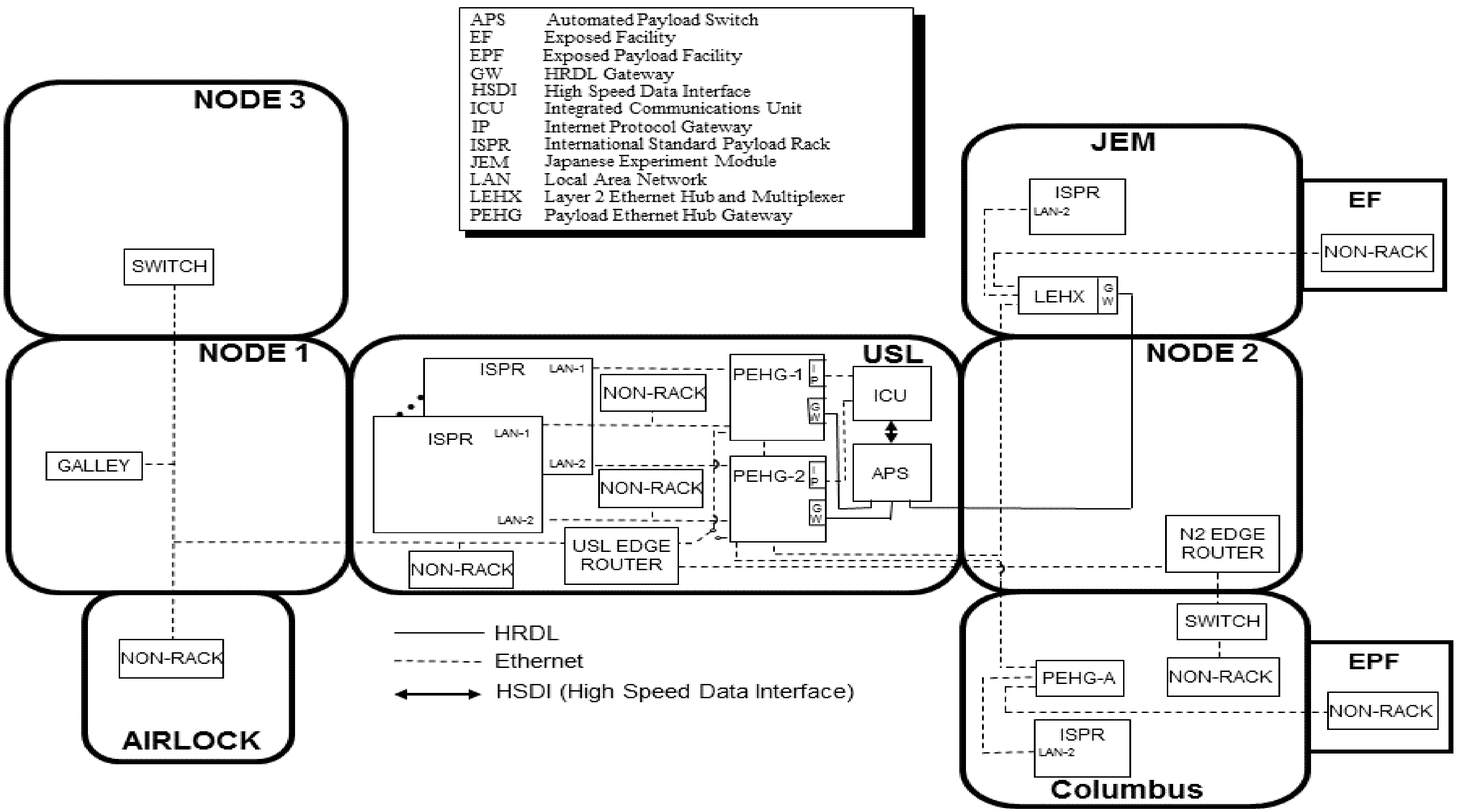


FIGURE I.3.5-1 PAYLOAD WIRED ETHERNET SIMPLIFIED BLOCK DIAGRAM

I.3.5.1 SUBRACK SPECIFIC ETHERNET REQUIREMENTS

EXPRESS and WORF subrack payloads are referred to section I.3.8.3 for Ethernet interface requirements. Section I.3.8.3 contains pointers (where required) back to section I.3.5.2 for specific Ethernet requirements needed by EXPRESS and WORF subrack payloads or are applicable to KuIP.

I.3.5.2 GENERAL PAYLOAD ETHERNET REQUIREMENTS

The requirements in this section apply to all payloads capable of transmitting data over Ethernet and are listed in Table I.3.5.2-1. This includes data that may be transmitted with wired connections or wireless connections. It also includes

- Payloads planning to use KuIP
- Payloads connected to Racks
- Non-rack Payloads

TABLE I.3.5.2-1 PAYLOAD REQUIREMENT AND GUIDELINES (2 PAGES)

Paragraph Number	Paragraph Title	User Devices		Cabling
		Wireless	Wired	
I.3.5.2.1.1	IEEE 802.3 10/100BaseTX Interface		A	
I.3.5.2.1.2	Ethernet Signal Characteristics		A	
I.3.5.2.1.3.1.A	Payload MAC Addresses	A	A	
I.3.5.2.1.3.1.B	Payload MAC Addresses	A	A	
I.3.5.2.1.3.2	MAC-Layer Multicast		A	
I.3.5.2.1.4	fcs Field	A	A	
I.3.5.2.1.5	Port Configuration		A	
I.3.5.2.1.6.A	Ethernet Cable Characteristics			A
I.3.5.2.1.6.B	Twisted Pair Count			A
I.3.5.2.1.7	Link Transmission Parameters			A
I.3.5.2.1.8	Isolation and Grounding			A
I.3.5.2.1.9.1	IEEE 10BASE-T, 100BASE-TX, and 1000Base-T 8-Pin Modular Connector (RJ-45)		A	A
I.3.5.2.1.9.3.B	Rack UIP and UOP Connector/Pin Assignments		A	
I.3.5.2.1.9.3.D	Rack UIP and UOP Connector/Pin Assignments		A	
I.3.5.2.1.9.3.F	Rack UIP and UOP Connector/Pin Assignments		A	
I.3.5.2.2.1	Ethernet Wireless Standards	A		
I.3.5.2.2.2.1	2.4 GHz Spectrum	A		
I.3.5.2.2.2.2	Internal 5 GHz Spectrum	A		
I.3.5.2.2.2.3	External 5 GHz Spectrum	A		
I.3.5.2.2.2.4	Wireless Security	A		
I.3.5.2.2.2.5	Wireless Profiles	A		
I.3.5.2.2.2.6	SSIDS	A		
I.3.5.2.2.2.7	Manual Wireless Connection	A		
I.3.5.2.2.2.8	Dynamic Wireless Connection	A		

TABLE I.3.5.2-1 PAYLOAD REQUIREMENT AND GUIDELINES (2 PAGES)

Paragraph Number	Paragraph Title	User Devices		Cabling
		Wireless	Wired	
I.3.5.2.3.1	IPv4	A	A	
I.3.5.2.3.1.1	IPv4 Addressing	A	A	
I.3.5.2.3.1.2	Default Gateway/Gateway of Last Resort	A	A	
I.3.5.2.3.2	ICMP	A	A	
I.3.5.2.3.3	ARP	A	A	
I.3.5.2.3.4	Static Routing	A	A	
I.3.5.2.3.5	Licklider Transmission Protocol	A	A	
I.3.5.2.4.1	Transmission Control Protocol	A	A	
I.3.5.2.4.2.A	User Datagram Protocol	A	A	
I.3.5.2.4.2.B	User Datagram Protocol	A	A	
I.3.5.2.4.3	Bundle Protocol	A	A	
I.3.5.2.5.1.2	NTP	A	A	
I.3.5.2.5.1.3	RTP	A	A	
I.3.5.2.5.1.4	SNMP Version 3	A	A	
I.3.5.2.5.1.5	Secure File Transfer	A	A	
I.3.5.2.5.1.6	CCSDS File Delivery Protocol (CFDP)	A	A	
I.3.5.2.6	KuIP Communication	A	A	
I.3.5.2.7.A	PEHG HRDL Gateway Downlink Protocols	A	A	
I.3.5.2.7.B	PEHG HRDL Gateway Downlink Protocols	A	A	
I.3.5.2.8.A	Integrated Rack Ethernet Connectivity		A	
I.3.5.2.8.B	Integrated Rack Ethernet Connectivity		A	
I.3.5.2.8.C	Integrated Rack Ethernet Connectivity		A	
I.3.5.2.8.D	Integrated Rack Ethernet Connectivity		A	

I.3.5.2.1 IEEE 802.3 REQUIREMENTS

I.3.5.2.1.1 IEEE 802.3 10/100 BASETX INTERFACE

Payloads with a wired Ethernet interface **shall** conform with IEEE 802.3 (equivalent to the ISO/IEC/IEEE 8802-3), Information technology – Telecommunications and information exchange between systems – Local and metropolitan area networks – Specific requirements – Part 3: Carrier sense multiple access with collision detection (CSMA/CD) access method and physical layer specifications, in accordance with SSP 52050, paragraph 3.3, Medium Rate Data Link.

I.3.5.2.1.2 ETHERNET SIGNAL CHARACTERISTICS

Payloads which require connectivity to the Ethernet **shall** meet the electrical characteristics of Ethernet in accordance with IEEE 802.3 with the following exceptions:

IEC 60060-3 High-Voltage test techniques – Part 3: Definitions and requirements for on-site testing

IEC 60950-1 Information technology equipment -Safety – Part 1: General requirements

I.3.5.2.1.3 MAC ADDRESSES

I.3.5.2.1.3.1 PAYLOAD MAC ADDRESSES

A. Payloads implementing Ethernet **shall** have a (unique) Ethernet Media Access Control (MAC) physical address (MAC Address) either issued by the IEEE Registration Authority or provide the capability to configure a unique MAC address for Ethernet Interfaces per IEEE 802.3 (ISO/IEC/IEEE 8802-3). Modification of a universally unique MAC address will be coordinated with ISS Payload Software Engineering and Integration (PSE&I), for each Ethernet interface.

B. The payload's MAC address *should* be set prior to the Ethernet terminal going active. The integrated rack, subrack, or non-rack payload will indicate the MAC address in the payload unique software ICD.

Note: Recommendation to the integrated rack developer is to hard code the MAC address.

I.3.5.2.1.3.2 MAC-LAYER MULTICAST

Payloads using MAC-Layer multicast *should* implement MAC-Layer multicast in accordance with IEEE 802.3

I.3.5.2.1.4 FRAME CHECK SEQUENCE FIELD

A packet generated by a payload *should* include the Cyclic Redundancy Check (CRC), which is used by the transmit and receive algorithms to generate a CRC value for the Frame Check Sequence (FCS) field. The FCS field contains a 4−octet (32−bit) CRC value. This value is computed as a function of the contents of the source address, destination address, length, user data and Pad (that is, all fields except the preamble, Start Frame Delimiter (SFD), and FCS). It is typically appended by hardware and is used to detect errors in transmission.

I.3.5.2.1.5 PORT CONFIGURATION

Integrated racks and non-rack payloads (including U.S. payloads on the COL EPF or the JEM EF) that communicate via Ethernet *should* use one or both of the options below for port configuration.

(1) Provide the capability to configure the port speed and duplex setting for each of its Ethernet interfaces for either 10 or 100 Mbps and Half- or full-duplex.

(2) Provide the capability to auto negotiate Ethernet interface speed and duplex in accordance with IEEE 802.3 (ISO/IEC/IEEE 8802-3). 10/100BaseTX protocols for each of its Ethernet interfaces.

Notes:

1) Payloads that are installed in the USL or COL or U.S. payloads on the COL EPF transmit data through the PEHG. Payloads that are installed in the JEM or U.S. payloads on the JEM EF transmit data through the LEHX or PEHG. Payloads that

are installed in any other USOS module transmit data through the Edge Router or equivalent infrastructure device.

2) LEHX does not accept 10/100 Base-TX fixed full-duplex operation from the user.

I.3.5.2.1.6 ETHERNET CABLE CHARACTERISTICS

A. Payloads using 100 Base-TX and 1000 Base-T *should* use network segments that consist of Category 5e shielded twisted pair cables in accordance with EIA/TIA 568-B.2, Commercial Building Telecommunications Cabling Standard Part 2: Balanced Twisted-Pair Cabling Components, Annex N, or 22AWG Twisted Shielded Pair SSQ 21655 cabling.

B. All payload cable segments *should* be constructed using at least 2-pairs of shielded twisted pair Category 5e cabling for IEEE 802.3 10/100 Base-TX.

Table I.3.5.2.1.6-1 shows data rates and pair count for each standard.

TABLE I.3.5.2.1.6-1 DATA RATES AND ASSOCIATED PAIR COUNT

DATA RATE	PAIR COUNT
10 Mbps	2 pair
100 Mbps	2 pair
1000 Mbps *	4 pair

*Currently, only 10/100 Mbps capability exists on ISS. 1000 Mbps is planned for a future expansion to certain locations on the Ethernet architecture.

I.3.5.2.1.7 LINK TRANSMISSION PARAMETERS

Payloads using network end-to-end cables *should* use cables meet the transmission parameters specified in Section 25.4.9.2 of IEEE 802.3 (ISO/IEC/IEEE 8802-3) for:

- Insertion Loss
- Differential Characteristic Impedance, with a ± 20 percent tolerance for connecting hardware
- Return Loss
- Differential Near-End Crosstalk (NEXT)

I.3.5.2.1.8 ISOLATION AND GROUNDING

Payloads using wired Ethernet **shall** isolate and ground any Ethernet equipment and cables per IEEE 802.3 (ISO/IEC/IEEE 8802-3), Telecommunications and information exchange between Systems-Local and Metropolitan Area Networks-Specific Requirements-Part 3: Carrier Sense Multiple Access with Collision Detection (CSMA/CD) Access Method and Physical Layer Specifications Corrigendum 1.

I.3.5.2.1.9 CONNECTORS

I.3.5.2.1.9.1 IEEE 10 BASE-T, 100 BASE-TX, AND 1000 BASE-T 8-PIN MODULAR CONNECTOR (RJ-45)

Payloads using IEEE 10 Base-T, 100 Base-TX, and 1000 Base-T 8-pin modular connectors (RJ-45) *should* use connectors that meet or exceed EIA/TIA 568-B.2 Appendix K, Commercial Building Telecommunications Cabling Standard Part 2: Balanced Twisted-Pair Cabling Components.

I.3.5.2.1.9.2 MIL-STD CIRCULAR CONNECTORS

It is recommended that payloads use Ethernet connectors that adhere to the Category 5e electrical characteristics of ANSI/EIA/TIA 568-B.2, Commercial Building Telecommunications Cabling Standard Part 2: Balanced Twisted-Pair Cabling Components Standard. However, many cabled segments use MIL-STD connectors in accordance with SSQ 21635 due to the existing ISS infrastructure.

I.3.5.2.1.9.3 RACK UIP AND UOP CONNECTOR/PIN ASSIGNMENTS

A. Integrated rack and non-rack payload connectors P46 and P47 mating requirements to the UIP connectors J46 and J47 are shown in paragraphs N.3.1.1.7.A and N.3.1.1.7.B.

B. Integrated rack and non-rack payload connectors P46 and P47 **shall** meet the pin out interfaces of the UIP J46 and J47 connectors as shown respectively in Figure N.3.1.1.8-4 and Figure N.3.1.1.8-5.

C. Non-rack payload connector P4 mating requirements to the UOP connectors J4 are shown in paragraphs G.3.1.1.A and G.3.1.1.B.

D. Non-rack payload connector P4 **shall** meet the pin out interfaces of the UOP connectors J4 as shown in Figure G.3.1.1.1-2.

E. Non-rack payload connector P3 mating requirements to the SUP connector J3 are specified in paragraphs G.3.1.1.A and G.3.1.1.B.

F. Non-rack payload connector P3 **shall** meet the pin out interfaces of the SUP connector J03 as shown in Figure G.3.1.1.2-7.

I.3.5.2.2 WIRELESS (RADIO) PHYSICAL LAYER

The wireless Ethernet architecture is based on the IEEE 802.11, Part 11. This wireless infrastructure is capable of using the following protocols:

- 802.11b
- 802.11g
- 802.11n

Wireless end user devices consist of network devices that connect wirelessly to the WAPs. Examples of wireless user devices include laptops, printers, and PDAs.

I.3.5.2.2.1 ETHERNET WIRELESS STANDARDS

Payloads using wireless Ethernet *should* meet the protocol and standards per Table I.3.5.2.2.1-1.

TABLE I.3.5.2.2.1-1 WIRELESS ETHERNET PROTOCOLS AND STANDARDS

Protocol	Standard
IEEE 802.11b/g	IEEE 802.11 Part 11: Wireless LAN Medium Access Control (MAC) and Physical Layer (PHY) Specifications
IEEE 802.11n	IEEE 802.11 Part 11: Wireless LAN Medium Access Control (MAC) and Physical Layer (PHY) Specifications

I.3.5.2.2.2 WIRELESS LOCAL AREA NETWORK

I.3.5.2.2.2.1 2.4 GHZ SPECTRUM

Payloads using wireless Ethernet 2.4 GHz communication *should* utilize the 2.401 - 2.473 GHz band.

I.3.5.2.2.2.2 INTERNAL 5 GHZ SPECTRUM

Payloads using internal wireless Ethernet 5 GHz communication *should* utilize the 5.150 – 5.825 GHz band.

I.3.5.2.2.2.3 EXTERNAL 5 GHZ SPECTRUM

Payloads using external wireless Ethernet 5 GHz communication *should* utilize the 5.25 – 5.35 GHz band.

I.3.5.2.2.2.4 WIRELESS SECURITY

Payloads using wireless Ethernet **shall** be capable of configuring security access using WPA2 – PSK [AES] per IEEE 802.11 Part 11: Wireless LAN Medium Access Control (MAC) and Physical Layer (PHY) Specifications.

I.3.5.2.2.2.5 WIRELESS PROFILES

Payloads using wireless Ethernet *should* provide the capability to be configured with multiple profiles.

I.3.5.2.2.2.6 SSIDS

Payloads using wireless Ethernet that support network roaming functionality between WAPs *should* provide the capability to be configured for multiple SSIDs.

I.3.5.2.2.2.7 MANUAL WIRELESS CONNECTION

Payloads using wireless Ethernet *should* provide the capability to be manually configured to connect to a specified WAP.

I.3.5.2.2.2.8 DYNAMIC WIRELESS CONNECTIONS

Payloads using wireless Ethernet that support network roaming functionality between WAPs *should* provide the capability to dynamically detect and connect to the strongest WAP signal from the device's list of pre-configured profiles.

I.3.5.2.3 NETWORK/INTERNET LAYER REQUIREMENTS

I.3.5.2.3.1 IPV4

Payloads using IPv4 **shall** implement IPv4 in accordance with the following IETF RFCs:

IETF RFC 791, Internet Protocol

IETF RFC 6864, Updated Specification of the IPv4 ID Field.

I.3.5.2.3.1.1 IPV4 ADDRESSING

A. Payloads using IPv4 *should* provide the capability to assign IPv4 addresses, for each Ethernet Interface, in accordance with IETF RFC 950, Internet Standard Subnetting Procedure.

B. Payloads using IPv4 addresses *should* provide the capability to change the device IPv4 address.

I.3.5.2.3.1.2 DEFAULT GATEWAY/GATEWAY OF LAST RESORT

Payloads using IPv4 **shall** implement a default gateway/gateway of last resort in accordance with the following IETF RFCs:

IETF RFC 1122, Requirements for Internet Hosts—Communication Layers
IETF RFC 6298, Computing TCP's Retransmission Timer
IETF RFC 6633, Deprecation of ICMP Source Quench Messages
IETF RFC 6864, Updated Specification of the IPv4 ID Field

I.3.5.2.3.2 ICMP

Payloads using ICMP *should* implement ICMP in accordance with the following IETF RFCs:

IETF RFC 792, Internet Control Message Protocol

IETF RFC 6633, Deprecation of ICMP Source Quench Messages.

I.3.5.2.3.3 ARP

Payloads using ARP *should* implement ARP in accordance with the following IETF RFCs:

IETF RFC 826, An Ethernet Address Resolution Protocol

IETF RFC 5227, IPv4 Address Conflict Detection.

I.3.5.2.3.4 STATIC ROUTING

Payloads using static routing *should* implement static routing in accordance with the following IETF RFCs:

IETF RFC 1812, Requirements for IP Version 4 Routers, Section 7.4

IETF RFC 2644, Changing the Default for Directed Broadcasts in Routers

IETF RFC 6633, Deprecation of ICMP Source Quench Messages

I.3.5.2.3.5 LICKLIDER TRANSMISSION PROTOCOL

Payloads using Licklider Transmission Protocol *should* implement Licklider Transmission Protocol in accordance with CCSDS 734.1-R-2, Licklider Transmission Protocol (LTP) for CCSDS.

I.3.5.2.4 TRANSPORT LAYER REQUIREMENTS

I.3.5.2.4.1 TRANSMISSION CONTROL PROTOCOL

Payloads using TCP *should* implement TCP in accordance with IETF RFC 793, Transmission Control Protocol.

I.3.5.2.4.2 USER DATAGRAM PROTOCOL

A. Payloads using UDP *should* implement UDP in accordance with IETF RFC 768, User Datagram Protocol.

B. Payloads using UDP-Multicast *should* implement UDP-Multicast in accordance with IETF RFC 5771, IANA Guidelines for IPv4 Multicast Address Assignments.

I.3.5.2.4.3 BUNDLE PROTOCOL

Payloads using Bundle Protocol *should* implement Bundle Protocol in accordance with CCSDS 734.2-B-1, CCSDS Bundle Protocol Specification.

I.3.5.2.5 APPLICATION, PRESENTATION, AND SESSION LAYERS REQUIREMENTS

This sections details the requirements necessary for payload devices to access the Ethernet services provided at the Application, Presentation and Session Layers of the OSI Reference Models. Requirements in this section are designed to provide a guideline for user devices that require access to one or more of the following services:

- Application Protocols
  - Secure FTP
  - HTTP/HTTPS
  - NTP
  - RTP

- SSH
- SNMP V3
- TFTP
- CFDP

I.3.5.2.5.1 APPLICATION PROTOCOLS

I.3.5.2.5.1.1 FTP

FTP is a legacy protocol and is replaced by more secure Protocol SSH and Secure FTP.

Note: FTP Servers are available on infrastructure devices, including the SSC File Server. FTP is used to upload Firmware upgrades and configuration files.

I.3.5.2.5.1.2 NTP

Payloads requiring an Ethernet time source *should* implement Network Time Protocol (NTP) in accordance with IETF RFC 5905, Network Time Protocol Version 4: Protocol and Algorithms Specification.

I.3.5.2.5.1.3 RTP

Payloads using Real-Time Transport Protocol (RTP) *should* implement RTP in accordance with the following IETF RFCs:

IETF RFC 3550, RTP: A Transport Protocol for Real-Time Applications

IETF RFC 5506, Support for Reduced-Size Real-Time Transport Control Protocol (RTCP): Opportunities and Consequences

IETF RFC 5761, Multiplexing RTP Data and Control Packets on a Single Port

IETF RFC 6051, Rapid Synchronization of RTP Flows

I.3.5.2.5.1.4 SNMP VERSION 3

Payloads using SNMP Version 3 Protocol **shall** implement SNMP Version 3 Protocol in accordance with the following IETF RFCs:

IETF RFC 3411, An Architecture for Describing Simple Network Management Protocol (SNMP) Management Frameworks

IETF RFC 3412, Message Processing and Dispatching for the Simple Network Management Protocol (SNMP)

IETF RFC 3413, Simple Network Management Protocol (SNMP) Applications

IETF RFC 3414, User-based Security Model (USM) for Version 3 of the Simple Network Management Protocol (SNMPv3)

IETF RFC 3415, View-Based Access Control Model (VACM) for the Simple Network Management Protocol (SNMP)

IETF RFC 3416, Version 2 of the Protocol Operations for the Simple Network Management Protocol (SNMP)

IETF RFC 3417, Transport Mappings for the Simple Network Management Protocol (SNMP)

IETF RFC 3418, Management Information Base (MIB) for the Simple Network Management Protocol (SNMP).

IETF RFC 4789, Simple Network Management Protocol (SNMP) over IEEE 802 Networks

IETF RFC 5343, Simple Network Management Protocol (SNMP) Context EngineID Discovery

IETF RFC 5590, Transport Subsystem for the Simple Network Management Protocol (SNMP)

I.3.5.2.5.1.5 SECURE FILE TRANSFER

Payloads performing software loading or file transfers across Ethernet **shall** be secured by one or more of the following methods:

- Secure FTP with TLS: This is implemented in accordance with IETF RFC 4217, Securing FTP with TLS; legacy devices are grandfathered and may use FTP.
- FTP Usernames and Passwords: This is implemented to protect the FTP services.
- HTTP/HTTPS: This is implemented in accordance with IETF RFC 2817, Upgrading to TLS within HTTP/1.1.
- SSH: This is implemented in accordance with IETF RFC 4251, The Secure Shell (SSH) Protocol Architecture.
- Secure Copy (SCP): This is implemented based on the remote procedure call program in the Berkeley Software Distribution (BDS) source code (sometimes called Berkeley Unix).
- TFTP: TFTP is used to upgrade firmware on infrastructure devices such as the BRI (Smart Switch Router). TFTP Servers and Clients are implemented in accordance with IETF RFC 1350, The TFTP Protocol (Revision 2).
- Transport Layer Security (TLS): This protocol is implemented in accordance with the following IETF RFCs:
  - IETF RFC 5246, The Transport Layer Security (TLS) Protocol Version 1.2
  - IETF RFC 5746, Transport Layer Security (TLS) Renegotiation Indication Extension
  - IETF RFC 5878, Transport Layer Security (TLS) Authorization Extensions
  - IETF RFC 6176, Prohibiting Secure Sockets Layer (SSL) Version 2.0

These methods include file transfer, configuration, and software loading.

I.3.5.2.5.1.6 CCSDS FILE DELIVERY PROTOCOL (CFDP)

Payloads using CFDP for file transfers *should* implement CFDP in accordance with CCSDS 727.0-B-4.

I.3.5.2.6 KUIP COMMUNICATION

Payloads utilizing KuIP via space-to-ground and ground-to-space communication links over Ethernet *should* adhere to the protocols specified in SSP 52050, paragraph 3.3.7 and Table 3.3.7-1 KuIP Protocol Assignments.

Note: Payloads cannot use KuIP as a hazard control.

I.3.5.2.7 PEHG HRDL GATEWAY DOWNLINK PROTOCOLS

A. Integrated racks and non-rack payloads in the USL or COL or U.S. payloads on the COL EPF sending data to the ground through the USOS Space to Ground Link using Space Packets *should* use the protocols defined in SSP 52050, paragraphs 3.3.4.6, Length/Type Field, and 3.3.5.1, PEHG HRDL Gateway Protocol.

Note: User devices in the USL or COL or U.S. payloads on the COL EPF that satisfy these protocol requirements will be compatible with the PEHG gateway.

B. Integrated racks and non-rack payloads in the JEM or U.S. payloads on the JEM EF sending data to the ground through the USOS Space to Ground Link using Space Packets *should* use the protocols defined in SSP 52050, paragraphs 3.3.4.6, Length/Type Field, 3.3.5.1, PEHG HRDL Gateway Protocol, and 3.3.6, LEHX Gateway Protocol.

Note: User devices in the JEM or U.S. payloads on the JEM EF that satisfy these protocol requirements will be compatible with the LEHX gateway and the PEHG gateway.

I.3.5.2.8 INTEGRATED RACK ETHERNET CONNECTIVITY

Integrated Rack Ethernet connectivity information is found in section 3.3, Medium Rate Data Link, of SSP 52050.

A. An integrated rack with an Ethernet connection **shall** have no more than one physical connection per LAN. An integrated rack with an Ethernet connection may have one physical connection to LAN-1 and one physical connection to LAN-2. LAN-1 is located in J46 and LAN-2 is located in J47.

B. An integrated rack **shall** not route or transmit the same Ethernet frame or packet to the ISS LANs simultaneously.

C. An integrated rack with internal Ethernet LAN (s) **shall** provide isolation between the ISS Ethernet LANs and the internal LANs with either an Ethernet Bridge or an Internet Protocol router that connects the LAN-1 and LAN-2 to the internal rack LAN(s).

D. Wired Payloads in the USL and IP modules that use Ethernet for payload-to-payload communications are considered “user devices” and *should* be compatible with the appropriate infrastructure device (PEHG and/or LEHX and/or Edge Router and/or Hirschmann Switch).

I.3.6 HIGH RATE DATA LINK (HRDL)

I.3.6.1 PAYLOAD TO ICU PROTOCOLS

I.3.6.1.1 CCSDS PACKET PROTOCOL

CCSDS packet protocol is defined in SSP 50184, section 3.3.3.1, CCSDS Packet Protocol, Physical Media, Physical Signaling & Link Level Protocol Specifications for Ensuring Interoperability of High Rate Data Link Stations on the International Space Station.

I.3.6.1.1.1 PACKET DATA FRAMES

Integrated racks *should* implement data frames in accordance with SSP 50184 section 3.3.3.1.1, CCSDS Packet Data Frames and Figure 3.3.3-1, HRDL CCSDS Packet Format & Framing.

I.3.6.1.1.2 PACKET DATA RATES

Integrated racks *should* modulate the HRDL data rate by the insertion of Sync symbols in the data stream. The number and distribution of Sync symbols are defined in SSP 50184, section 3.3.3.1.2, Packet Data Rates.

I.3.6.1.1.3 PACKET FORMAT

Integrated racks *should* implement data packets in accordance with SSP 50184, section 3.3.3.1.3, CCSDS Packet Format and Figure 3.3.3-2 CCSDS Packet Format.

I.3.6.1.2 BITSTREAM PROTOCOL

Bitstream protocol is defined in SSP 50184, section 3.3.3.2, Bitstream Protocol.

I.3.6.1.2.1 DATA FRAMES

Integrated racks *should* transmit data on the HRDL network as bitstream data in accordance with SSP 50184, section 3.3.3.2.1, Bitstream Data Frames and Figure 3.3.3-3, HRDL Bitstream Format, sections 3.3.3.2.1.1, Bitstream Data Frame Sizes, and 3.3.3.2.1.2, Bitstream Inter-Frame Gaps.

I.3.6.1.2.2 DATA RATES

Integrated racks *should* modulate the HRDL data rate by the insertion of Sync symbols in the data stream. The number and distribution of Sync symbols are defined in SSP 50184, section 3.3.3.2.2, Bitstream Data Rates.

I.3.6.2 HRDL INTERFACE CHARACTERISTICS

I.3.6.2.1 PHYSICAL SIGNALING

Physical signaling of the HRDL *should* be in accordance with SSP 50184, section 3.1, Physical Signaling.

I.3.6.2.1.1 PHYSICAL SIGNALING DATA RATES

A. The integrated rack *should* assign its selectable data rate values between zero (0) and 95 Mbps. The data rate must be adjustable in steps that minimize bandwidth waste through the ICU.

Note: The ideal data rate step size is 0.432 Mbps.

B. Transmitted data *should* be designed to be in accordance with SSP 50184, section 3.3.1.2, General Data Rates.

Note: The integrated rack's maximum designed data rate is subject to planning.

I.3.6.2.2 ENCODING

Integrated racks using the HRDL *should* encode the data in accordance with SSP 50184, section 3.1.3, Encoding.

I.3.6.3 HRDL OPTICAL POWER

I.3.6.3.1 HRDL TRANSMITTED OPTICAL POWER

The integrated rack that transmits data on the HRDL, with or without an ARIS adapter, **shall** be designed to transmit a HRDL signal in accordance with SSP 50184, section 3.1.1, Transmitter Optical Characteristics at an average optical power greater than -16.75 dBm and less than -8.3 dBm. The integrated rack transmitted optical power will be measured at the integrated rack P7 connector to the UIP using the Halt symbol in accordance with SSP 50184, Table 3.1-3, 4B/5B NRZI Encoding.

I.3.6.3.2 HRDL RECEIVED OPTICAL POWER

The integrated rack that receives data on the HRDL, with or without an ARIS adapter, *should* be designed to receive a HRDL signal in accordance with SSP 50184, section 3.1.2, Receiver Optical Characteristics at an average optical power less than or equal to -30.45 dBm. The integrated rack received optical power will be measured at the integrated rack P7 connector to the UIP using the Halt symbol in accordance with SSP 50184, Table 3.1-3, 4B/5B NRZI Encoding.

I.3.6.4 HRDL FIBER OPTIC CABLE

The integrated rack *should* use fiber optic cable in accordance with SSQ 21654, Cable, Single Fiber, Multimode, Space Quality, General Specification for, or meet/exceed the performance of the SSQ cable.

I.3.6.5 HRDL FIBER OPTIC CABLE BEND RADIUS

The integrated rack *should* develop the routing, installation and handling procedures to assure the minimum bend radius of 2 inches or greater is maintained at all times for the Fiber Optic Cable, as derived from SSQ 21654, section 3.10.5, except where protected by a connector backshell, where a one half inch radius is permitted for bends of 90 degrees or less.

I.3.6.6 HRDL CONNECTORS

A. Integrated rack connector P7 mating requirement to the UIP connector J7 is specified in paragraphs N.3.1.1.7.A and N.3.1.1.7.B.

B. Integrated rack connector P7 *should* meet the pin out interfaces of the UIP J7 connector as specified in Figure N.3.1.1.8-6.

I.3.6.7 HRDL STATE

The HRDL state *should* be in accordance with SSP 50184, section 3.3.1.1, HRDL State Diagram.

I.3.7 LAPTOP COMPUTERS AND PORTABLE COMPUTING DEVICES

Beginning of Laptop Definition:

The Laptop Computer category is broadly defined herein to include any portable computing device that contains a processor, display, user interface, and communications functions that performs software-driven applications. This category includes both standard "laptop" computers with full-size keyboards and displays, as well as small computing devices, such as smartphones, tablet PCs, or other devices capable of running an operating system and interfacing with networks or other computers. In both cases, the devices must be approved by NASA OD at the Computer Resources Control Panel (CRCP), for use within the ISS pressurized volume.

The standard ISS personal computers are COTS laptops modified by the ISS Program and provided for use on-orbit. The current U.S. standard personal computer is the Lenovo T61p model number 6457-HU1 (part number SEG33120761-301) as defined in JSC 64267, T61p Laptop Interface Requirements Document (IRD).

JSC 64267 defines and controls the U.S. Laptop hardware, exclusive of any specific operational use. JSC 64267 also provides details of the laptops hardware, firmware Basic Input Output System (BIOS), and authorized connectivity.

For the T61p laptops, the official list of authorized equipment that can be connected to them is owned by NASA OD and managed by NASA NE. Additions to the Laptop Certification Matrix are made by providing certification paperwork to NASA NE via NASA OD, including hardware drawings, toxic test data (offgassing), and EMI test data. NASA OD Computer Resources team facilitates the review of the data and assuming there are no issues, NASA NE will add the item to the Laptop Certification Matrix. This Laptop Certification Matrix replaces the Appendix E list that was originally carried in the laptop GCAR and was replaced during the transition to the Cargo Mission Contract.

All U.S. laptops are considered Criticality 1R hardware and are controlled by NASA OD and the CRCP. A laptop is pulled from the ISS "computer pantry" and assigned to individual users, including payload facilities, by NASA OD. IP laptops are not controlled by NASA OD or the CRCP. The respective space agency owner is responsible for making sure they operate properly. IP laptop interfaces in the USL are still managed by NASA C&DH.

Software applications and operating systems to be used on the U.S. Laptop are controlled by the organization which develops them, and the Computer Software Configuration Items (CSCIs) are approved by their respective owning boards and panels. The U.S. Laptop can be configured to meet a variety of applications, including the following:

(1) Station Support Computer (SSC). The SSC is connected to the JSL via the Mission Support LAN, which is a Virtual LAN on the JSL. The primary purpose of the SSC is to provide crew support applications, (e.g., Manual Procedure & Onboard Short Term Plan viewers, the Inventory Management System Database, and Worldmap). Files and data can be transferred between ISS and MCC-H via the Orbital Communications Adaptor (OCA) function in the ICU. A few payloads are hosted on the SSC platform and SSC software load, including Synchronized Position Hold, Engage, Re-orient, Experimental Satellites (SPHERES), Journals, and Earth Knowledge Acquired by Middle School Students (EarthKAM).

Note: Payloads using facility and platform laptops, including SSCs, still must assess the laptop interface requirements in section I.3.7 and I.3.7.1.

(2) PCS. The PCS is specifically used to support core systems and is connected to the C&C MDM to command and monitor vehicle systems. However, the PCS can be connected via MIL-STD-1553B to the Payload MDM and support Payload and Payload related command and control functions. Payload displays can be developed to show any Health & Status data parameter or generate a command packet that is defined in the PDL. Payload Developer use of a new payload display on the PCS must be documented and agreed to in the Payload Developer’s Payload Integration Agreement.

Note: Payload PCS displays are not designed to be “always on”. They are typically used during contingency operations only, when the POIC/HOSC or Remote Site ground equipment is unavailable. *The Payloads Office has no plans to create any new payload PCS displays.*

(3) Rack Payload Laptop. The Rack Payload Laptop is a rack unique laptop which is provided by the ISS Program for the operation of the rack and payloads within or remote to the rack. An example is the EXPRESS Laptop Computer used with all EXPRESS racks. Payload Developer use of a Rack Payload Laptop must be documented and agreed to in the Payload Developer’s PIA.

(4) Non-Rack Payload Laptop. Non-rack payloads are non-permanent science payloads that require temporary use of a laptop onboard. When one of these non-rack payloads is deployed, a laptop is assigned from the ISS computer pantry, is used for the payload during science activities, and is returned to the ISS computer pantry when the activity is complete. Prior to using a laptop in this manner, a request must be submitted to the CRCP via a Workflow Change Request (CR) to request the use of a laptop onboard to allow for sparing and manifesting planning. As with other payload laptop use, all hardware that connects to the T61p must be flight certified and added to the T61p authorized equipment list prior to use onboard. Since laptops provided from the ISS computer pantry are generally provided with an erased hard drive, all software for these applications except specific BIOS version (controlled by NASA OD) is developed and provided by the PD, including providing the operating system and any settings (Complementary Metal Oxide Semiconductor (CMOS), etc.) that are required for the payload.

Note: International partners may continue to use A31p laptops for payloads verified to the original A31p laptop requirements in SSP 57000 Revision H.

End of Laptop Definition.

A. All payloads operating in the USOS and all NASA-sponsored payloads operating in the ISS that require a laptop **shall** use a U.S. ISS Program Laptop which is a T61p laptop, part number SEG33120761 with firmware load SKG33120762.

B. Payload software loads, that are to be used on a U.S. T61p laptop, *should* be compatible with the T61p part number / firmware load configuration shown in I.3.7.A prior to first use on-orbit. A payload's software load includes operating system, application software, and any other files they need for their configuration.

C. Laptop computers and other portable computing devices capable of running software applications and interfacing with networks, other computers, or portable data storage devices, **shall** actively run virus scanning software.

Note: The virus scanning requirement in this paragraph is applicable only to U.S. payloads and any payloads being operated in the USOS. IP laptops and portable computing devices are bound by the agreements in SSP 50482, ISS Program Software Management Plan, and other agreements with NASA OD and OX.

D. The laptop computer and other portable computing device virus-scanning software **shall** update the virus definition files at least once per calendar quarter while in operation. It is recommended that the latest version of Symantec, Norton, McAfee, or ClamAV anti-virus scanning software and the latest virus definition files, or equivalent, be used. The current scanner for NASA is Symantec Endpoint Protection.

Notes:

1) This requirement does not apply to devices that are embedded or enclosed within a payload volume and do not connect via wired or wireless interface to ISS data systems.

2) The virus scanning definition files requirement in this paragraph is applicable only to U.S. payloads and any payloads being operated in the USOS. IP laptops and portable computing devices are bound by the agreements in SSP 50482 and other agreements with NASA OD and OX.

E. Wireless communication functions within the portable computing device, such as IEEE 802.11 Wi-Fi, Bluetooth, or Cellular mobile applications, **shall** be disabled unless required for a specific payload application that has been approved by the CRCP and is documented in their meeting minutes.

Note: The wireless communication requirement in this paragraph is applicable only to U.S. payloads and any payloads being operated in the USOS. IP laptops and portable computing devices are bound by the agreements in SSP 50482 and other agreements with NASA OD and OX.

I.3.7.1 U.S. LAPTOP HARDWARE

Payload use of U.S. laptop hardware is requested through NASA OD and the CRCP. IP laptops are transferred from the ISS pantry via barter from NASA OD and are spared per current agreements, wherein “spares” means that OD provides the additional laptops to various users from a reserve quantity in storage. Per agreements at the May 2011 MASCB in Montreal, IP peripheral hardware that interfaces with the onboard laptops will be added to the authorized equipment list, similar to payload equipment and will be worked via the IP systems groups directly with NASA OD. IP payload organizations requiring such equipment documentation must coordinate with their IP systems representatives, who will coordinate same with NASA OD.

A. The Integrated Rack, including all subrack payloads or deployed instruments which interface with the rack, *should* require no more than one U.S. Laptop computer per payload rack.

B. Payload items interfacing with the T61p laptop **shall** be listed in the NASA-managed Laptop Certification Matrix.

Note 1: In order to be listed in the Laptop Certification Matrix, payloads must provide specific test data and documentation to NASA OD/NASA NE who, assuming they approve, adds the interfacing items to the Laptop Certification Matrix.

Note 2: Items certified by IPs for use with IP laptops are not automatically included in the Laptop Certification Matrix. If an IP item must be used with a NASA laptop, the item must be added to the Laptop Certification Matrix.

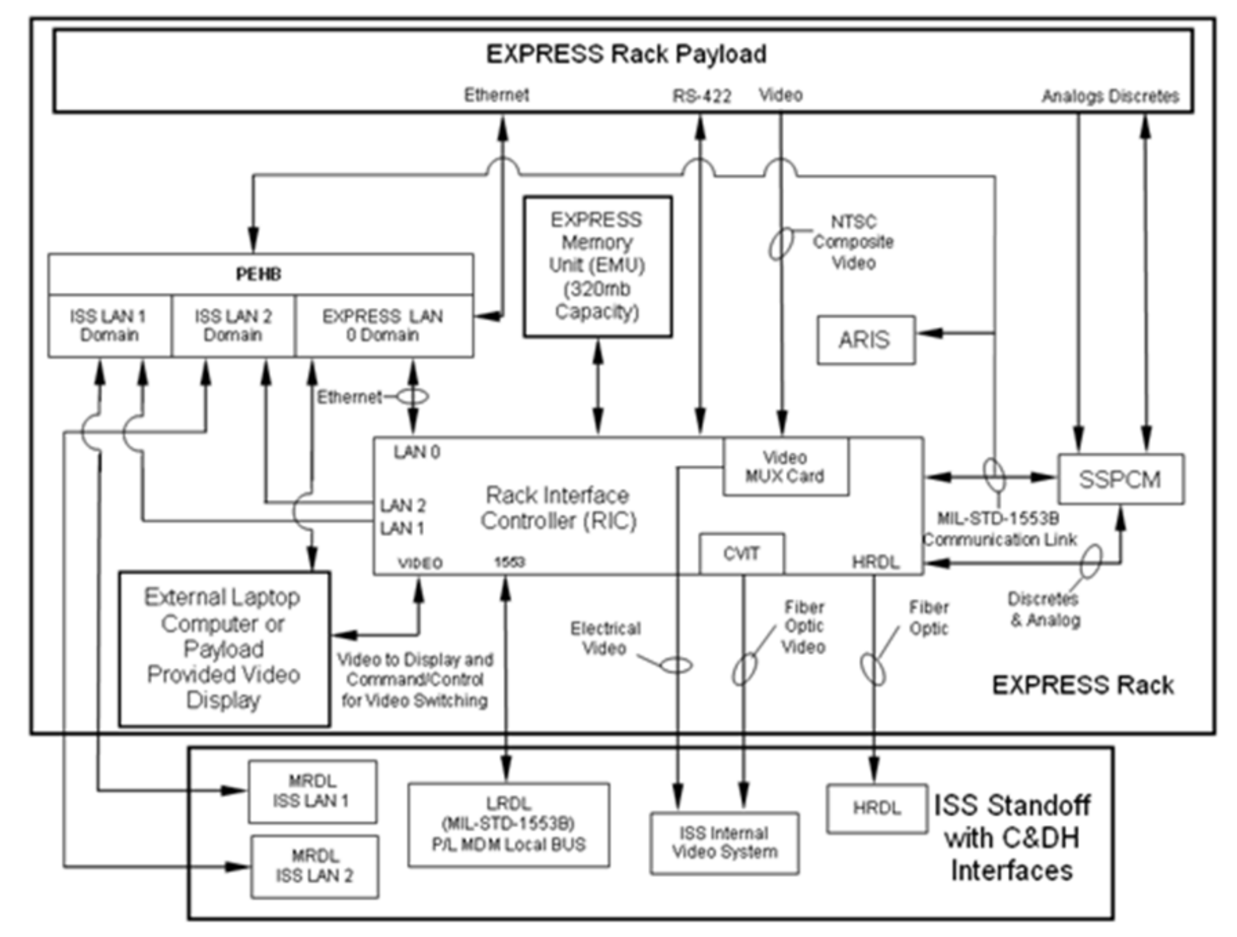
C. Nonvolatile memory (see Note 1) **shall** be free of virus or other forms of malicious software (e.g. worm, Trojan, spyware, etc.). This requirement is not applicable to nonvolatile memory that cannot be analyzed for viruses and other malicious software (see Note 2).

Note 1: Nonvolatile memory includes optical media (CDs, DVDs, etc.), flash storage media (USB drives, Smart Media, Secure Digital, etc.), and magnetic media (hard disk, tape, etc.).

Note 2: It may not be technically possible to scan if there is a lack of functional capability in common industry analyzing tools to access particular nonvolatile memory. It also may not be possible to scan if there is a configuration of the system hardware and software that prevents analysis (e.g. embedded nonvolatile memory that is inaccessible to external analyzing tools).

I.3.8 EXPRESS SUBRACK C&DH INTERFACES

There are various Command and Data Handling (C&DH) interfaces available for the EXPRESS Rack payload which utilizes a MLE locker, MLE replacement locker, or ISIS drawers. Figure I.3.8-1 illustrates the payload-to-EXPRESS Rack C&DH interfaces. Each of these interfaces is defined in the following paragraphs. There are NO audio interfaces available in the EXPRESS Rack. The EXPRESS Rack can display one PL analog video on the Laptop, and downlink one PL analog video at the same time, and those videos can be from the same PL or a different PL. The EXPRESS laptop and software are defined in I.3.8.6.



Note: The PEHB will be replaced with the PEHG in the future as shown in Figure I.3.8-1 (Page 2 of 2).

FIGURE I.3.8-1 EXPRESS PAYLOAD C&DH INTERFACES (PAGE 1 OF 2)

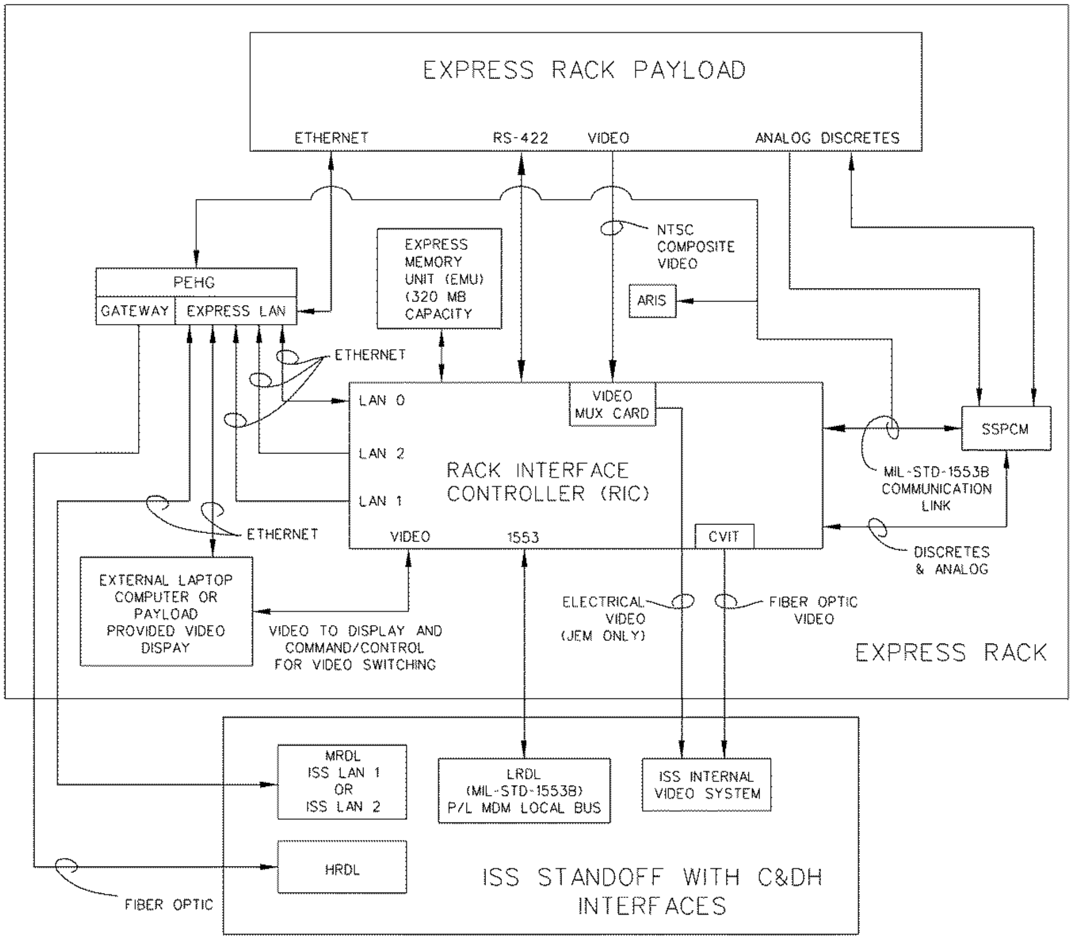


FIGURE I.3.8-1 EXPRESS PAYLOAD C&DH INTERFACES (PAGE 2 OF 2)

Data Deliverable: Provide EXPRESS subrack Payload C&DH interface definition to complete Table I.3.8-1.

TABLE I.3.8-1 EXPRESS SUBRACK PAYLOAD C&DH INTERFACES

Data Interface	Quantity of Interfaces	Data Downlink	Downlink Rate (Mb/Sec)	Remarks
RS-422				
Ethernet (See Note)				
Analog/Discrete				

Note: Include Identification and Duration of each major operational mode in Remarks.

I.3.8.1 EXPRESS SUBRACK CONNECTOR/PIN INTERFACE

I.3.8.1.1 MLE/MLE REPLACEMENT PAYLOAD

Connector part numbers and pin functions for the MLE or MLE replacement payload **shall** be as defined in Table I.3.8.1.1-1.

TABLE I.3.8.1.1-1 COMMAND/TELEMETRY CONNECTOR PIN ASSIGNMENTS FOR THE MLE/MLE REPLACEMENT PAYLOAD

Connector P/N: MS27467T15F35S Rack Cable-End Connector		Data Direction	Connector P/N: MS27468T15F35P Payload Connector	
Function	**Pin**		**Pin**	**Function**
RS170 (+)	1	←	1	RS170 (+)
RS170 (-)	2	←	2	RS170 (-)
Spare	3		3	Spare
Analog 1 (+)	4	←	4	Analog 1 (+)
Analog 1 (-)	5	←	5	Analog 1 (-)
Analog 2 (+)	6	←	6	Analog 2 (+)
Analog 2 (-)	7	←	7	Analog 2 (-)
Discrete #1 (+)	8	← or →	8	Discrete #1 (+)
Discrete #1 (-)	9	← or →	9	Discrete #1 (-)
Discrete #2 (+)	10	← or →	10	Discrete #2 (+)
Discrete #2 (-)	11	← or →	11	Discrete #2 (-)
Discrete #3 (+)	12	← or →	12	Discrete #3 (+)
Discrete #3 (-)	13	← or →	13	Discrete #3 (-)
Ethernet RX (+) IN	14	←	14	Ethernet TX (+) OUT
Ethernet RX (-) IN	15	←	15	Ethernet TX (-) OUT
Ethernet TX (+) OUT	16	→	16	Ethernet RX (+) IN
Ethernet TX (-) OUT	17	→	17	Ethernet RX (-) IN
Spare	18		18	Spare
Spare	19		19	Spare
Spare	20		20	Spare
Spare	21		21	Spare
Spare	22		22	Spare
Spare	23		23	Spare
PPCB 01 (+)	24	↔	24	PPCB 01 (+)
PPCB 01 (-)	25	↔	25	PPCB 01 (-)
PPCB 02 (+)	26	↔	26	PPCB 02 (+)
PPCB 02 (-)	27	↔	27	PPCB 02 (-)
Spare	28		28	Spare
PPCB 03 (+)	29	↔	29	PPCB 03 (+)
PPCB 03 (-)	30	↔	30	PPCB 03 (-)
PPCB 04 (+)	31	↔	31	PPCB 04 (+)
PPCB 04 (-)	32	↔	32	PPCB 04 (-)
Spare	33		33	Spare
RS422 RX (+)	34	←	34	RS422 TX (+)
RS422 RX (-)	35	←	35	RS422 TX (-)
RS422 TX (+)	36	→	36	RS422 RX (+)
RS422 TX (-)	37	→	37	RS422 RX (-)

I.3.8.1.2 ISIS DRAWERS

A. Connector part numbers and pin functions for the ISIS drawer payload **shall** be as defined in Table I.3.8.1.2-1.

TABLE I.3.8.1.2-1 COMMAND/TELEMETRY CONNECTOR PIN ASSIGNMENTS FOR THE ISIS DRAWER PAYLOAD (3 PAGES)

CONNECTOR P/N: M83733/2RA131 RACK CONNECTOR		DATA DIRECTION	CONNECTOR P/N: M83733/3RA131 PAYLOAD CONNECTOR	
FUNCTION	PIN		PIN	FUNCTION
Reserved	1		1	Reserved
Reserved	2		2	Reserved
Spare	3		3	Spare
Discrete #1 (+)	4	← or →	4	Discrete #1 (+)
Discrete #2 (+)	5	← or →	5	Discrete #2 (+)
Reserved	6		6	Reserved
Reserved	7		7	Reserved
Reserved	8		8	Reserved
Continuity Discrete (+)	9	←→	9	Continuity Discrete (+)
Reserved	10		10	Reserved
Spare	11		11	Spare
Spare	12		12	Spare
Discrete #1 (-)	13	← or →	13	Discrete #1 (-)
Discrete #2 (-)	14	← or →	14	Discrete #2 (-)
Reserved	15		15	Reserved
Reserved	16		16	Reserved
Reserved	17		17	Reserved
Reserved	18		18	Reserved
Reserved	19		19	Reserved
Reserved	20		20	Reserved
Spare	21		21	Spare
Spare	22		22	Spare
Spare	23		23	Spare
Analog #1 (+)	24	←	24	Analog #1 (+)
Reserved	25		25	Reserved
Reserved	26		26	Reserved
Reserved	27		27	Reserved
Reserved	28		28	Reserved
Reserved	29		29	Reserved
Reserved	30		30	Reserved
Reserved	31		31	Reserved
Spare	32		32	Spare
Spare	33		33	Spare
Reserved	34		34	Reserved
Reserved	35		35	Reserved
Reserved	36		36	Reserved
Reserved	37		37	Reserved
Reserved	38		38	Reserved
Reserved	39		39	Reserved
Reserved	40		40	Reserved
Reserved	41		41	Reserved
Spare	42		42	Spare
Spare	43		43	Spare

TABLE I.3.8.1.2-1 COMMAND/TELEMETRY CONNECTOR PIN ASSIGNMENTS FOR THE ISIS DRAWER PAYLOAD (3 PAGES)

CONNECTOR P/N: M83733/2RA131 RACK CONNECTOR		DATA DIRECTION	CONNECTOR P/N: M83733/3RA131 PAYLOAD CONNECTOR	
FUNCTION	PIN		PIN	FUNCTION
Analog #1 (-)	44	←	44	Analog #1 (-)
Reserved	45		45	Reserved
Reserved	46		46	Reserved
RS170 (+)	47	←	47	RS170 (+)
Reserved	48		48	Reserved
Reserved	49		49	Reserved
Reserved	50		50	Reserved
PPCB 01 (+)	51	↔	51	PPCB 01 (+)
Reserved	52		52	Reserved
Spare	53		53	Spare
Spare	54		54	Spare
Not used	55	deleted	55	Not used
Reserved	56		56	Reserved
Spare	57		57	Spare
Reserved	58		58	Reserved
Reserved	59		59	Reserved
Reserved	60		60	Reserved
PPCB 01 (-)	61	↔	61	PPCB 01 (-)
PPCB 02 (-)	62	↔	62	PPCB 02 (-)
Spare	63		63	Spare
Spare	64		64	Spare
Spare	65	deleted	65	Spare
Reserved	66		66	Reserved
RS 422 TX (+)	67	→	67	RS 422 RX (+)
RS170 (-)	68	←	68	RS170 (-)
Reserved	69		69	Reserved
Reserved	70		70	Reserved
Spare	71		71	Spare
Reserved	72		72	Reserved
Spare	73		73	Spare
Spare	74		74	Spare
Spare	75		75	Spare
Reserved	76		76	Reserved
Spare	77		77	Spare
RS 422 RX (+)	78	←	78	RS 422 TX (+)
Reserved	79		79	Reserved
Reserved	80		80	Reserved
Reserved	81		81	Reserved
Reserved	82		82	Reserved
PPCB 02 (+)	83	↔	83	PPCB 02 (+)
Spare	84		84	Spare
Spare	85		85	Spare
Spare	86		86	Spare
Reserved	87		87	Reserved
RS 422 TX (-)	88	→	88	RS 422 RX (-)
Spare	89		89	Spare

TABLE I.3.8.1.2-1 COMMAND/TELEMETRY CONNECTOR PIN ASSIGNMENTS FOR THE ISIS DRAWER PAYLOAD (3 PAGES)

CONNECTOR P/N: M83733/2RA131 RACK CONNECTOR		DATA DIRECTION	CONNECTOR P/N: M83733/3RA131 PAYLOAD CONNECTOR	
FUNCTION	**PIN**		**PIN**	**FUNCTION**
Reserved	90		90	Reserved
Reserved	91		91	Reserved
Spare	92		92	Spare
PPCB 03 (+)	93	↔	93	PPCB 03 (+)
Reserved	94		94	Reserved
Reserved	95		95	Reserved
Spare	96		96	Spare
Reserved	97		97	Reserved
Spare	98		98	Spare
RS 422 RX (-)	99	←	99	RS 422 TX (-)
Reserved	100		100	Reserved
Reserved	101		101	Reserved
Spare	102		102	Spare
PPCB 03 (-)	103	↔	103	PPCB 03 (-)
Reserved	104		104	Reserved
Ethernet RX (+)	105	←	105	Ethernet TX (+)
Reserved	106		106	Reserved
Reserved	107		107	Reserved
Reserved	108		108	Reserved
Reserved	109		109	Reserved
Reserved	110		110	Reserved
Spare	111		111	Spare
Spare	112		112	Spare
PPCB 04 (+)	113	↔	113	PPCB 04 (+)
Spare	114		114	Spare
Reserved	115		115	Reserved
Ethernet RX (-)	116	←	116	Ethernet TX (-)
Reserved	117		117	Reserved
Spare	118		118	Spare
Reserved	119		119	Reserved
Reserved	120		120	Reserved
Continuity Discrete (-)	121	↔	121	Continuity Discrete (-)
Spare	122		122	Spare
Spare	123		123	Spare
PPCB 04 (-)	124	↔	124	PPCB 04 (-)
Reserved	125		125	Reserved
Spare	126		126	Spare
Reserved	127		127	Reserved
Ethernet TX (+)	128	→	128	Ethernet RX (+)
Ethernet TX (-)	129	→	129	Ethernet RX (-)
Reserved	130		130	Reserved
Reserved	131		131	Reserved

B. The ISIS drawer payload **shall** jumper the Command/Telemetry connector (P2) pin contact 9 to pin contact 121 per Table I.3.8.1.2-1. This is to allow software to verify that the connector is mated when the ISIS drawer is in the installed position.

I.3.8.1.3 PPCB

The Point-to-Point Communications Bus (PPCB) provides hardwired communication between adjacent payloads (ISIS drawers or MLEs) within the same EXPRESS Rack. Connector part numbers and pin functions for the PPCB *should* be as defined in Tables I.3.8.1.1-1 and I.3.8.1.2-1.

The PPCB provides hardwired communication between adjacent payloads (ISIS drawers or MLEs with the EXPRESS rack as shown in Figure I.3.8.1.3-1) within the same EXPRESS Rack. PPCB hardwired connectivity is as follows: MDL1 to MDL2 and MDL5, MDL2 to MDL1 and MDL3, MDL3 to MDL2 and MDL4, MDL to MDL3 and ISIS01, ISIS01 to MDL4 and ISIS02, ISIS02 to ISIS1 and MDL8, MDL8 to ISIS02 and MDL7, MDL7 to MDL6 and MDL8, MDL6 to MDL5 and MDL7, and MDL5 to MDL1 and MDL6.

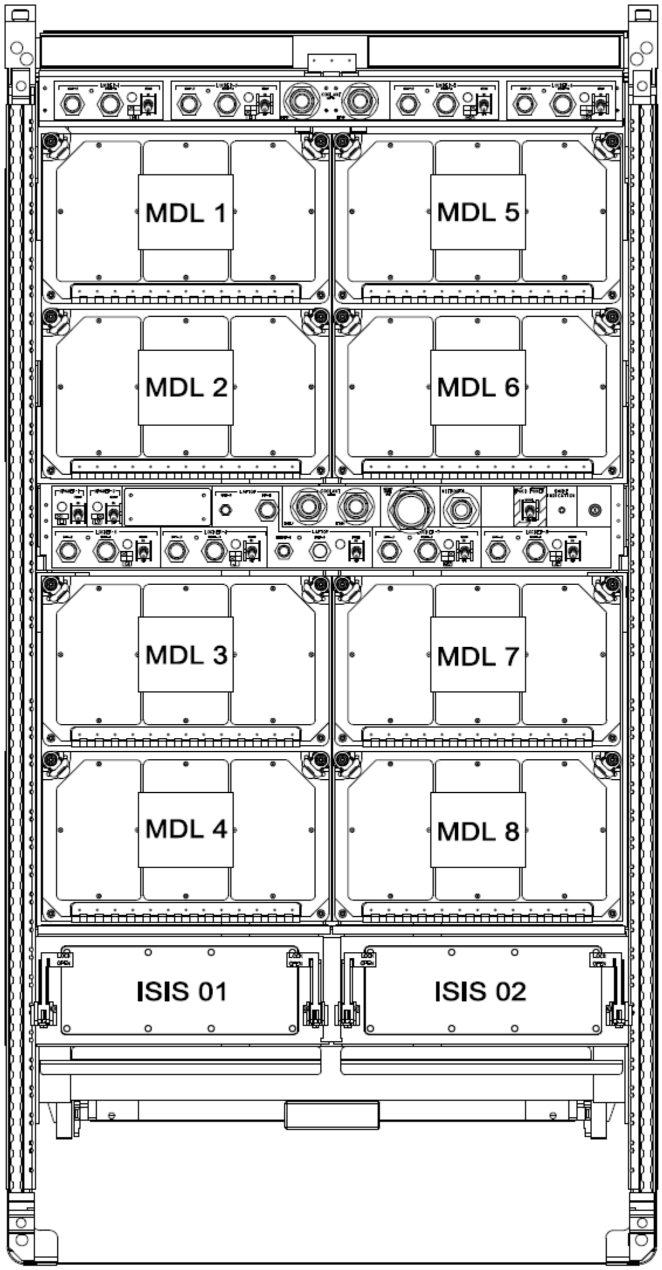


FIGURE I.3.8.1.3-1 SUBRACK LOCATIONS

I.3.8.2 RS-422 COMMUNICATIONS

I.3.8.2.1 SIGNAL CHARACTERISTICS

The subrack payload using an RS-422 serial channel *should* meet the interface and signal characteristics requirements of specification ANSI/TIA/EIA-422, Electrical Characteristics of Balanced Voltage Differential Interface Circuits. The baud rate is subrack payload selectable and will be 1200, 2400, 4800, 9600, 19200, or 38400 baud. The RS-422 will use eight data bits as one character, one stop bit, and no parity. A message must never have an idle time of more than two contiguous characters between the sync word and the message checksum word. Messages must be separated by at least a five-character idle time.

I.3.8.2.2 REQUEST/COMMAND FORMAT

All commands from the RIC to the subrack payload and requests from the subrack payload to the RIC will be packetized. Request/Command formats are defined in paragraphs I.3.8.2.3 and I.3.8.3.4.

I.3.8.2.3 COMMAND PROCESSING REQUIREMENTS

The RIC is capable of processing up to 10 subrack payload command packets per second, with up to 64 16-bit word packets, including CCSDS overhead (11 words) and EXPRESS Header (four words). The PEP timeline will not send more than 10 command packets per second. The S-band can uplink up to eight command packets per second. The subrack payload *should* be capable of receiving, verifying and processing commands of the size as described in the Message Byte Count in the EXPRESS Header for up to a maximum of 52 l6-bit words, including second, third, and fourth EXPRESS header words shown in Table I.3.8.7.3.1-1 and up to 49 command data words shown in Figure I.3.8.7.3.7-1.

I.3.8.3 ETHERNET COMMUNICATIONS

I.3.8.3.1 SIGNAL CHARACTERISTICS

The subrack payload interfacing with the EXPRESS Rack Payload Ethernet Hub Bridge (PEHB) **shall** meet the signal characteristics of IEEE 802.3 (10BASE-T section).

I.3.8.3.2 COMMUNICATIONS PROTOCOL

The subrack payload communicating with the RIC and/or the laptop via the Ethernet PEHB *should* use software protocol Transmission Control Protocol/Internet Protocol (TCP/IP). The TCP/IP format is shown in Figure I.3.8.3.2-1.

	MSB									LSB
IP	VERSION	IHL	TYPE OF SERVICE	TOTAL LENGTH						
	IDENTIFICATION			FLAGS (3)	FRAGMENT OFFSET (13)					
	TIME TO LIVE		PROTOCOL	HEADER CHECKSUM						
	SOURCE ADDRESS									
	DESTINATION ADDRESS									
TCP	SOURCE PORT			DESTINATION PORT						
	SEQUENCE NUMBER									
	ACKNOWLEDGEMENT NUMBER									
	DATA OFFSET (4)	RESERVED (6)	URG	ACK	PSH	RST	SYN	FIN	WINDOW	
	CHECKSUM			URGENT POINTER						
DATAA	YOUR DATA . . .									

FIGURE I.3.8.3.2-1 TCP/IP FORMAT DEFINITION FOR ETHERNET COMMUNICATIONS

I.3.8.3.3 REQUEST/COMMAND FORMAT

All commands to the subrack payload from the RIC and requests from the subrack payload to the RIC will be packetized.

I.3.8.3.4 COMMAND PROCESSING REQUIREMENTS

The RIC is capable of processing up to 10 subrack payload command packets per second with up to 64 16-bit words per packet, including CCSDS overhead (11 words) and EXPRESS header (four words). The subrack payload PEP timeline will not send more than ten (10) command packets per second. The S-band can uplink up to eight command packets per second. The subrack payload *should* be capable of receiving, verifying and processing commands of the size as described in the Message Byte Count in the EXPRESS header for up to a maximum of 52, 16-bit words, including second, third, and fourth EXPRESS header words shown in the Table I.3.8.7.3.1-1 and up to 49 command data words shown in Figure I.3.8.7.3.7-1.

I.3.8.4 ANALOG COMMUNICATIONS

It is noted that all analog communications are via the SSPCM. The sampling rate of the subrack payload data by the RIC from the SSPCM will be 1.0 Hz, 10 Hz, or 100 Hz. The SSPCM samples at 1 kHz. All analogs for a single subrack payload location must be sampled at the same rate. The resolution/accuracy of the subrack payload data by the SSPCM will be 12 bits analog-to-digital conversion with a ±1 percent of full scale accuracy.

I.3.8.4.1 SIGNAL CHARACTERISTICS

An analog signal input to the EXPRESS Rack **shall** be a -5 Vdc to +5 Vdc output signal (i.e., differential input to the SSPCM).

I.3.8.4.2 ANALOG DRIVER CHARACTERISTICS

The electrical characteristics of the subrack payload analog driver circuit (output from the subrack payload) **shall** be compatible with the SSPCM receiver circuit illustrated in Figure I.3.8.4.2-1.

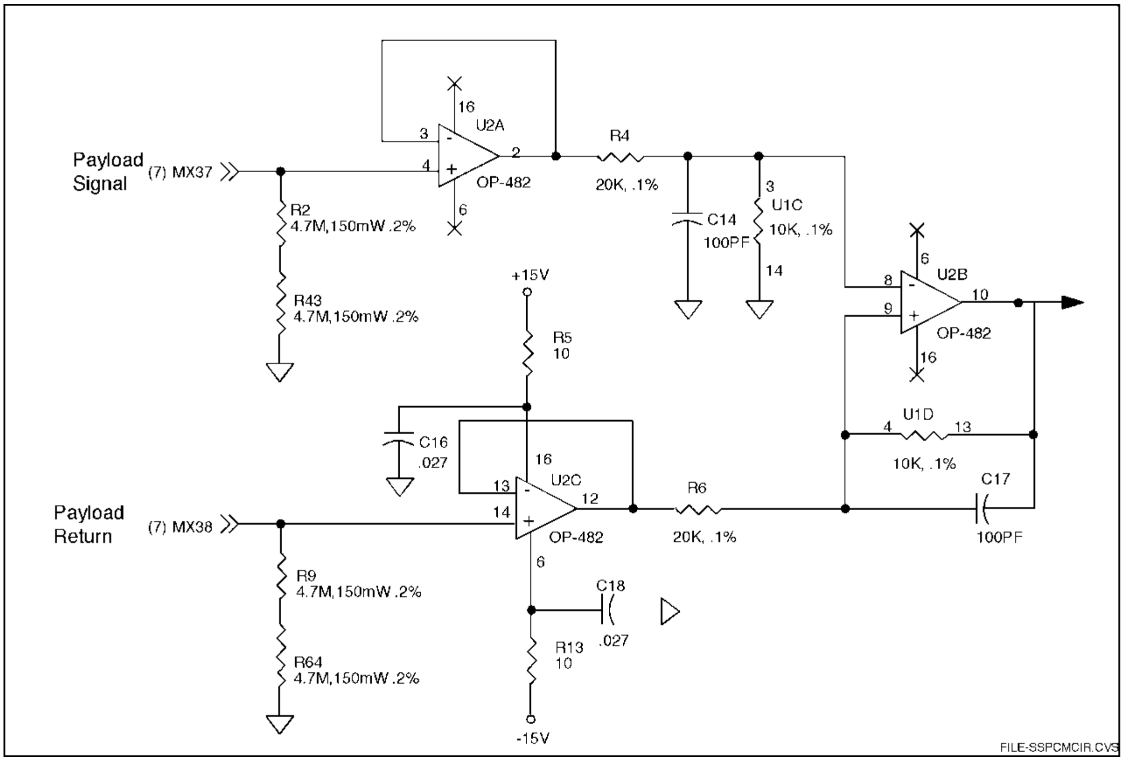


FIGURE I.3.8.4.2-1 INPUT AMPLIFIER FOR ANALOG SIGNALS TO BE DIGITIZED (SSPCM ANALOG RECEIVER CIRCUIT)

I.3.8.5 DISCRETE COMMUNICATIONS

All discrete communications are via the SSPCM. The following paragraphs are written with the SSPCM as the reference (i.e., outputs are from the SSPCM, and inputs are to the SSPCM). Discretes are bi-directional and programmed at the SSPCM. The sampling rate of the payload data by the RIC from the SSPCM will be 1 Hz. The SSPCM samples at 1 kHz. All discrete communication by the same payload (MLE or ISIS drawer) is sampled at the same rate. The sample rate between payloads can be different.

I.3.8.5.1 DISCRETE SIGNAL CHARACTERISTICS

The discrete output (from the SSPCM) signal is a differential signal, and the discrete input (to the SSPCM) is a differential signal.

I.3.8.5.1.1 DISCRETE OUTPUT LOW LEVEL

The PD hardware *should* receive a digital “zero” level output of -3.5 Vdc line-to-line.

I.3.8.5.1.2 DISCRETE OUTPUT HIGH LEVEL

The PD hardware *should* receive a digital “one” level output of +3.5 Vdc line-to-line.

I.3.8.5.1.3 DISCRETE OUTPUT MAXIMUM FAULT CURRENT

The PD hardware *should* not be damaged by indefinite exposure to a misconnection to -27 to 32 Vdc source or sustained short. Output current under these conditions will be limited to 27 milliAmperes (mA) continuous and up to 150 mA for duration of up to (one) 1 second.

I.3.8.5.1.4 DISCRETE INPUT LOW LEVEL

The PD hardware *should* provide a low level input (logic low level) within the voltage range of -0.5 Vdc to +2.0 Vdc.

I.3.8.5.1.5 DISCRETE INPUT HIGH LEVEL

The PD hardware *should* provide a high level input (logic high level) within the voltage range of +2.5 Vdc to +6.0 Vdc.

I.3.8.5.1.6 DISCRETE INPUT MINIMUM AND MAXIMUM FAULT VOLTAGE

The PD hardware output voltage due to a fault **shall** be greater than -27 Vdc and less than +32 Vdc.

I.3.8.5.2 DISCRETE DRIVER AND RECEIVER CHARACTERISTICS

The electrical characteristics of the payload discrete driver circuit and receiver circuit *should* be designed to match the SSPCM receiver circuit and driver circuit illustrated in Figure I.3.8.5.2-1.

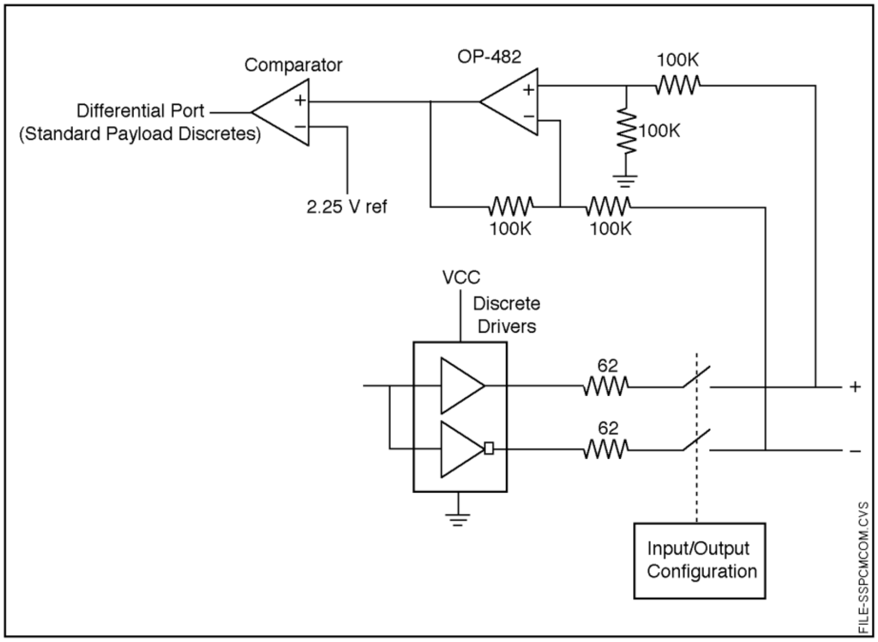


FIGURE I.3.8.5.2-1 SSPCM DISCRETE RECEIVER CIRCUIT AND DRIVER CIRCUIT FOR DISCRETE COMMUNICATIONS

I.3.8.6 LAPTOP COMPUTERS AND SOFTWARE

The EXPRESS Rack provides C&DH interfaces for subrack payload use. The RIC, SSPCM, and PEHB provide direct interfaces to the EXPRESS subrack payload. Bidirectional communication with equipment on board ISS and to ground facilities is through these equipment items. File transfer downlink of subrack payload data files via PL MDM is limited due to operations constraints.

The RIC provides digital and analog data management services, including, but not limited to, data formatting, data multiplexing, and command distribution and serves as an interface buffer between EXPRESS and the ISS C&DH. The RIC interfaces to the ISS via the MIL-STD-1553B bus as LRDL, Ethernet via the PEHB, fiber optical as HRDL, and Pulse Frequency Modulation (PFM) video. The low rate link to the PL MDM is for commands, uplink files, Ancillary Data (payload Unique and Broadcast), PEP service requests and responses, time, Health and Status data (H&S), payload file downlink and low rate telemetry data.

A subrack payload “user device” that downlinks Ethernet data to the ground via the PEHB, can be either through the RIC with EXPRESS Header (with up to 1248 bytes per packet), or bypassing the RIC with the subrack payload generating the CCSDS Header (with data between 84 to 1484 bytes per packet) with an even number of data bytes are compliant with the following Ethernet:

A. Subrack payloads using the RIC bypass and HRDL *should* meet the requirements in Paragraph I.3.5.2.7.A or I.3.5.2.7.B.

B. Subrack payloads using the KuIP *should* meet the requirements in Paragraph I.3.5.2.6.

The HRDL is for high rate telemetry downlink. All messages (other than video) between the RIC and ISS are in CCSDS format. Data transmitted by the RIC to the ISS via LRDL must consist of an even number of bytes. If the subrack payload generates an odd number of data bytes, the RIC will fill the message to an even number of bytes. Messages between the RIC and the subrack payload or laptop are in EXPRESS packet format with sync word (55AA) and EXPRESS Header (see table in paragraph I.3.8.7.3.1). When the RIC forwards each message to the desired destination, the EXPRESS Header will be kept, except the RIC will remove the EXPRESS Header from the Health and Status data before sending it to the PL MDM. The SSPCM provides power to the EXPRESS Rack payload and subsystem and provides an interface for analog/discrete data collection and an interface for discrete output commands. The SSPCM and the RIC communicate via MIL-STD-1553B interfaces and various discrete signals. The Ethernet LAN located within the EXPRESS Rack allows the subrack payload to communicate to the EXPRESS laptop, the EXPRESS RIC, to other subrack payloads in the same EXPRESS Rack, or to other equipment/payloads outside the rack via the PEHB. The PEP is the part of the PL MDM that serves as a single point of control for payload data and commands in the ISS C&DH system. From the prospective of the EXPRESS subrack payload, the PEP and the PL MDM are the same. The RIC inserts the primary and the secondary CCSDS headers to each telemetry packet for downlink to the PL MDM or the PEHG or the Automated Payload Switch (APS). The RIC builds the CCSDS header per the assigned APID in the RIC table. The subrack payload will not see the CCSDS header except for broadcast ancillary data where the CCSDS header is included as part of the packet that is sent to the subrack payload from the RIC. For uplink commands, the HOSC will generate the CCSDS header. The important portions in the CCSDS header are the packet length and the APID.

I.3.8.6.1 LAPTOP COMPUTERS AND PORTABLE COMPUTING DEVICES

The subrack payload *should* not utilize/manifest its own laptop. The software which interfaces to the subrack payload is identified in the subsequent paragraphs.

The Laptop Computer category is broadly defined herein to include any portable computing device that contains a processor, display, user interface, and communications functions that performs software-driven applications. This category includes both standard “laptop” computers with full-size keyboards and displays, as well as small computing devices, such as smartphones, tablet PCs, or other devices capable of running an operating system and interfacing with networks or other computers. In both cases, the devices, when used within the ISS pressurized volume, must be approved for use by NASA Avionics and Software Office and the Payload Software Control Panel (PSCP).

The EXPRESS Rack Laptop (LAP), which is also called the EXPRESS Laptop Computer (ELC), is the only laptop that interfaces with the EXPRESS Rack RIC and the subrack payload.

I.3.8.7 EXPRESS RACK SOFTWARE

A. For the subrack payload requiring data downlink via the RIC with a data rate greater than or equal to 1.2 Mbps for more than a 4 hour period per day or more than 600 Kbps for a period of more than 48 hours, the subrack payload *should* be designed to accept commands resulting in a variable downlink rate lower than 1.2 Mbps or less than 600 Kbps, which will meet subrack payload criteria.

B. In addition to meeting requirement A above, the keep-alive payload *should* be designed to accept commands resulting in a variable downlink rate of less than 400 Kbps during the keep-alive period.

C. For the subrack payload requiring data downlink via the RIC bypass with a data rate greater than or equal to 2.0 Mbps, the payload *should* be designed to accept commands resulting in a variable downlink rate less than 2.0 Mbps. Downlinks exceeding this rate will be operationally timelined. Payloads unable to vary the downlink rate below this rate may be operationally timelined.

Figure I.3.8.7-1 depicts the EXPRESS Rack RIC CSCI interfaces to the payload and other items. Table I.3.8.7-1 summarizes the EXPRESS Rack RIC CSCI direct interfaces to the payload item. There are other services available to the payload shown in Figure I.3.8.7-1; however, the CSCI interfaces between the subrack Ethernet payload and the ISS Ethernet must go through the PEHB (i.e., indirect interface). In this section, messages sent to the payload will be referred to as “commands/response,” and messages sent from the payload will be referred to as “data/requests.”

Science and/or Health and Status information sent from the subrack payload will be referred to as either “data” or “telemetry.” Telemetry from all subrack payloads is limited by the RIC's throughput capability, which for the Ethernet is 1.89 Mbps (in a rack with or without ARIS) and for HRDL is 1.9 Mbps (with or without ARIS). **These resources are shared by all payloads in the same rack.** At the beginning, each telemetry packet must include the four word EXPRESS header, as shown in Table I.3.8.7-2 for the telemetry packet and Figure I.3.8.7-2 for Health and Status data.

Figure I.3.8.7-3 illustrates at a high level the end-to-end description of command flow from the PEP (such as a ground, timeline, and the ECW limit check response command) to a subrack payload. Figure I.3.8.7-4 illustrates at a high level the end-to-end description of the request flows from a subrack payload to the PEP.

The EXPRESS RIC uses eight (8) bits with most significant bit first as one byte and 16 bits as one (1) word (two (2) bytes). The EXPRESS RIC expects data with the most significant byte first and least significant byte last and a word order with the most significant word first and least significant word last.

A sync word, required for every packet between the RIC and subrack payload for both RS-422 and Ethernet interface, is used to identify the beginning of a new packet. Once the sync word is identified, the RIC uses the Message Byte Count in the EXPRESS Header to verify the size of each packet. The RIC passes the data packet when the sync word and packet size are verified correct. If the next sync word is not found in the appropriate location, the RIC will discard the packet and search again for a sync word and packet size that correctly matches the Message Byte Count in the EXPRESS Header.

For each message from the RIC to the subrack payload, the RIC adds the sync word prior to sending the message. Upon receipt of a subrack payload message by the RIC, the RIC removes the sync word prior to further processing.

The value of the Header Version, part of the first word of the EXPRESS Header, is "0000" for the current version. The Message Byte Count is calculated by summing the number of bytes from the Message Type to the last message data byte but not including the RS-422 serial checksum word. The Message Type is used by the RIC to identify the command/data/status contained in the message. The Function Code (source or destination) is used by the RIC to route each message for each interface in the rack. The EXPRESS Header (words two (2) to four (4)) and the EXPRESS telemetry secondary header are in 16-bit integer format. The RIC processes each message based on the Function Code and the Message Type in the EXPRESS Header.

For data/messages the RIC checks the EXPRESS Header format. If the header format is incorrect, the message will be discarded and no retransmission will be requested. An invalid command status will be sent to the EXPRESS laptop for commands with an incorrect header format.

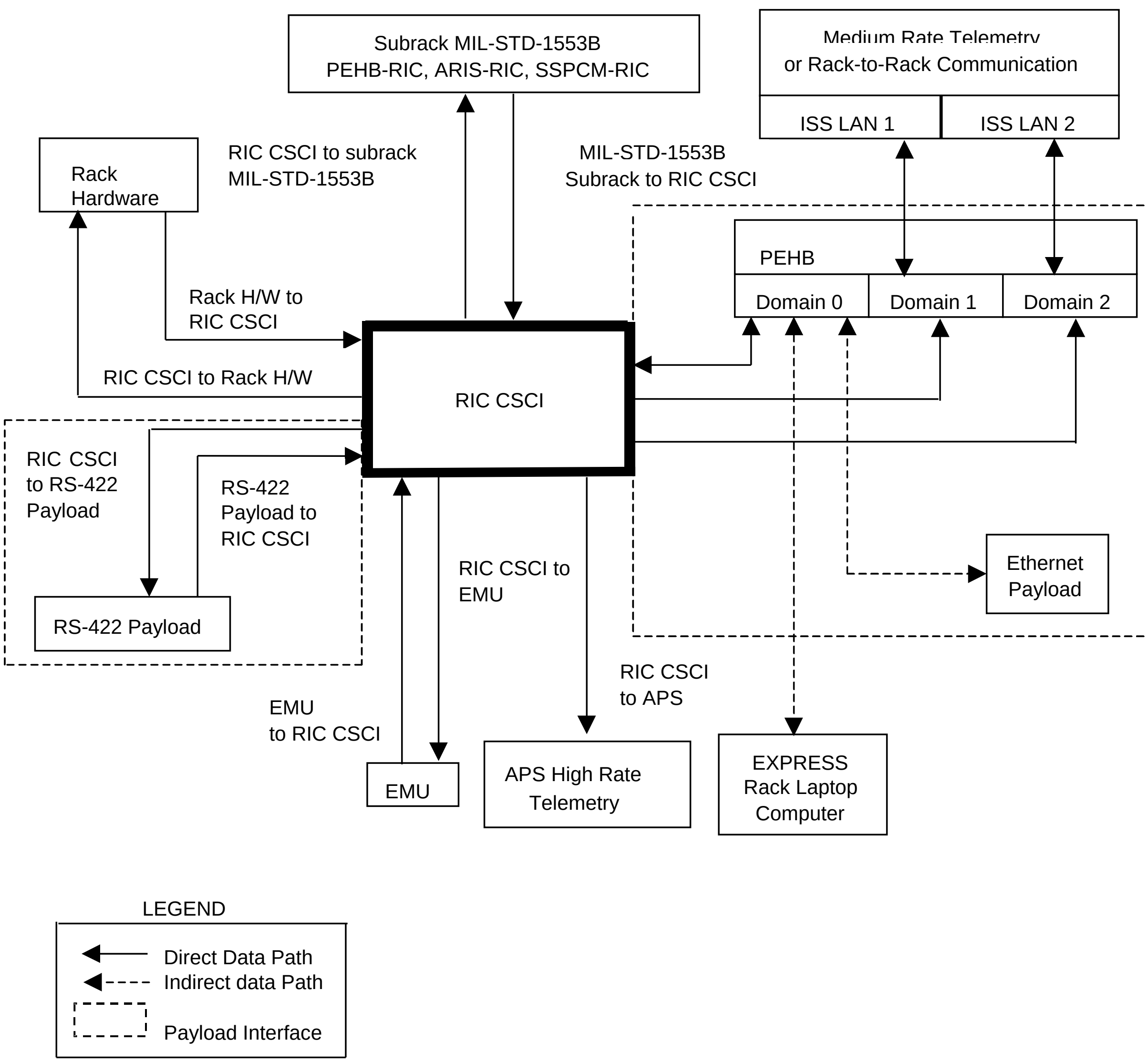


FIGURE I.3.8.7-1 EXPRESS RIC CSCI INTERFACE DIAGRAM FOR RIC-TO-PAYLOADS AND OTHER RACK HARDWARE ITEMS

TABLE I.3.8.7-1 EXPRESS RACK PAYLOAD RELATED RIC CSCI EXTERNAL INTERFACE IDENTIFICATION

Name	Description	Interface Type
RS-422 PLD to RIC CSCI	Status, service requests, and data sent from payload via ANSI/TIA/EIA-422.	Software
RIC CSCI to RS-422 PLD	Request and data sent to a payload via ANSI/TIA/EIA-422.	Software
RIC CSCI to Ethernet PEHB Domain “0”	Request and data sent to a payload and laptop via Ethernet.	Software
Ethernet PEHB Domain “0” to RIC CSCI	Status, service requests, and data sent from payload and laptop via Ethernet to the RIC.	Software

TABLE I.3.8.7-2 EXPRESS TELEMETRY PACKET FORMAT

<table>
<tr><th>MSB</th><th></th><th></th><th></th><th></th><th></th><th></th><th></th><th></th><th></th><th></th><th></th><th></th><th></th><th></th><th>LSB</th></tr>
<tr><td colspan="16">SYNC (55AA)</td></tr>
<tr><td colspan="16">EXPRESS Header</td></tr>
<tr><td colspan="16">EXPRESS Telemetry Secondary Header</td></tr>
<tr><td colspan="8">Data Byte 1</td><td colspan="8">Data Byte 2</td></tr>
<tr><td colspan="8">Data Byte 3</td><td colspan="8">Data Byte 4</td></tr>
<tr><td colspan="16"></td></tr>
<tr><td colspan="8">Data Byte n-1</td><td colspan="8">Data Byte n
(maximum Ethernet n = 1248 Data Bytes
maximum ANSI/TIA/EIA-422 n = 1248 Data Bytes)</td></tr>
<tr><td colspan="16">EXPRESS serial checksum word (only applicable for ANSI/TIA/EIA-422 messages between the RIC and the payload. Consists of the sum, with no carry, of all message bytes, including Sync Word, prior to the EXPRESS Serial Checksum word).</td></tr>
</table>

PAYLOAD HEALTH AND STATUS DATA

1 Word	1 Word	1 Word	92 Words
Payload Subset ID	Service Request ID	Service Request Data Word	Payload Data Words (first one is ECW)

RIC-TO-PAYLOAD MDM

1 Word	4 Words	←	92 Words, Maximum, Payload Data		→
Sync Word (55AA)	EXPRESS Header	ECW	H&S Cycle Counter	Payload Message***** Figure I.3.4.1.3-3	Payload Data

PAYLOAD-TO-RIC

*****Payloads are not required to reserve the Payload Message area within the H&S Data

FIGURE I.3.8.7-2 PAYLOAD HEALTH AND STATUS

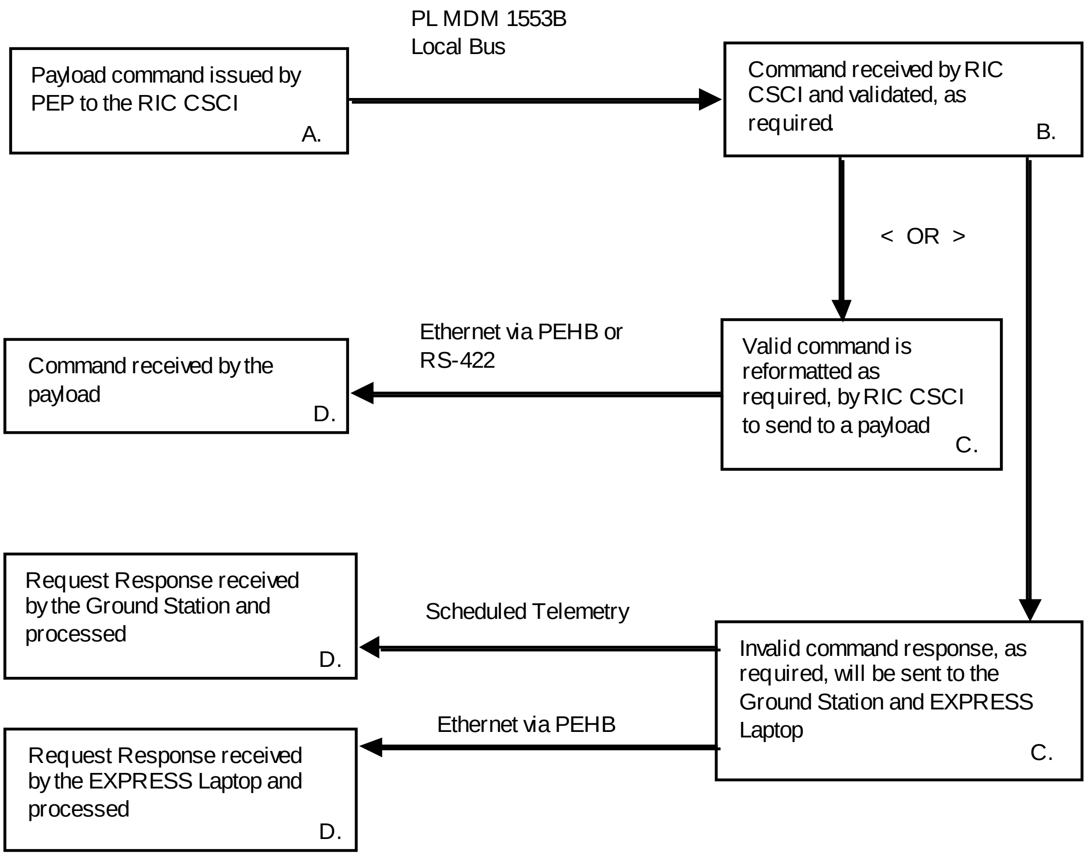


FIGURE I.3.8.7-3 PAYLOAD PEP COMMAND

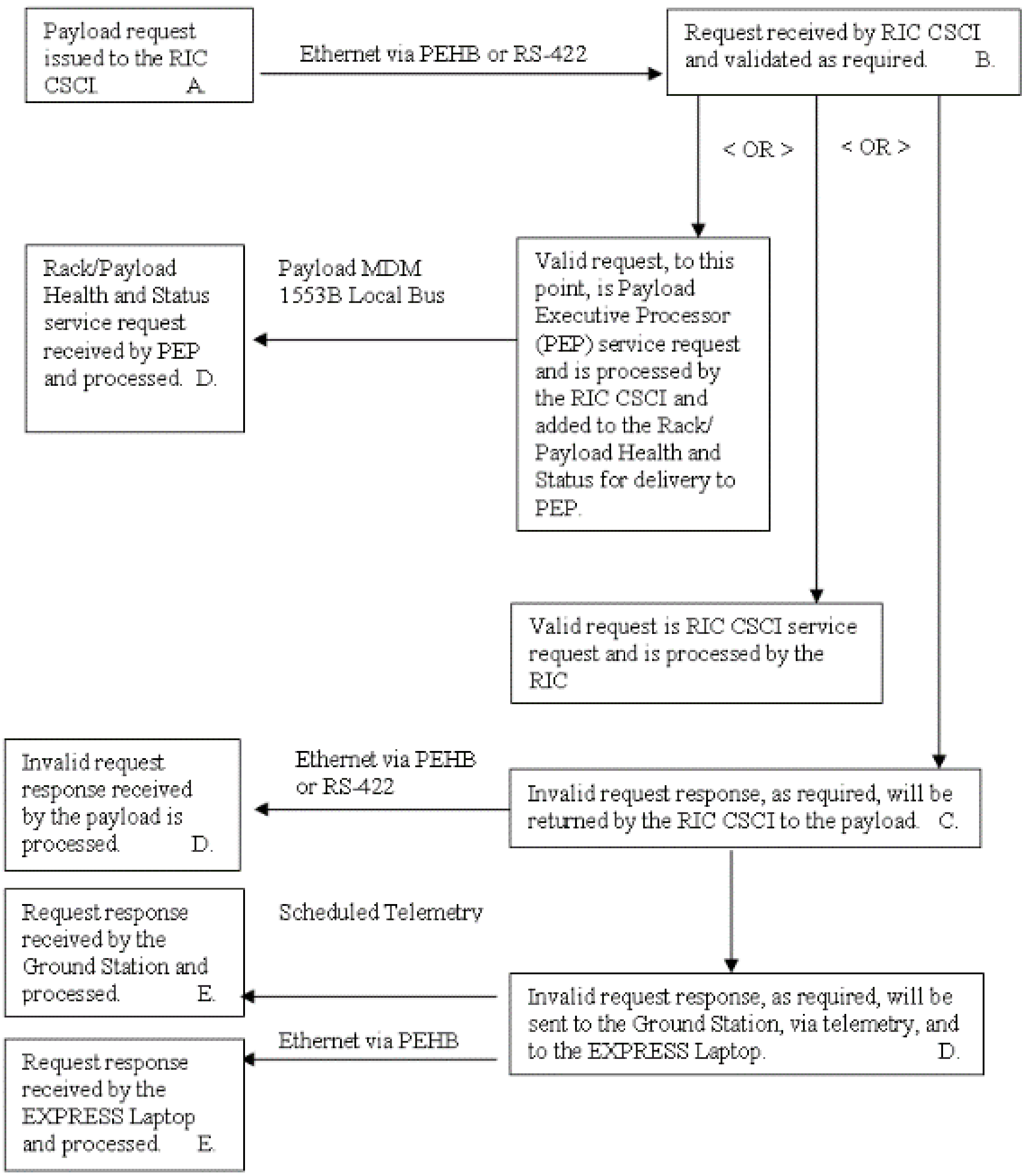


FIGURE I.3.8.7-4 END-TO-END SERVICE REQUEST FOR PAYLOAD FLOW

I.3.8.7.1 EXPRESS RACK PEHB INTERFACE (ETHERNET)

The subrack payload Ethernet connection through the RIC *should* conform to IEEE 802.3 Type 10 BASE-T TCP/IP protocol format compliant. The RIC will not be involved with payload-to-payload communications within the same rack or between different racks, other than to store the subrack payload Ethernet MAC address within the PEHB Content Addressable Memory. Payload-to-payload communication can use any type of protocol compatible with Ethernet 8802-

3 10BASE-T, as long as the other subrack payload can accept the information. The RIC CSCI interfaces to the PEHB (Figure I.3.8.7-1), in accordance with IEEE 802.3 Ethernet, are for downlink of subrack payload medium rate telemetry, communications with the EXPRESS Rack laptop CSCI, and communications with the subrack payload for commanding, file transfer, Health and Status, service request, broadcast Time, and Ancillary data. The RIC CSCI communicates with the subrack payload or Laptop by using the TCP/IP protocol. The TCP/IP header structure as described in Figure I.3.8.3.2-1 is standard Berkley 4.3 with five (5) 32-bit TCP header words and five (5) 32-bit IP header words. The subrack payload requiring a HRDL can access this interface via the PEHB to the RIC and then to the ISS APS. Ethernet-to-Ethernet or RS-422-to-Ethernet communication in the same or different racks is via the PEHB.

When sending data to the RIC via a network connection, the subrack payload must be sure to send only complete, well-formed EXPRESS messages (that is, EXPRESS sync word, EXPRESS header, and data bytes all in a single unit). If the subrack payload's data cannot fit into a single EXPRESS message, then multiple EXPRESS messages must be used. If a subrack payload must send its data piecemeal (for example, sync word and the EXPRESS header in one message, some data in another message, and more data in yet another message), then all the pieces that comprise a complete EXPRESS message must be received in sequential order by the RIC before any other data from that subrack payload is received. (Otherwise, the EXPRESS message cannot be assembled correctly, resulting in data loss and a broken network connection).

The IP address is assigned by the ISS Program in the C&DH Data Set within the PDL after the PD promotes the C&DH data set to the Submitted level. Once assigned, the IP address remains with the subrack payload even if the subrack payload is moved to another EXPRESS rack location. The valid TCP/IP port number range is 6212 to 6999 and is assigned by the ISS Program.

The RIC is the client and the subrack payload is the server for all communication between the RIC and the subrack payload. For communication between the EXPRESS laptop and the RIC or subrack payload, the EXPRESS laptop is the client and the RIC or subrack payload is the server. The client establishes communication and afterwards maintains an open connection. If the connection is lost, the client deletes the current socket and creates a new socket. The server will need to reset the connection when this occurs. Communication between the RIC and the subrack payload or between the EXPRESS laptop and a subrack payload is a two (2)-way transfer.

The RIC does not use the Ethernet address in processing. The Ethernet address of the subrack payload is used to configure the PEHB Content Addressable Memory for communication with another payload outside the rack. The PD will input to the payload Ethernet address to the PDL C&DH data set.

PEHB Ethernet interfaces for software are listed below:

A. ISS Payload Ethernet Hub/Gateway Interfaces

There is no direct physical interface between the RIC CSCI or subrack payload and the ISS LAN 1 and ISS LAN 2; however, there is an IEEE 802.3 Ethernet connection between the PEHB and the ISS LAN 1 and 2, which provides a logical Ethernet communications interface between the RIC CSCI or subrack payload and the ISS LAN 1 and 2 through the PEHB, that is used for downlink of medium rate telemetry and rack-to-rack communications (see Figure I.3.8.7-1).

B. Laptop Ethernet Interface

There is no direct physical interface between the RIC CSCI or subrack payload and the EXPRESS Rack laptop CSCI; however, there is an IEEE 802.3 Ethernet connection between the PEHB and the EXPRESS Rack laptop, which provides a logical Ethernet communications interface between:

- The RIC CSCI and the EXPRESS Rack laptop CSCI through the PEHB, with communication in accordance with TCP/IP, for normal operations.
- The subrack payload and the EXPRESS Rack laptop CSCI through the PEHB to be used for subrack payload data transfers to/from Payload Application Software (PAS) running on the laptop.

C. Payload Ethernet Interface

There is no direct physical Ethernet interface between the RIC CSCI and the subrack payload; however, there is an IEEE 802.3 Ethernet connection between the PEHB and the payload, which provides a logical Ethernet communications interface between:

- The RIC CSCI and the subrack payload through the PEHB, with communication in accordance with TCP/IP Ethernet transmission protocol.
- The subrack payload and the ISS LAN Payload Ethernet Hub Gateway 1 (PEHG1) and PEHG2, through the PEHB bridging function, to be used for subrack payload to subrack payload or rack-to-rack communications or subrack payload direct Ethernet data downlink with payload provided CCSDS Header.
- The subrack payload and the EXPRESS Rack laptop CSCI through the PEHB, to be used for subrack payload data transfers to PAS running on the laptop.

The data and files elements for the subrack payload-to-RIC Ethernet interfaces with which a subrack payload *should* comply are shown in Table I.3.8.7.1-1, Payload Ethernet External Interface Data Element. The length/type field of the MAC portion of TCP/IP protocol must indicate a MAC client protocol (type interpretation) using the value 0800 h within the 2 bytes between the Ethernet source address and IP header. The TCP/IP is supported by the RIC embedded VxWorks, Operating System. The VxWorks network supports the associated Internet.

TABLE I.3.8.7.1-1 PAYLOAD ETHERNET EXTERNAL INTERFACE DATA ELEMENT (2 PAGES)

Description	Source	Destination	Frequency	Data Format
Ethernet PLD to RIC				
Payload Health and Status	PLD	RIC	1 Hz	Ethernet
PEP Bundle Request	PLD	RIC	Async	Ethernet
PEP Procedure Execution Request	PLD	RIC	Async	Ethernet
Rack Time Request	PLD	RIC	Async	Ethernet
Ancillary Data Config Control	PLD	RIC	Async	Ethernet
Payload Telemetry Downlink Data	PLD	RIC	Async	Ethernet
EMU File Transfer Request	PLD	RIC	Async	Ethernet
PLD File Transfer Data Block	PLD	RIC	Async	Ethernet
PLD File Transfer Request	PLD	RIC	Async	Ethernet

TABLE I.3.8.7.1-1 PAYLOAD ETHERNET EXTERNAL INTERFACE DATA ELEMENT (2 PAGES)

Description	Source	Destination	Frequency	Data Format
RIC to Ethernet Payload				
Ancillary Data Set	RIC	PLD	Async,.1, 1 Hz	Ethernet
Broadcast Ancillary Data Packet	RIC	PLD	10 Hz	Ethernet
Rack Request Response	RIC	PLD	Async	Ethernet
Rack Time Response	RIC	PLD	Async	Ethernet
EMU File Transfer Request	RIC	PLD	Async	Ethernet
PLD File Transfer Request	RIC	PLD	Async	Ethernet
PLD File Transfer Data Block	RIC	PLD	Async	Ethernet

D. Subrack payloads using the payload-to-payload communication protocol between racks or to other payload locations *should* meet the requirements listed in paragraph I.3.5.2.7.A or B.

I.3.8.7.1.1 SUBRACK PAYLOAD USING DATA DOWNLINK VIA THE RIC BYPASS

A. The subrack payload **shall** meet the CCSDS Data requirements listed in Table I.3.8.7.1.1-1.

TABLE I.3.8.7.1.1-1 CCSDS REQUIREMENTS

SSP 57000 Requirement	Title/Subject
I.3.3.1.1	CCSDS DATA PACKETS
I.3.3.1.2	CCSDS DATA FIELD

B. The subrack payload **shall** meet the MAC Address requirement I.3.5.2.1.3.1.A.

I.3.8.7.2 EXPRESS RACK RIC SERIAL INTERFACE (RS-422)

The RIC CSCI interfaces to subrack payloads requiring a serial interface as described in ANSI/TIA/EIA-422-B. The data elements for this interface with which subrack payloads must comply are shown in Table I.3.8.7.2-1, Payload RS-422 External Interface Data Element. Note: Only if a request is invalid will a response be sent to the subrack payload making the request. The request response will be returned within 1 s of validation of the request except for requests to the PEP. The subrack payload interface to the RIC by RS-422 format must have a serial checksum at the end of each data message. The sync word in front of the EXPRESS Header is used in the communication protocol for RS-422 to indicate the beginning of a new message. The content from the first word of the EXPRESS Header through the word before the serial checksum word is the subrack payload message. When the RIC receives Health and Status, subrack payload telemetry, or subrack payload files, the RIC removes the sync word and the serial checksum word prior to further processing.

When a subrack payload command, Time response, Ancillary data, Request Response, or file comes from the PEP, the RIC adds the sync word at the beginning and the serial checksum word at the end before sending it to the subrack payload. The EXPRESS serial checksum word is used only by the RIC and is computed as the sum, with no carry, of all message bytes including the sync word but excluding the checksum word itself. No flow control is used in the RS-422 interface.

A. Packets *should* be separated by a minimum idle time equivalent to 5 data characters. Idle time consists of a period of time when no data is present on the interface.

B. The messages *should* be complete and contiguous (must never have idle time of more than two contiguous characters between sync word and message checksum word).

Note: The RS-422 checksum word is the summation of all bytes, starting with and including the sync word (55AA) but not including the checksum, with no carry (over the word boundary).

As an example, a subrack payload with Function Code “100” requesting time from the RIC would send the message “55AA 0006 004D 0100 0001 0154” with a checksum of “0154 h”.

55AA = Sync word
0006 = Version and Byte Count

004D = Message Type

0100 = Source Function Code (Payload)

0001 = Destination Function Code (RIC)

0154 = Checksum word (Sum of bytes from 55 + AA + 00 + 06 + 00 + 4D + 01+ 00 + 00 + 01)

TABLE I.3.8.7.2-1 PAYLOAD RS-422 EXTERNAL INTERFACE DATA ELEMENT

DESCRIPTION	SOURCE	DESTINATION	FREQUENCY	DATA FORMAT
RS-422 Payload to RIC				
PEP Bundle Request	PLD	RIC	Async	RS-422
PEP Procedure Execution Request	PLD	RIC	Async	RS-422
Payload Health and Status	PLD	RIC	1 Hz	RS-422
EXPRESS Telemetry Downlink Data	PLD	RIC	Async	RS-422
Rack Time Request	PLD	RIC	Async	RS-422
Ancillary Data Config Control	PLD	RIC	Async	RS-422
EMU File Transfer Request	PLD	RIC	Async	RS-422
PLD File Transfer Request	PLD	RIC	Async	RS-422
PLD File Transfer Data Block	PLD	RIC	Async	RS-422
RIC to RS-422 Payload				
Ancillary Data Set	RIC	PLD	Async,.1, 1 Hz	RS-422
Broadcast Ancillary Data Packet	RIC	PLD	10 Hz	RS-422
Payload Command	RIC	PLD	Async	RS-422
Payload Request Response	RIC	PLD	Async	RS-422
Rack Time Response	RIC	PLD	Async	RS-422
EMU File Transfer Request	RIC	PLD	Async	RS-422
PLD File Transfer Request	RIC	PLD	Async	RS-422
PLD File Transfer Data Block	RIC	PLD	Async	RS-422

I.3.8.7.3 PAYLOAD INTERFACE DATA ELEMENTS

I.3.8.7.3.1 EXPRESS HEADER

The subrack payload *should* use the header word format defined in Table I.3.8.7.3.1-1, EXPRESS Header, during communications between the subrack payload and the RIC CSCI across the physical ANSI/TIA/EIA-422 interface or across the logical Ethernet interface through the PEHB. Requests to the RIC can originate from the PEP (Command from Ground Station), laptop, or in a very few cases, a subrack payload. The data types for the parameters in the EXPRESS Header are 16-bit integer. The only exception is that the first word (16-bit integer) of the EXPRESS Header will be divided to one 4-bit integer (Header Version) and one 12-bit integer (Message Byte Count). EXPRESS header including Version (0 h), Message Byte Count (sum of the bytes from Message Type to the last message data byte in Hex, but not including the RS-422 checksum word), Message Type (RIC unique identifier for the command/data/status contained in the message), and Function Code (source or destination) Function codes are unique for each interface.

TABLE I.3.8.7.3.1-1 EXPRESS HEADER

MSB															LSB
Header Version (4 bits)				Message Byte Count (12 bits)											
Command Message Type/Measurement Message Type															
Function Code (Source)															
Function Code (Destination)															
Message Byte Count = Total Remaining Bytes in associated message, excluding Serial Checksum Words where applicable															

I.3.8.7.3.2 UNIQUE IDENTIFIER NUMBERS

The subrack payload **shall** use the TCP port number, IP Address for TCP/IP, and Function Code which are assigned in PDL by the ISS Program after the PD promotes the C&DH Data Set. Subrack payloads using the Ethernet interface use a subnet mask of 255.255.0.0. The subrack payload's Ethernet port number is 6215. Subrack payloads application resident on the EXPRESS Rack laptop will use the specific EXPRESS Rack laptop's IP address (obtained from the ISS Program) with unique port number (assigned within the C&DH data set in PDL).

A unique Function Code is assigned to each PAS and subrack payload interface and is used by the RIC for communication with the subrack payload application and subrack payload. For a subrack payload with both RS-422 and Ethernet interfaces in a single MLE or ISIS location, only one interface will be accessed by the RIC at a time. Switching between the interfaces requires an update to the Payload Configuration File Format table in the RIC which involves shutdown of the subrack payload. For a multiple locker or drawer payload, it is possible to interface to an RS-422 interface in one locker/drawer and an Ethernet interface in another locker/drawer. An additional Function Code would be assigned for the second interface. Table I.3.8.7.3.2-1 defines Function Codes for payloads, RIC, and Ground Station.

TABLE I.3.8.7.3.2-1 FUNCTION CODE ASSIGNMENTS

RACK LOCATION/FUNCTION	ASSIGNMENT
RIC	0001 h
Ground Station	000F h
Individual PLD/PA	0010 h - FFFE h
RIC Reserved	0000 h, 0002 h – 000E h, and FFFF h

I.3.8.7.3.3 EXPRESS TELEMETRY SECONDARY HEADER

The EXPRESS telemetry secondary header is contained within the data field of the EXPRESS packet and subsequently the CCSDS user data field when downlinked. This header identifies the type of telemetry, and optionally, sequence count, and time tag. The subrack payload *should* use the format of the EXPRESS telemetry secondary header specified in Table I.3.8.7.3.3-1 for telemetry data downlink.

TABLE I.3.8.7.3.3-1 EXPRESS TELEMETRY SECONDARY HEADER

MSB															LSB
Telemetry Data Type															
Sequence Count (Per Telemetry Data Type)*															
Time Tag (Most Significant Bit (MSB) of Coarse Time)*															
Time Tag (Least Significant Bit (LSB) of Coarse Time, LSB = 1 second)*															
*RIC generated telemetry will use as shown. Payload usage is optional; however, it is suggested this format be used for PLDs needing to rebuild messages on the ground.															

I.3.8.7.3.4 PAYLOAD TELEMETRY PACKET

All payload telemetry from the subrack payload to the RIC *should* be packetized in accordance with the packet format shown in Table I.3.8.7-2. The payload downlink telemetry packet must include the EXPRESS Header, EXPRESS telemetry secondary header, and subrack payload telemetry data. The sync word will be in front of the EXPRESS Header, but is not part of the telemetry message. For an RS-422 subrack payload, the serial checksum word will be at the end of the packet.

For a downlink telemetry packet, the destination Function Code is the RIC (0001h), and the Message Type is 009Ch in the EXPRESS Header. The first word of the EXPRESS telemetry secondary header (telemetry Data Type) along with the source Function Code in the EXPRESS Header is used by the RIC to identify the telemetry PLD APID on Telemetry Configuration File Format for use in construction of the CCSDS header. The HOSC uses the Data Type as the Format ID. The telemetry Data Type can be any value between 0001 h and FFFF h (default). The RIC can handle up to six data types per subrack payload: one (1) for the default pass (FFFF) and five (5) for exception passes based on the telemetry Data Type. The Sequence Count and Time Tag (two (2) words) in the EXPRESS telemetry secondary header are recommended but are optional.

Telemetry can be of variable length. The maximum size of each packet is 1,248 data bytes plus the sync word, the EXPRESS Header, and the EXPRESS telemetry secondary header. The subrack payload telemetry packet will always be in an even number of bytes. To select the telemetry downlink channel via either low rate, medium rate, or the high rate, the PD submits the selection in the PDL C&DH Data Set Downlink Telemetry Data Packets form which will be incorporated into the Telemetry Configuration File Form. The RIC does not send a response if telemetry data is sent while the link is not available. The RIC simply collects and forwards the data for downlink during the periods of time when the telemetry link is available. All telemetry data sent while the link is not available is discarded. More than one telemetry APID may be assigned to a single subrack payload, depending on requirements.

The subrack payload telemetry rate is entirely dependent on the rate the subrack payload transmits the telemetry to the RIC and the downlink resources available to the RIC. Subrack payload telemetry received from a subrack payload that exceeds the RIC resources to downlink or comes from a subrack payload that does not have an entry in the Telemetry Configuration table will be discarded. However, prolonged periods of excessive RS-422 traffic can cause RIC problems that may result in a RIC reboot. Excessive Ethernet traffic will be throttled by the RIC and could cause the data to be backed up on the subrack payload side. The EXPRESS laptop and Ground Station are notified of data loss through an increase in the data lost count in the EXPRESS Rack Health and Status data. When a valid subrack payload message is received but the telemetry path designated in the Telemetry Configuration tables has not been activated using the Downlink Configuration Control command to the RIC, a Payload Response will be sent to the subrack payload. The invalid response will be reported to the Ground Station and the EXPRESS laptop. The Downlink Configuration Control table is used to notify the RIC to start or stop the telemetry service. When the subrack payload input is less than the minimum telemetry data size, the RIC will fill at the end of the packet to meet the minimum length requirement.

For a subrack payload telemetry packet, the RIC verifies the EXPRESS Header and the telemetry Data Type in the EXPRESS telemetry secondary header. For an Ethernet telemetry packet, the RIC removes the sync word, adds the CCSDS header in front of the EXPRESS Header, and sends the message to the designated channel per the Telemetry Configuration File in the RIC. For an RS-422 subrack payload telemetry packet, the RIC removes the sync word and the serial checksum word and adds the CCSDS header before sending the message out.

I.3.8.7.3.5 EXPRESS RIC INTERFACE REQUESTS AND RESPONSES

Six types of request for RIC or PEP services that can be made by subrack payloads are PEP Bundle Request, PEP Procedure Execution Request, Rack Time Request, Ancillary Data Configuration Control, Payload File Transfer Request, and EXPRESS Memory Unit (EMU) Payload File Transfer Request. PEP-related requests, originating from the Ground Station, EXPRESS laptop, or the payload are sent to the PL MDM via the EXPRESS Rack Health and Status data. Figure I.3.8.7-4 defines the end-to-end flow of the subrack payload service request. The request response from the PEP will be forwarded to the subrack payload by the RIC when the response arrives from the PEP, normally within 1 to 20 seconds depending upon how many other commands/request responses are already in the queue.

A. The requests and messages initiated by the subrack payload when communicating with the RIC CSCI *should* be in accordance with Table I.3.8.7.3.5-1, Request Message Type Assignments/Location, and Table I.3.8.7.3.5-2, Status Message Type Assignments/Location.

B. The request header/message/word definitions used by the subrack payload *should* be in accordance with Tables I.3.8.7.3.5.1-1, I.3.8.7.3.5.2-1, I.3.8.7.3.5.3-1, I.3.8.7.3.5.4-1, I.3.8.7.3.5.5.1-1 and I.3.8.7.3.5.5.2-1.

TABLE I.3.8.7.3.5-1 REQUEST MESSAGE TYPE ASSIGNMENTS/LOCATION

MESSAGE TYPE		FUNCTION CODE	
DESCRIPTION	**ASSIGNMENT**	**SOURCE**	**DESTINATION**
REQUEST MESSAGES			
PEP Bundle Request	0049 h	GS, LAP, PLD	RIC
PEP Procedure Execution Request	004C h	GS, LAP, PLD	RIC
Rack Time Request	004D h	LAP, PLD	RIC
Ancillary Data Configuration Control	0020 h	GS, LAP, PLD, PA	RIC
PLD File Transfer Request	0041 h	PLD, RIC	RIC, PLD
EMU File Transfer Request	0042 h	GS, LAP, PLD	RIC
Configuration Control Messages			
Ancillary Data Configuration Control	0020 h	GS, LAP, PLD, PA	RIC

TABLE I.3.8.7.3.5-2 STATUS MESSAGE TYPE ASSIGNMENTS/LOCATION

MESSAGE TYPE		FUNCTION CODE	
DESCRIPTION	**ASSIGNMENT**	**SOURCE**	**DESTINATION**
RACK RESPONSES			
Rack Time Response	0080 h	RIC	LAP, PLD
PLD Request Response	0082 h	RIC	PLD
PA Request Response	0082 h	LAP	PA
Data Packet			
Ancillary Data Set	0098 h	RIC	PLD, PA
Broadcast Ancillary Data Set	0099 h	RIC	PLD, PA
Payload Health and Status	009B h	PLD	RIC
EXPRESS Telemetry Packet	009C h	PLD	RIC
PLD File Transfer Data Block	00A4 h	PLD, RIC	RIC, PLD
Rack Analog and Discrete Data	00B0 h	LAP*	PA
*In this instance, LAP refers to the LAP Named Pipe interface to a PA and not the LAP function code. Reference specific message type definition for source or destination function code.			

I.3.8.7.3.5.1 PEP BUNDLE REQUEST

The PEP bundles contain groups of Timeliner Procedures (Sequences) that are to be automatically executed on the PL MDM. It could consist of monitoring parameters, issuing messages, issuing commands (at a specific time, or after a specific time delay if desired, etc.). The purpose of the PEP Bundle Request is to request a bundle of Timeliner commands on the

PEP to be installed, halted, or removed. Table I.3.8.7.3.5.1-1 defines the format for the PEP Bundle Request. The Bundle Identifier Parameter is a unique integer value assigned by the PEP relating to the bundle of Timeliner commands stored on the PL MDM.

TABLE I.3.8.7.3.5.1-1 PEP BUNDLE REQUEST

MSB															LSB
SYNC (55AA)															
EXPRESS Header (Message Type = 0049 h)															
PEP Request Identifier: (Integer value) 21 = Install, 22 = Halt, 23 = Remove															
Bundle Identifier Parameter: (Unique value relating to a User Interface Language (UIL) Bundle assigned by PEP)															

I.3.8.7.3.5.2 PEP PROCEDURE EXECUTION REQUEST

The purpose of the PEP Procedure Execution Request is to request a Timeliner sequence on the PEP to be started, stopped, or resumed. Table I.3.8.7.3.5.2-1 defines the format for the PEP Procedure Execution Request. The Payload Dependent Sequence Identifier is a unique integer value, assigned by the PEP, relating to the Timeliner sequence stored on the PL MDM. The procedures are compiled into the bundles using the compiler for Timeliner.

Once the appropriate Timeliner files are on the PL MDM, commands may be issued to the Timeliner (or requested of the PL MDM by a payload) for the execution of those procedures.

TABLE I.3.8.7.3.5.2-1 PEP PROCEDURE EXECUTION REQUEST

MSB															LSB
SYNC (55AA)															
EXPRESS Header (Message Type = 004C h)															
Request Identifier: (Integer value) 18 = Start, 19= Stop, 20 = Resume															
Payload Dependent Sequence Identifier: (Unique integer value relating to the sequence assigned by PEP)															

I.3.8.7.3.5.3 RACK TIME REQUEST

The subrack payload will receive broadcast time either with the predefined rate as specified by the subrack payload input on the PDL C&DH section, or by periodic request from the subrack payload. The predefined rate will be in the Payload Configuration Control File (ISS Program generated based on subrack payload input information in the PDL). The time increment is every 30 seconds. For example, if the time request rate on the PDL is “0”, the subrack payload will receive the time every 30 seconds. If the request rate is “1”, the subrack payload will receive the time every 60 seconds. If the request rate is “2”, the subrack payload will receive the time every 90 seconds. If the subrack payload requires updates more frequently than once every 30 seconds, the subrack payload *should* send the rack time request to the RIC and the RIC will respond within a few seconds after the request has been processed. The rack time request format is defined in Table I.3.8.7.3.5.3-1. The requesting source is identified by the source Function Code in the EXPRESS Header. In response to the Rack Time Request the RIC distributes the PEP Broadcast time in the format described in the Rack Time Response Table I.3.8.7.3.5.3-2. The RIC time response will be based on the last broadcast time received from the PL MDM.

TABLE I.3.8.7.3.5.3-1 RACK TIME REQUEST

MSB															**LSB**
SYNC (55AA)															
EXPRESS Header (Ref. Table 112.3.1-1) (Message Type = 004D h)															

TABLE I.3.8.7.3.5.3-2 RACK TIME RESPONSE

MSB		
SYNC (55AA)		
EXPRESS Header **(Message Type = 0080 h)**		
CCSDS Preamble Field =‘01010000’B	MSB of BCD Year Field (19-20)	
LSB of BCD Year Field (0-99)	BCD Month Field (1-12)	
BCD Day of Month Field (1-31)	BCD Hour Field (0-23)	
BCD Minutes Field (0-59)	BCD Seconds Field (0-59)	
Spare - 000 h		Binary Sub-seconds high (0-15)*
Binary Sub-seconds Low (0-65535)*		
Universal Time Coordinate (UTC) Time Conversion Parameter (0-65535) Always set to zero. Note this data is contained in Broadcast Ancillary Data		
Non-CCSDS Seconds/sub-seconds (0-65535) The one’s portion of the seconds plus the sub-seconds information of the CCSDS time converted to a straight binary count rounded to the nearest 256 microsecond (LSB = 256 microsec)		
* Combining sub-second high and sub-second low, the total range is 0 - 1048560 at one microsecond per count.		

I.3.8.7.3.5.4 ANCILLARY DATA CONFIGURATION CONTROL

The purpose of this command is to request Unique Ancillary Data (UAD) set or Broadcast Ancillary Data (BAD) frame routing or to request a periodic ancillary data set routing. The Ancillary Data Configuration Control can come from the Ground Station, EXPRESS laptop, PAS, or subrack payload. After a UAD set or BAD frame routing request is validated, the ancillary data configuration table is updated. If a UAD set has been requested, a service request is then sent to the PEP to acquire the requested ancillary data set. The ancillary data configuration table is not updated after a periodic ancillary data set routing request has been validated. Invalid responses will be reported to the Ground Station, EXPRESS laptop, PAS, or subrack payload in response to command (request) validation. The PEP can deliver up to 10 UAD sets per second. The RIC can deliver up to 10 messages with a combination of UAD sets or Broadcast Ancillary data frames per second. For de-coding UAD set word messages, reference D684-11300-01, Unique Ancillary Data Sets Interface Definition Document.

The Request ID specifies whether to add or delete the ancillary data configuration entry associated with the Data Set ID and Function Code in the request from the Ancillary Data Configuration Control, Table I.3.8.7.3.5.4-1. If the Request ID is an Aperiodic Request, the ancillary data set will be requested once (one shot) and the Ancillary Data Configuration file will not be changed. The Ancillary Data Configuration Control only consists of cyclically required Ancillary data sets shown in Table I.3.8.7.3.5.4-2.

TABLE I.3.8.7.3.5.4-1 ANCILLARY DATA CONFIGURATION CONTROL

MSB															LSB
SYNC (55AA)															
EXPRESS Header (Message Type = 0020 h)															
Destination Function Code (Destination of the Ancillary Data)															
Spare (00 b) (2 bits)		Request Identifier[1] (2 bits)		Spare (0 h) (4 bit)				Data Set Identifier/Frame Number[2] (8 bits)							
Notes [1] Request Identifier: 00 b = Aperiodic (One shot) Request (no change to Ancillary Configuration Table and does not apply to Broadcast Ancillary Data Frame) 01 b = Add Entry, 11 b = Delete Entry [2] Data Set Identifier: 01 h - 64 h = 1 thru 100 Ancillary Data Sets ID for Ancillary Data Frame Number: 80 h - E3 h = 0 thru 99 Frame Number for Broadcast Ancillary Data E4 h all frames of Broadcast Ancillary Data to PLD FF h = Unused Data Set Identifier or Frame Number															

TABLE I.3.8.7.3.5.4-2 ANCILLARY DATA SET

MSB															LSB
SYNC (55AA)															
EXPRESS Header (Message Type = 0098 h)															
Spare (0 h) (8 bits)								Data Set Identifier* (8 bits)							
Ancillary Data Set Word*															
Ancillary Data Word n (Maximum of 23)															
*Data Set Identifier: 01 h - 64 h = 1 thru 100 Ancillary Data Sets															

The Data Set ID/Frame Number specifies the UAD set or Broadcast ancillary data frame to be acquired for the Function Code.

The subrack payload will receive the Broadcast Ancillary data with 64 words per packet shown in Table I.3.8.7.3.5.4-3. Each packet includes a CCSDS header (the first eight (8) words), 36 words of one (1)-Hz data, and 20 words of 0.1-Hz data. It takes ten (10) seconds to complete the transmission of the Broadcast Ancillary Data Set. For de-coding Broadcast Ancillary data set word messages, reference SSP 50540. The subrack payload receiving the Broadcast Ancillary data frame *should* check the Frame ID (least 7 significant bits of the CCSDS header word eight (8)) before further processing.

TABLE I.3.8.7.3.5.4-3 BROADCAST ANCILLARY DATA SET

Field ID	Word #	MSB					LSB
SYNC (55AA)							
EXPRESS Header	1	Header Version	Message Byte Count				
	2	Message Type = 0099 h					
	3	Function Code (source)					
	4	Function Code (destination)					
Primary CCSDS Header	1	Version #	Type	Sec Hdr Flag	APID (11 bit field)		
	2	Seq Flags	Packet Sequence Count (14 bits)				
	3	Packet Length (# octets - 1 following this field)					
Sec CCSDS Header	4	Time (MSBs of Course time)					
	5	Time (LSBs of Course Time, LSB = 1 second)					
	6	Fine Time	Time ID	Check word	Spare	Packet Type	
	7	Spare	Element ID	1	Version ID	Format ID	
	8	Spare 9 bit Field	Frame ID (7 bit field)				
1 Hz Area	9 to 44	Broadcast Ancillary Data Word					
0.1 Hz Area	45 to 64	Broadcast Ancillary Data Word					

I.3.8.7.3.5.5 FILE TRANSFER REQUEST

A subrack payload can send a request for file transfer service to the RIC. The File Transfer ID in the Payload File Transfer Request (see table in paragraph I.3.8.7.3.5.5.1) is either subrack payload to EMU or EMU to subrack payload. The File Transfer ID in the EMU File Transfer Request (see table in paragraph I.3.8.7.3.5.5.2) is EMU to ground station. Include the EXPRESS Header, request type, File Transfer ID, File name and Block Number to restart (if required) as described in the tables in paragraph I.3.8.7.3.5.5.1 and I.3.8.7.3.5.5.2. The Block Number to restart is used to restart a file transfer either for read or write at specified block numbers, and that must be between one and the maximum block number of the file.

I.3.8.7.3.5.5.1 PAYLOAD FILE TRANSFER REQUEST

The Payload File Transfer Request command provides the capability for a subrack payload to request a file transfer between the subrack payload and the RIC EMU. The format a subrack payload *should* use for the Payload File Transfer Request is shown in Table I.3.8.7.3.5.5.1-1.

TABLE I.3.8.7.3.5.5.1-1 PAYLOAD FILE TRANSFER REQUEST

<table>
<tr><th>MSB</th><th></th><th></th><th></th><th></th><th></th><th></th><th></th><th></th><th></th><th></th><th></th><th></th><th></th><th></th><th>LSB</th></tr>
<tr><td colspan="16">SYNC (55AA)</td></tr>
<tr><td colspan="16">EXPRESS Header
(Message Type = 0041 h)</td></tr>
<tr><td colspan="2">1</td><td colspan="2">2</td><td colspan="12">Reserved for RIC</td></tr>
<tr><td colspan="8">Filename[3] (character #1)</td><td colspan="8">Filename (character #2)</td></tr>
<tr><td colspan="8">Filename (character #3)</td><td colspan="8">Filename (character #4)</td></tr>
<tr><td colspan="8">Filename (character #5)</td><td colspan="8">Filename (character #6)</td></tr>
<tr><td colspan="8">Filename (character #7)</td><td colspan="8">Filename (character #8)</td></tr>
<tr><td colspan="8">Filename (character #9)</td><td colspan="8">Filename (character #10)</td></tr>
<tr><td colspan="8">Filename (character #11)</td><td colspan="8">Filename (character #12)</td></tr>
<tr><td colspan="16">Block Number to Restart</td></tr>
<tr><td colspan="16">[1] Transfer Request Type :-----------------00 b = File Transfer Start, 01 b = File Transfer Stop,
10 b = File Transfer Restart-------------11 b = File Transfer Complete

[2] File Transfer ID:-------00 b = payload to EMU------------------------------01 b = EMU to payload

[3] The Filename is NUL (00 h) ASCII character byte filled on the end for any Filename plus extension less than 12 characters.</td></tr>
</table>

The source Function Code in the EXPRESS Header identifies the subrack payload making the Payload File Transfer Request. The Transfer Request Type identifies the type of RIC File Transfer Service requested. The available requests are File Transfer Start, File Transfer Stop, File Transfer Restart, and File Transfer Complete.

The File Transfer ID identifies the direction of the Payload File Transfer Request, either "payload to EMU" or "EMU to payload." Only one (1) file transfer in each direction (EMU to payload or payload to EMU) will be allowed to take place at any one time. The Payload ("PLD") directory will be used in all subrack payload file transfer transactions.

The Filename is the name of the file being stored to or retrieved from the EMU. When the incoming Filename is new, the RIC commands the EMU to create a new Filename and store the data. When the Filename already exists on the EMU, the file will be overwritten by the new file of the same name. A valid Filename consists of 12 ASCII character bytes configured as follows:

A Filename of zero (0) to eight (8) case sensitive ASCII character bytes optionally followed by NUL (00 h) ASCII character bytes (0 ASCII characters in the filename prefix is only valid if there is at least one (1) ASCII character in the file extension.), or the period (2E h) delimiter ASCII character byte optionally followed by NUL ASCII character bytes, or an extension of zero (0) to three (3) case sensitive ASCII character bytes followed by NUL ASCII character bytes (zero (0) ASCII characters in the file extension is only valid if there is at least one (1) ASCII character in the file prefix). All subrack payload files will be stored in the "PLD" directory on the EMU.

In all cases, the 12 ASCII character fields will have a contiguous set of characters forming a valid Filename and will be (if required) end-filled with NUL ASCII character bytes. Valid Filename examples would include: filename.ext, f.e, file, .ex

The Payload File Transfer Request can only come from the subrack payloads. Once validated and initiated, until the file transfer transaction has been terminated, ONLY the requesting subrack payload is allowed to send further Payload File Transfer Requests of that specific File Transfer ID type (EMU to payload or payload to EMU). After successful validation:

For a “payload to EMU” transfer:

The RIC will set “payload-to-EMU File Transfer” status bit in EXPRESS Rack Health and Status to “In Progress.”

If upon file transfer transaction startup an error occurs in storing data to the EMU:

1. The RIC will send the originating Payload File Transfer Request back to that subrack payload except the RIC will set the Transfer Request Type to “File Transfer Stop.”
2. The RIC will send an “EMU File Access Error” Rack Request Response to the EXPRESS laptop and Ground Stations, via telemetry.
3. The RIC will set the “payload-to-EMU File Transfer” status bit in the EXPRESS Rack Health and Status to “Not in Progress.”

The RIC will expect valid, contiguous Payload File Transfer Data Blocks to begin arriving from the requesting subrack payload (Source Function code of the Payload File Transfer Request).

Upon receipt of a Payload File Transfer Data Block with the Current Block Number equal to the Total Block Number:

1. The RIC will send the originating Payload File Transfer Request back to that subrack payload except the RIC will set the Transfer Request Type to “File Transfer Complete.”
2. The RIC will set the “payload to EMU File Transfer” status bit in the EXPRESS Rack Health and Status to “Not in Progress.”

Upon receipt of a Payload File Transfer Data Block with a noncontiguous Current Block Number, the RIC will send the originating Payload File Transfer Request back to that subrack payload except the RIC will set the Transfer Request Type to “File Transfer Restart” and the ‘Block Number to Restart’ will be set to the correct contiguous Current Block expected.

The following conditions will cause the RIC to terminate the payload file transfer of “payload to EMU” ID at any time prior to receiving a Current Block Number equal to the Total Block Number:

If an error occurs in storing data to the EMU:

1. The RIC will send the originating Payload File Transfer Request back to that subrack payload except the RIC will set the subrack payload Request Type to “File Transfer Stop.”
2. The RIC will send an “EMU File Access Error” Rack Request Response to the EXPRESS laptop and Ground Stations, via telemetry.
3. The RIC will attempt to delete the portion of the subrack payload file that has been stored on the EMU.
4. The RIC will set the “payload to EMU File Transfer” status bit in the EXPRESS Rack Health and Status to “Not in Progress.”

If a contiguous period of 10 seconds passes by without the receipt of a valid Payload File Transfer Data Block from the valid subrack payload source:

1. The RIC will send the originating Payload File Transfer Request back to that subrack payload except the RIC will set the Transfer Request Type to “File Transfer Stop.”
2. The RIC will send a “Payload to EMU File Transfer Terminated” Rack Request Response to the EXPRESS laptop and Ground Stations, via telemetry.
3. The RIC will delete the portion of the subrack payload file that has been stored on the EMU.
4. The RIC will set the “Payload to EMU File Transfer” status bit in the EXPRESS Rack Health and Status to “Not in Progress”.

If the RIC receives a Payload File Transfer Request with an ID of “Payload to EMU” and a Transfer Request Type of “File Transfer Stop”:

1. The RIC will delete the portion of the subrack payload file that has been stored on the EMU.
2. The RIC will send a “Payload to EMU File Transfer Terminated” Rack Request Response to the EXPRESS laptop and Ground Stations, via telemetry.
3. The RIC will set the “Payload to EMU File Transfer” status bit in the EXPRESS Rack Health and Status to “Not in Progress” at any time prior to receiving a Current Block Number equal to the Total Block Number.

At any time prior to receiving a Current Block Number equal to the Total Block Number, if the RIC receives a valid Payload File Transfer Request with an ID of “Payload to EMU” and a Transfer Request Type of “File Transfer Restart” or “File Transfer Complete,” the RIC will ignore the request.

For an “EMU to Payload” transfer and a Transfer Request Type of “File Transfer Start” or a “File Transfer Restart” with a “Block Number to Restart”:

The RIC will set “EMU to Payload File Transfer” status bit in EXPRESS Rack Health and Status to “In Progress.”

Upon file transfer transaction startup an error in retrieving data from the EMU:

1. The RIC will send the originating Payload File Transfer Request back to that subrack payload except the RIC will set the Transfer Request Type to “File Transfer Stop.”
2. The RIC will send an “EMU File Access Error” Rack Request Response to the EXPRESS laptop and Ground Stations, via telemetry.
3. The RIC will set the “EMU to Payload File Transfer” status bit in the EXPRESS Rack Health and Status to “Not in Progress.”

The RIC will start sending Payload File Transfer Data Blocks, reference Table I.3.8.7.3.5.5.1-2, to the requesting payload (Source Function code of the Payload File Transfer Request).

Upon sending the Current Block Number equal to the Total Block Number, the RIC will set the “EMU to Payload File Transfer” status bit in the EXPRESS Rack Health and Status to “Not in Progress.”

TABLE I.3.8.7.3.5.5.1-2 PAYLOAD FILE TRANSFER DATA BLOCK

<table>
<tr><th>MSB</th><th></th><th></th><th></th><th></th><th></th><th></th><th></th><th></th><th></th><th></th><th></th><th></th><th></th><th></th><th>LSB</th></tr>
<tr><td colspan="16" align="center">SYNC (55AA)</td></tr>
<tr><td colspan="16" align="center">EXPRESS HEADER
(MESSAGE TYPE = 00A4 H)</td></tr>
<tr><td colspan="16">Current Block Number</td></tr>
<tr><td colspan="16">Total Block Number</td></tr>
<tr><td colspan="8">Data Byte #1</td><td colspan="8">Data Byte #2</td></tr>
<tr><td colspan="16"></td></tr>
<tr><td colspan="8">Data Byte #n-1</td><td colspan="8">Data Byte #n
(where n <= 1248 bytes per block)</td></tr>
</table>

At any time prior to sending a Current Block number equal to the Total Block Number. If the RIC receives a valid Payload File Transfer Request with an ID of “EMU to Payload” and a Transfer File Type of “File Transfer Restart,” the RIC will find the correct “Block Number to Restart” of data and continue the file transfer transaction with the next block being sent having a Current Block Number equal to the “Block Number to Restart.”

The following conditions will cause the RIC to terminate the subrack payload file transfer of “EMU to Payload” File Transfer ID at any time prior to sending a Current Block Number equal to the Total Block Number:

If an error occurs in retrieving data from the EMU:

1. The RIC sends the valid subrack payload a Payload File Transfer Request with an ID “EMU to Payload” and a Transfer Request Type of “File Transfer Stop.”
2. The RIC will also issue a Rack Request Response of “EMU to Payload File Transfer Terminated” to the EXPRESS laptop and Ground Stations, via telemetry.
3. The RIC will set the “EMU to Payload File Transfer” status bit in the EXPRESS Rack Health and Status to “Not in Progress.”

The RIC receives a Payload File Transfer Request with an ID “EMU to Payload” and a Transfer Request Type of “File Transfer Stop”:

1. The RIC will also issue a Rack Request Response of “EMU to Payload File Transfer Terminated” to the EXPRESS laptop and Ground Stations, via telemetry.
2. The RIC will set the “EMU to Payload File Transfer” status bit in the EXPRESS Rack Health and Status to “Not in Progress.”

At any time prior to sending a Current Block Number equal to the Total Block Number, if the RIC receives a valid Payload File Transfer Request with an ID of “EMU to Payload” and a Transfer Request Type of “File Transfer Complete,” the RIC will ignore the request.

The following invalid responses will be reported, in response to EXPRESS command validation:

The Request Responses will be sent to the EXPRESS laptop and Ground Stations via telemetry and to the requesting payload.

The Payload Response error codes are defined in Table I.3.8.7.3.5.5.1-3.

The Payload File Transfer Data Block is the mechanism to transfer data between the RIC and subrack payloads. Table I.3.8.7.3.5.5.1-2 defines the format for the Payload File Transfer Data Block.

All file transfers to and from the RIC will be staged on the EMU. The Payload File Transfer Data Block command allows the user to control these file transfers. File transfers between the EMU and the EXPRESS laptop will be accomplished under the EXPRESS laptop control using a standard FTP mechanism. The RIC CSCI will not take part in this FTP file transfer.

The Current Block Number gives the block number of the Payload File Transfer Data Block. The maximum size of a Payload File Transfer Data Block is 1,248 data bytes. When the Payload File Transfer to be sent or received is larger than 1,248 data bytes, it will take multiple data blocks to complete the message.

TABLE I.3.8.7.3.5.5.1-3 REQUEST/PAYLOAD RESPONSE CODE (3 PAGES)

ERROR CODE		
REQUEST RESPONSE	**ERROR CODE (INTEGER)**	**REQUEST ERROR CODE DESCRIPTION**
No Error	0	Possible response to Procedure Execution Start, Procedure Execution Stop, Procedure Execution Resume, Install Bundle, Halt Bundle or Remove Bundle.
Invalid Ancillary Data Set Requested	1	Possible response to Ancillary Data Start request
Undefined Ancillary Data Set Requested	2	Possible response to Ancillary Data Start request
Request Ancillary Data Set Already Being Provided	3	Possible response to Ancillary Data Start request
Request Ancillary Data Set Not Being Provided	4	Possible response to Ancillary Data Stop request
Invalid Cycle Flag	5	Possible response to Ancillary Data Start request
Invalid File ID	15	Possible response to payload File Read or File Write request
PEP Command Buffer Full	20	Possible response to any payload request
Queue Full	21	Possible response to any payload request
Invalid Payload Request	23	Possible response to any payload request
Invalid Payload Index	24	Possible response to any payload request or CCSDS command
Invalid Sequence ID	30	Possible response to Procedure Start, Procedure Stop, or Procedure Resume request
Invalid Bundle ID	31	Possible response to Install Bundle, Halt Bundle, or Remove Bundle request
Sequence ID Not Found	32	Possible response to Procedure Start, Procedure Stop, or Procedure Resume request
Bundle ID Not Found	33	Possible response to Install Bundle, Halt Bundle, or Remove Bundle request
Unauthorized Sequence Execution Request	34	Possible response to Procedure Start, Procedure Stop, or Procedure Resume request
Unauthorized Bundle Execution Request	35	Possible response to Install Bundle, Halt Bundle, or Remove Bundle request
Timeliner Cmd Queue Full	36	Possible response to Install Bundle, Halt Bundle, Remove Bundle, Procedure Start, Procedure Stop, or Procedure Resume request

TABLE I.3.8.7.3.5.5.1-3 REQUEST/PAYLOAD RESPONSE CODE (3 PAGES)

ERROR CODE		
REQUEST RESPONSE	**ERROR CODE (INTEGER)**	**REQUEST ERROR CODE DESCRIPTION**
Max Transactions in Progress	64	Possible response to a Start File Read or a Start File Write
FMT Timeout	68	Possible response to a Start File Read or a Start File Write.
Unauthorized File Request	76	Possible response to a Start File Read or a Start File Write.
File Transfer Completed	79	Possible response to a Start File Read or a Start File Write.
Restart File Transfer	80	Possible response to a Start File Read or a Start File Write.
File Transfer Error	82	Possible response to a Start File Read or a Start File Write.
Invalid Express Header Version	-268	EXPRESS header version does not match current version
Invalid Express Header Byte Count	-269	Message byte count does not match message length or pre-defined length
Invalid Express Header Message Type	-270	Message type value does not match any defined RIC message type
Invalid Source Function Code	-271	Source Function Code Does not exist or is not allowed to send this Message Type
Source Function Code Not Active	-272	Source Function Code is not active
Invalid Destination Function Code	-273	Destination Function Code does not exist or Destination Function Code is not accessible.
Destination Function Code Not Active	-274	Destination Function Code is not active
Invalid Mode	-275	command incompatible with RIC operating mode
EMU File Access Error or File not Found	-276	access to EMU lost due to memory or communication error or file not found
Invalid Ancillary Data Set	-280	data set requested is outside valid range and does not exist
Invalid Add Entry Request	-281	entry to be added already exists or rack equipment is not available for addition
Invalid Delete Entry Request	-282	entry to be deleted does not exist or is not a valid entry to delete
Invalid Modify Entry Request	-283	entry to be modified does not exist or is not a modifiable entry
Invalid Checksum Word	-286	A command or response received from the PEP has an invalid Checksum Word.
PLD Is Activated	-287	PLD commanded to be modified is powered and/or has an activated communication interface
Invalid Discrete Request	-288	Discrete channel set command contains invalid value
Invalid Rack Location	-293	location has already been assigned to another Function Code or is out of legal range
Invalid PLD Application Function Code	-295	PA Function Code is not unique in this rack
Invalid Serial Baud Rate Selected	-297	invalid serial baud rate was selected
Invalid Request Identifier	-298	undefined request identifier was entered
Ancillary Data Table Full	-308	Maximum number of Ancillary Data entries exceeded (either >16 Function Code entries or > 10 ancillary data sets requested per Function Code)
Duplicate IP Address	-309	IP Address already exists in another entry
Duplicate Subset ID	-310	Subset ID already exists in another entry
Invalid Comm Port Type	-311	Comm Port Type selected is not a valid choice for that entry
Rack Table Full	-312	Attempt to add entry when the Rack Config Table is already full. A current entry must be removed to allow a new entry.

TABLE I.3.8.7.3.5.5.1-3 REQUEST/PAYLOAD RESPONSE CODE (3 PAGES)

ERROR CODE		
REQUEST RESPONSE	**ERROR CODE (INTEGER)**	**REQUEST ERROR CODE DESCRIPTION**
Invalid Function Code	-313	Function Code is out of valid range or is already assigned to another entry or Source Function Code does not match Ancillary Data Destination Function Code
Bogus Execution Path	-315	An internal RIC invalid call was made.
Invalid Health and Status Size	-316	An invalid size was entered for the Health and Status Size
Invalid TCP/IP Port Number	-317	TCP/IP Port number was out of valid range
Rack Telemetry Config Table Full	-332	An entry cannot be added until a current entry is deleted, because the Rack Telemetry Config Table is full.
Rack Telemetry Config Checkpoint Failure	-334	An internal RIC failure has inhibited the update of the Telemetry Config Checkpoint file on the EMU.
Ancillary Config Checkpoint Failure	-336	An internal RIC failure has inhibited the update of the Ancillary Data Config Checkpoint file on the EMU.
Invalid Entry Specified	-340	The entry to be modified is invalid.
EMU to GS File Transfer in Progress	-341	A Ground Station Transfer is already in progress when another transfer request is made.
EMU to GS File Transfer Terminated	-342	A Ground Station Transfer was terminated before it was complete.
Invalid Block Number	-343	A File transfer request contains an invalid block number to restart from.
Invalid Health and Status Size	-344	The PLD Health and Status message does not match the Rack Config Table configured size.
Payload Telemetry Config Table Full	-345	An invalid command to add PLD Telemetry Config entry to a full PLD Telemetry configuration table.
Function Code Not Configured	-353	A command was issued to interface with a PLD Function Code that is not configured.
Invalid Channel Number	-363	Invalid channel number was entered
PLD to EMU File Transfer In Progress	-368	PLD to EMU File Transfer was requested while one is already is in progress
PLD to EMU File Transfer Terminated	-369	PLD to EMU File Transfer was terminated while in progress
EMU to PLD File Transfer In Progress	-370	EMU to PLD File Transfer was requested while one is in progress
EMU to PLD File Transfer Terminated	-371	EMU to PLD File Transfer was terminated while in progress
Invalid EMU File Checksum	-376	A file being retrieved from the EMU contains an invalid checksum.
Invalid Laptop File Checksum	-377	A file being retrieved from the laptop contains an invalid checksum.
Laptop File Access Error or File not Found	-378	Access to laptop storage drive lost due to memory or communication error.

The Total Block Number gives the number of Payload File Transfer Data Block message blocks which must be sent or received to complete the Payload File Transfer. Note that the maximum numbers of Payload File Transfer Data Blocks that can be sent are 65,535, or in other words, a single maximum file size of 81,787,680 data bytes in length can be transferred.

If a contiguous period of 10 seconds passes without receipt of a valid File Transfer Data Block from the RIC, it is recommended the subrack payload consider either communication lost or a transmit error. The subrack payload will delete the portion of the file that has been received and resubmit the Payload File Transfer Request.

I.3.8.7.3.5.5.2 EMU FILE TRANSFER REQUEST

Subrack payloads also have the capability to issue EMU File Transfer Control commands to request a file transfer between the EMU and Ground Station. Table I.3.8.7.3.5.5.2-1 defines the format for the EMU File Transfer Control.

TABLE I.3.8.7.3.5.5.2-1 EMU FILE TRANSFER REQUEST

<table>
<tr><th>MSB</th><th></th><th></th><th></th><th></th><th></th><th></th><th></th><th></th><th></th><th></th><th></th><th></th><th></th><th></th><th>LSB</th></tr>
<tr><td colspan="16">SYNC (55AA)</td></tr>
<tr><td colspan="16">EXPRESS Header
(Message Type = 0042 h)</td></tr>
<tr><td colspan="2">1</td><td colspan="2">2</td><td colspan="12">Reserved for RIC</td></tr>
<tr><td colspan="8">Directory (character #1)</td><td colspan="8">Directory (character #2)</td></tr>
<tr><td colspan="8">Directory (character #3)</td><td colspan="8">/ (2F h)</td></tr>
<tr><td colspan="8">Filename [3] (character #1)</td><td colspan="8">Filename (character #2)</td></tr>
<tr><td colspan="8">Filename (character #3)</td><td colspan="8">Filename (character #4)</td></tr>
<tr><td colspan="8">Filename (character #5)</td><td colspan="8">Filename (character #6)</td></tr>
<tr><td colspan="8">Filename (character #7)</td><td colspan="8">Filename (character #8)</td></tr>
<tr><td colspan="8">Filename (character #9)</td><td colspan="8">Filename (character #10)</td></tr>
<tr><td colspan="8">Filename (character #11)</td><td colspan="8">Filename (character #12)</td></tr>
<tr><td colspan="16">Payload Dependent File Identifier (Not used by Payload)
(Unique integer value relating to a file stored on the PLD MDM assigned by PEP)</td></tr>
<tr><td colspan="16">Block Number to Restart</td></tr>
<tr><td colspan="16">[1] EMU Request Type : 00 b = File Transfer Start, 01 b = File Transfer Stop,
0 b = File Transfer Restart 11 b = File Transfer Complete
[2] File Transfer ID: 10 b = EMU to Ground Station 11 b = Reserved for RIC
[3] The Filename is NUL (00 h) ASCII character byte filled on the end for any Filename plus extension less than 12 characters.</td></tr>
</table>

For a File Transfer to Ground Station (for reading a file from the EMU and sending it to the configured Ground Station), the RIC CSCI will use the Telemetry Configuration table for establishing the telemetry path and APID.

The Directory identifies the EMU directory from which the file is being read.

The Filename is the name of the file being retrieved from the EMU. A valid Filename consists of 12 ASCII character bytes configured as follows:

1. A Filename of 0 to 8 case sensitive ASCII character bytes optionally followed by NUL (00 h) ASCII character bytes (the "0" ASCII characters in the filename prefix is only valid if there is at least one ASCII character in the file extension),
2. or the period (2E h) delimiter ASCII character byte optionally followed by NUL ASCII character bytes,

3. or an extension of zero (0) to three (3) case sensitive ASCII character bytes (the "0" ASCII characters in the filename prefix is only valid if there is at least one ASCII character in the file extension) followed by NUL ASCII character bytes.

In all cases, the 12 ASCII character fields will have a contiguous set of characters forming a valid Filename and will be (if required) end filled with NUL ASCII character bytes. Valid Filename examples would include: filename.ext, f.e, file, .ex.

In the case of an EMU to Ground Station transfer, the Block Number to Restart is not used and the complete file will be re-sent starting at Block 1.

The EMU File Transfer Requests will be accepted from the subrack payloads, Ground Stations, or the EXPRESS laptop at any time. Successive commands will override previous commands as long as Directory, Filename, File Transfer ID, and Payload Dependent File Identifier (when required) are the same as the last valid command. After successful validation:

For an EMU to Ground Station (GS) file transfer and a Transfer File Type of “File Transfer Start”:

The RIC will set “EMU to GS File Transfer” status bit in EXPRESS Rack Health and Status to “In Progress.”

The RIC will retrieve the requested file from the EMU in 1244 data byte blocks.

If upon startup an error occurs in retrieving data from the EMU:

The RIC will send an “EMU File Access Error” Rack Request Response to the EXPRESS laptop and Ground Stations, via telemetry.

And if a subrack payload originated the EMU File Transfer Request message transaction, the RIC will send back to that subrack payload the same EMU File Transfer Request message except the RIC will set the EMU Request Type to “File Transfer Stop.”

The RIC will set the “EMU to GS File Transfer” status bit in the EXPRESS Rack Health and Status to “Not in Progress.”

Based on the Source Function Code of the EMU File Transfer Request and the appropriate telemetry configuration table:

- The RIC will add an EXPRESS Header and EXPRESS Telemetry Secondary Header to each data block to create a Ground Station File Transfer Data Block (Table I.3.8.7.3.5.5.2-2). The source Function Code in the EXPRESS Header of this Ground Station file transfer data block will be the RIC.
- The RIC will add a CCSDS header with the rack (RIC) APID and send the telemetry message down through the scheduled telemetry transfer path.

TABLE I.3.8.7.3.5.5.2-2 GROUND STATION FILE TRANSFER DATA BLOCK

<table>
<tr><th>MSB</th><th></th><th></th><th></th><th></th><th></th><th></th><th></th><th></th><th></th><th></th><th></th><th></th><th></th><th></th><th>LSB</th></tr>
<tr><td colspan="16">EXPRESS Header
(Message Type – 009C h for Telemetry Message</td></tr>
<tr><td colspan="16">EXPRESS Telemetry Secondary Header
Telemetry Data Type = 00A7 h</td></tr>
<tr><td colspan="16">Current Block Number</td></tr>
<tr><td colspan="16">Total Block Number</td></tr>
<tr><td colspan="8">Data Byte #1</td><td colspan="8">Data Byte #2</td></tr>
<tr><td colspan="16">. . .</td></tr>
<tr><td colspan="8">Data Byte #n-1</td><td colspan="8">Data Byte #n
(Where n ≤ 1244 bytes per block)</td></tr>
</table>

Upon sending the Ground Station File Transfer Data Block with the Current Block Number equal to the Total Block Number, the RIC will set the “EMU to GS File Transfer” status bit in the EXPRESS Rack Health and Status to “Not in Progress.”

And, if a subrack payload originated the EMU File Transfer Request message transaction, the RIC will send back to that subrack payload the same EMU File Transfer Request message except the RIC will set the EMU Request Type to “File Transfer Complete.”

The following conditions will cause the RIC to terminate the EMU File Transfer Request of “EMU to GS” ID at any time prior to sending the Current Block Number equal to the Total Block Number:

Upon an error occurring in retrieving data from the EMU or the RIC receives an EMU File Transfer Request message with an ID “EMU to GS” and a Transfer Request Type of “File Transfer Stop”:

- The RIC will send an “EMU to GS File Transfer Terminated” Rack Request Response to the EXPRESS laptop and Ground Stations, via telemetry.

And, if a subrack payload originated the EMU File Transfer Request message transaction, the RIC will send back to that subrack payload the same EMU File Transfer Request message except the RIC will set the EMU Request Type to “File Transfer Stop.”

- The RIC will set the “EMU to GS File Transfer” status bit in the EXPRESS Rack Health and Status to “Not in Progress.”

At any time prior to sending the Current Block Number equal to the Total Block Number, if the RIC receives an EMU File Transfer Request message with an ID “EMU to GS” and a Transfer Request Type of “File Transfer Complete” the RIC will ignore the message.

The valid Directory names for an EMU File Transfer Request are shown in Table I.3.8.7.3.5.5.2-3, EMU Directory Assignments.

TABLE I.3.8.7.3.5.5.2-3 EMU DIRECTORY ASSIGNMENTS

Directory Name	Directory Level	Directory Usage
(root directory)	0	None required by EMU file structure.
CFG	1	Location of all configuration files
PLD	1	Location of Payload File Transfer files
STM	1	Location of Stored Telemetry files
SWL	1	Location of Software Load files

Note: All files saved in the CFG, PLD, and STM directories of the EMU and laptop hard drive will contain a RIC derived checksum added to the file when the file is saved into the directory. When a command is sent to retrieve a file, the checksum is recalculated and compared with the saved checksum. Anytime a newly calculated file checksum does not match the existing file checksum, the ground station and the laptop will be notified of an "Invalid EMU (Laptop) file Checksum (-376, -377)," and the command initiating the file read will be invalid. Following successful retrieval, the checksum will be removed before passing the file to the payloads or ISS.

The invalid responses will be sent to the requesting subrack payload and, via telemetry, to the Ground Station and the EXPRESS laptop.

The Rack Request Responses will be sent to the EXPRESS laptop and Ground Stations via telemetry and to the requesting subrack payload.

The Response error codes are defined in Table I.3.8.7.3.5.5.1-3.

I.3.8.7.3.5.6 PAYLOAD RESPONSE

The Payload Response shown in Table I.3.8.7.3.5.6-1 provides the subrack payload or PAS with a RIC operating response to a RIC Service Request or message validation.

TABLE I.3.8.7.3.5.6-1 PAYLOAD RESPONSE FORMAT

MSB															LSB
SYNC (55AA)															
EXPRESS Header (Message Type = 0082h)															
Payload Response Code															

I.3.8.7.3.6 PAYLOAD HEALTH AND STATUS DATA

The maximum number of Health and Status words is 92 data words (including ECW word) plus 4 words of EXPRESS Header. See Figure I.3.8.7-2 and Table I.3.8.7.3.6-1. The sync word and RS-422 serial checksum word are not counted as part of the 92 words. Any subrack payload measurement that requires any ISS process, service, or display on the ISS PCS will be included as subrack payload Health and Status data. The RIC will send only the Rack Subsystem Health and Status data to the EXPRESS laptop for display. Payload Health and Status data sent to and displayed by PAS resident on the EXPRESS laptop will be treated as a payload-to-payload message.

TABLE I.3.8.7.3.6-1 PAYLOAD HEALTH AND STATUS

MSB															LSB
SYNC (55AA)															
EXPRESS HEADER (REF. TABLE 11.2.3.1-1) (DESTINATION FUNCTION CODE = 0001 H) (MESSAGE TYPE = 009B H)															
Data Word 1															
●●●															
Data Word n (n Maximum Size = 92 Data Words for a single PLD)															
EXPRESS serial checksum word (only applicable for ANSI/TIA/EIA-422 messages between the RIC and payloads. Consists of the sum, with no carry, of all message bytes, including Sync Word, prior to the EXPRESS Serial Checksum word).															

The Health and Status contents are subject to review and approval by the Payload Safety Review Panel. The subrack payload can use the ECW word to monitor parameters for other than safety related purposes. It is recommended that the subrack payload using the PL MDM monitoring of the ECW word for other than the potential for fire, specify the value and expected reaction from the PL MDM. The integer one (1) (Advisory) will be located at the most right bit (last transmit bit) in the 16-bit word.

I.3.8.7.3.6.1 PAYLOAD HEALTH AND STATUS DATA – ECW (1ST WORD)

A. A powered subrack payload *should* continuously provide H&S (including Safety) data in number of words to the RIC at a rate of 1.0 Hz in the format shown in Table I.3.8.7.3.6-1, except subrack payloads that do not have C&DH interface with the RIC, or for those subrack payloads that use Software Toolkit for Ethernet Lab-Like Architecture (STELLA) software for communication with the RIC but do not generate H&S.

B. A powered subrack payload's H&S data *should* have a fixed length and fixed measurement location as stated in Paragraph I.3.8.7.3.6. Any subrack payload provided H&S data can be requested by other subrack payloads as part of ancillary data. When PL H&S packet size is different than the size defined in the PDL, the RIC will discard that packet and no error message will be generated. Gaps between the H&S packet is on an exception basis.

C. A subrack payload that does not require ECW for on-board Limit Check or ground monitoring of Expected Status **shall** reserve the first word of the subrack payload generated H&S data as the ECW word, and set the ECW word value to either zero (No Problem) or 1 (Advisory), except subrack payloads that do not have C&DH interface with the RIC, or for those subrack payloads that use STELLA software for communication with the RIC but do not generate H&S.

Note: A subrack payload is not required to provide ECW monitoring if the subrack payload is AAA cooled, because the subrack payload is relying on the EXPRESS rack for fire detection. Sealed subrack payloads and subrack payloads cooled by Cabin air are not required to provide ECW monitoring, subject to ISRP concurrence.

I.3.8.7.3.6.2 PAYLOAD HEALTH AND STATUS DATA – H&S CYCLE COUNTER (2ND WORD)

The H&S Cycle Counter will be used by payload operations personnel to determine whether H&S data being received is stale. Subrack payloads will provide as the second word of Health and Status data an H&S Cycle Counter in accordance with the following description:

A. The H&S Cycle Counter **shall** be an unsigned 16-bit integer in the range of zero to 65,535.

B. The H&S Cycle Counter **shall** be set to zero for the first H&S packet that the subrack payload transmits.

C. The H&S Cycle Counter **shall** be incremented by a value of one for each packet transmitted.

D. Once the H&S Cycle Counter reaches a value of 65,535 it **shall** reset to a value of zero and continue incrementing as described in paragraphs I.3.8.7.3.6.2.A, B and C.

I.3.8.7.3.6.3 PAYLOAD HEALTH AND STATUS DATA – PAYLOAD MESSAGE (3RD TO 92ND WORD)

Subrack payloads that require advisory messages to be displayed on a PCS onboard the ISS or displayed by payload operations personnel on the ground *should* include those messages in their H&S data as shown in Figure I.3.4.1.3-3. Subrack payloads that do not require advisory messages to be displayed on a PCS onboard the ISS or payload operations personnel on the ground are not required to reserve the payload message area within the H&S data.

I.3.8.7.3.6.3.1 PAYLOAD MESSAGE COUNTER (FIRST BYTE OF PAYLOAD MESSAGE)

Subrack payloads will provide as the first byte of the Payload Message a Payload Message Counter in accordance with the following description:

A. The Payload Message Counter *should* be an unsigned eight (8)-bit integer in the range of zero (0) to 255.

B. The Payload Message Counter *should* initially contain a value of zero (0).

C. The Payload Message Counter *should* be incremented by a value of one (1) with each message issued by the subrack payload.

D. Once the Payload Message Counter reaches a value of 255 it *should* reset to a value of zero, and continue incrementing as described in paragraphs I.3.8.7.3.6.3.1.A, B and C.

I.3.8.7.3.6.3.2 PAYLOAD MESSAGE IDENTIFIER

The message identifier *should* be an 8-bit unsigned integer in the range of zero (0) to 255. The value of the message and the associated text to be displayed will be captured during the development of the subrack payload C&DH Data Set.

I.3.8.7.3.7 EXPRESS PAYLOAD COMMANDING

A subrack payload *should* zero fill to the 13 words of the rack command words. For uplink commands, the S-Band requires a minimum of 24 words (48 bytes) including the eight (8) words of the CCSDS header, 1 word of the ISS reserved words, one (1) word of legal station mode, 13 words of rack command words, and 1 word of CCSDS command checksum. A subrack payload command comes to the subrack payload from the PEP via the RIC. A command can originate from the ground by uplink, with source Function Code 000F h, from on board by a timeliner command, a command from a PCS, or a response from the PEP limit check service. The rack command words include four (4) words of the EXPRESS Header and the subrack payload command data bytes, but not the sync word or RS-422 checksum word (for RS-422 payloads only). The Enhanced Huntsville Operations Support Center (EHS) builds the uplink command CCSDS packets for a subrack payload. The maximum number of command words is 64 per command packet from CCSDS header to command checksum word. Commands can be of variable length, but the variable field must be at the end of the packet.

After the RIC receives the command from the PEP, the RIC will compare the actual number of words received with the CCSDS packet length in word three (3), and check the CCSDS checksum word. The RIC uses the message byte count located at the first word of the EXPRESS Header for identifying the actual number of subrack payload command byte(s). After the verification process, the RIC removes the CCSDS header, ISS reserved word, legal station mode, fill bytes, and CCSDS checksum word. The RIC issues the subrack payload command (in number of bytes) to the destination function code based on the number from the message byte count. For an Ethernet subrack payload, the command message received by the payload will have the sync word at the beginning of the packet, the EXPRESS Header next, and then the subrack payload command data bytes. For an RS-422 subrack payload, the RIC will add the sync word at the beginning and add a serial checksum word at the end of the message before sending it out to the subrack payload. The RS-422 command must be on word boundary to assure that the serial checksum word is in the correct location. The sync word and the RS-422 checksum word added by the RIC are not part of the command message. The command message type (second word of the EXPRESS Header) is not used by the RIC and can be used by the subrack payload for its own purpose as long as the contents are between 0100 h and FFFE h (excluding).

There is no database in the EXPRESS laptop for storing subrack payload commands. However, a PAS on the laptop may store subrack payload commands and issue it to the RIC as a regular payload message between the PAS and the subrack payload. The source Function Code of the message is the PAS and the destination Function Code is the subrack payload.

The format of commands that leaves the EHS at MSFC on its way to subrack payloads is as shown in Figure I.3.8.7.3.7-1.

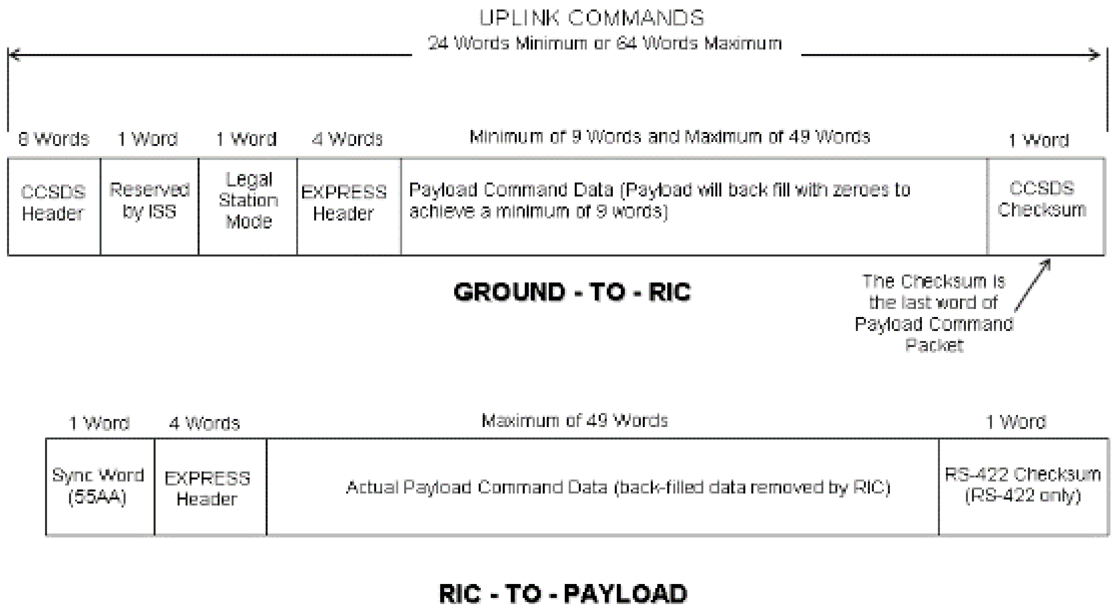


FIGURE I.3.8.7.3.7-1 FORMAT OF PAYLOAD COMMANDS

I.3.8.7.4 LAPTOP CSCI INTERFACES

The EXPRESS Rack laptop CSCI interfaces to the PEHB via IEEE 802.3, (TCP/IP protocol). Subrack payload interfaces to the laptop CSCI *should* be IEEE 802.3 CSMA/CD Local Area Network Specification, Type 10BASE-T TCP/IP protocol format compliant.

The EXPRESS Rack laptop CSCI interfaces to a subrack payload software application running on the laptop computer for exchange of subrack payload commands and data shown in Table I.3.8.7.4-1, LAP CSCI External Interface Identification. Commands destined for subrack payloads are initiated by the subrack payload software application. Data received from the RIC destined for the subrack payload software application is routed to the subrack payload software application.

TABLE I.3.8.7.4-1 LAP CSCI EXTERNAL INTERFACE IDENTIFICATION

NAME	DESCRIPTION	INTERFACE TYPE
LAP CSCI to PA	PLD data routed from the LAP CSCI to an experiment application running on the laptop computer	Software
PA to LAP CSCI	PLD requests initiated from the experiment application to be routed by the LAP CSCI	Software

The EXPRESS Rack laptop CSCI interfaces to the laptop computer hardware for obtaining user input events through the GUI, keyboard, or mouse and for sending data to the display screen.

The laptop CSCI interfaces with the User Interface (UI) application for the exchange of the user inputs and display data. The UI physical interface with the user includes the keyboard and GUI on the laptop display.

I.3.8.7.4.1 PAYLOAD-PROVIDED SOFTWARE/PERIPHERALS

All unique subrack payload software and applications will be subrack payload provided. The subrack payload may use Compact Disks (CDs)-Read Only Memory (ROM) or Digital Versatile/Video Disks (DVDs). It is recommended that the subrack payload make arrangement to allow for testing the experiment hardware with the intended software installed in the EXPRESS Rack laptop.

I.3.8.7.4.2 EXPRESS RACK LAPTOP DISPLAY REQUIREMENTS

ELC payload displays are the responsibility of the PD. Subrack payload displays **shall** conform to requirement I.3.1.2.

I.3.8.7.4.3 PAYLOAD APPLICATION SOFTWARE (PAS) INTERFACES

ELC hard drive space available for all payloads in the rack for T61p is 90 GBytes, which is available for all subrack payloads and is divided into ten 4 GByte, two 10 GByte and one 28 GByte for 10 subrack payloads use. The four (4) GByte partition is sized for nominal subrack payload usage, the ten (10) GByte partition is sized for the subrack payload that requires a large temporary data storage space, and the 28 GByte partition is sized for the subrack payload that has large video or digitized data demands. PAS includes subrack payload provided non-modified COTS software, modified COTS software and subrack payload developed laptop applications.

I.3.8.7.4.3.1 PAS DIRECT COMMUNICATIONS WITH THE SUBRACK PAYLOAD

Communication between the subrack payload and the PAS on the payload partition can be done directly through the PEHB LAN"0" if the communication is via the Ethernet using a direct socket that is established between the two. The rate of data transferred via the direct socket **shall** not exceed 100 kilobits per second. The subrack payload must provide in detail the protocol type, quantity of data in each direction, maximum file size, transmit rate, frequency to be transmitted and duration on the interface to the integrator. The availability of this interface is subject to operational constraints. The PAS resident on the ELC will be the client and the subrack payload will be the server. The PAS needs to know the IP address and port number of the subrack payload. This direct communication link is not available to the subrack payload that uses the RS-422 link.

I.3.8.7.4.3.2 SOFTWARE UPDATING PROCESS FOR LAPTOP

The method of loading the PAS and data files on the ELC is done by loading all files on a compact disk or DVD for transport to the ISS at the beginning of the “increment.” This removable media would contain the PAS and an install.exe or setup.exe which would install the application (as well as any data files needed by that application) into the predefined partition for that application. The compact disk or DVD may also contain file maintenance utilities by each subrack payload that will purge the disk space of artifact files from the previous “increment” and will ensure that the subrack payload files are loaded in the appropriate disk space. The PD will send the verified software upgrade to the Payload Software Integration and Verification (PSIV) via CD or DVD. The PSIV will copy the software to a removable media source and provide a Boeing part number for further certification by PSIV for on-orbit use.

I.3.8.7.4.3.3 PAYLOAD APPLICATION TO EXPRESS CSCI

The interface between EXPRESS LAP CSCI and a Payload Application is Named Pipe. Communication as shown in Figure I.3.8.7.4.3.3-1. The Payload Application receives the Payload Application message with correct Function Code from the LAP CSCI by Named Pipe (PIPEXXXX). The payload application sends the payload application message with correct Function Code to the LAP CSCI by SndRIC Pipe. The payload application message *should* include the EXPRESS Header and first word of the EXPRESS telemetry secondary header, telemetry Data Type, and up to 1,248 bytes of data as shown in Table I.3.8.7.4.3.3-1.

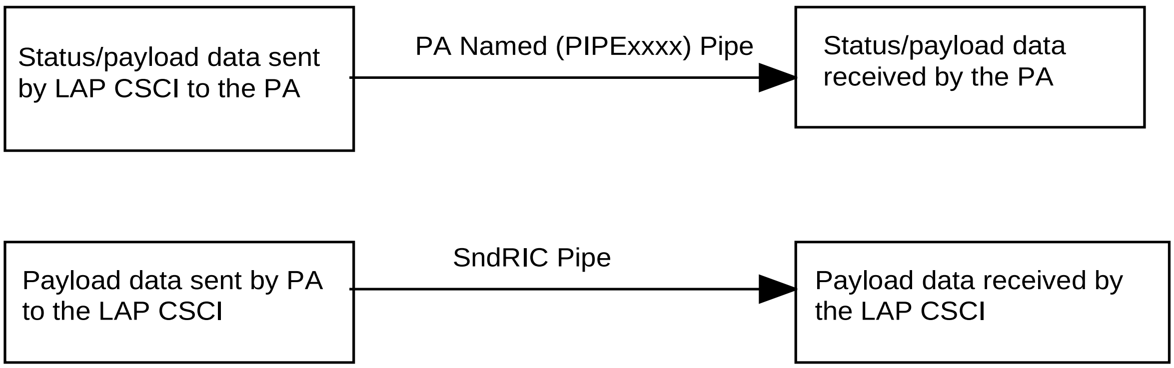


FIGURE I.3.8.7.4.3.3-1 EXPRESS LAPTOP CSCI TO PAYLOAD APPLICATION DATA FLOW

TABLE I.3.8.7.4.3.3-1 PA MESSAGE FORMAT

<table>
<tr><td>MSB</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td>LSB</td></tr>
<tr><td colspan="4">HEADER VERSION (4 BITS) [1]</td><td colspan="12">MESSAGE BYTE COUNT (12 BITS) [1, 2]</td></tr>
<tr><td colspan="16">Message Type [1]</td></tr>
<tr><td colspan="16">Function Code (Source) [1]</td></tr>
<tr><td colspan="16">Function Code (Destination) (0001 h or PA Function Code)[1]</td></tr>
<tr><td colspan="16">Telemetry Data Type (only required for telemetry packets)</td></tr>
<tr><td colspan="8">Data Byte 1</td><td colspan="8">Data Byte 2</td></tr>
<tr><td colspan="8">Data Byte 3</td><td colspan="8">Data Byte 4</td></tr>
<tr><td colspan="16"></td></tr>
<tr><td colspan="8">Data Byte n-1</td><td colspan="8">Data Byte n (maximum n = 1248 Data Bytes)</td></tr>
<tr><td colspan="16">1 EXPRESS Header required for ALL communication to the LAP or RIC.
2 Message Byte Count = Total Remaining Bytes in associated message excluding Serial checksum word where applicable.</td></tr>
</table>

The Payload Application receives the message with the correct Function Code from the EXPRESS laptop by Named Pipe (PIPEXXXX). In C++ the name path on the laptop is \\\\.\\pipe\\PIPExxxx where xxxx is the Payload Application Function Code (assigned by the ISS Program). In the event the Payload Application Named Pipe is full, the laptop CSCI does not send data and will try sending three times before discarding the data. If data is received from a Payload Application that has not connected via Named Pipe, then that data is discarded immediately.

Subrack payload messages sent from the Payload Application to the EXPRESS Laptop CSCI are by SndRIC or similar function. In C++ the name path is \\\\.\\pipe\\SndRIC. The SndRIC Pipe is set to handle as many messages as there is physical room for on the system. The SndRIC is created in a way that disallows interruption of a WriteFile or ReadFile in progress. If an error occurs indicating the SndRIC Pipe is busy, the subrack payload retries or quits.

The Payload Application can request RIC services and send telemetry data to the Ground Station by setting the destination Function Code to that of the RIC (0001h). The Payload Application request response format is the same as a subrack payload response.

EXPRESS Rack subsystem Health and Status data is sent to the EXPRESS Laptop for display via direct socket connection. Payload Health and Status data is not sent to the EXPRESS Laptop by the RIC. Payload Health and Status data to be processed or displayed by a Payload Application must be sent by each subrack payload as a subrack payload message to the Payload Application. The RIC will send all rack analog and discrete status data to all active Payload Applications connected via Named Pipe at a 1-Hz rate in the format shown in Table I.3.8.7.4.3.5-1. For specific drawer to analog/discrete usage, reference Table I.3.8.7.4.3.5-2

I.3.8.7.4.3.4 PAS COMPATIBILITY AND INSTALLATION FILES

A. PAS **shall** be compatible with the Lenovo T61P with Common Laptop Software Release 9.2 or greater (with Windows 7 Professional Service Pack 1, 32-bit Operating System).

B. PAS **shall** limit Write Files/data to the ELC partition assigned to the subrack payload. With prior approval from PSCP and successful testing by the PSIVF, Dynamic Link Library (dll) and similar files required for PAS operation can be written to the C: drive only during PAS installation and updating.

C. PAS **shall** provide a way to remove ‘read only’ files stored on the payload partition after the subrack payload completes service on the ISS.

D. PAS installation programs **shall** be capable of being installed on any ELC partition without requiring any additional editing to the PAS after installation is complete.

E. The PAS **shall** be compatible with the anti-virus software and definition files that run on the ELC.

I.3.8.7.4.3.5 PAS PROCESS AT PSIVF

The EXPRESS PAS load verification will be done at the PSIVF.

A. The latest flight version of PAS **shall** not have load conflicts (including port number conflicts) or affect the configuration and/or performance of the ELC application whether the PAS product is active or inactive.

B. PAS **shall** not run and/or write files/data on the ELC system drive (C. partition) except files required during PAS installation and updating.

C. The PD **shall** supply PAS that allows for an adjustable Random Access Memory (RAM) allocation that directly controls and allocates the amount of RAM available to the application in order to meet integration requirements.

D. The PAS **shall** be delivered to PSIV virus-free.

E. Any PAS update/change must be submitted to PSIV for retest.

TABLE I.3.8.7.4.3.5-1 RACK ANALOG AND DISCRETE DATA (2 PAGES)

MSB															LSB
Header Version (0 h) [1]				Message Byte Count (82 h) [1]											
Message Type (00B0 h) [1]															
Function Code (Source = 0001 h) [1]															
Function Code (Destination = PA Function Code)[1]															
SSPCM Discrete Status - 4 Words [2,3]															
16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1
Z	Z	Z	FE	28	27	26	25	24	23	22	21	20	19	18	17
44	43	42	41	40	39	38	37	36	35	34	33	32	31	30	29
Z	Z	Z	FE	56	55	54	53	52	51	50	49	48	47	46	45
SSPCM A/D Input Status - 58 Words															
Z	Z	Z	Z	Unsigned 12 Bit Magnitude - Input 0											
Z	Z	Z	Z	Unsigned 12 Bit Magnitude - Input 1											
Z	Z	Z	Z	Unsigned 12 Bit Magnitude - Input 2											
Z	Z	Z	Z	Unsigned 12 Bit Magnitude - Input 3											
Z	Z	Z	Z	Unsigned 12 Bit Magnitude - Input 4											
Z	Z	Z	Z	Unsigned 12 Bit Magnitude - Input 5											
Z	Z	Z	Z	Unsigned 12 Bit Magnitude - Input 6											
Z	Z	Z	Z	Unsigned 12 Bit Magnitude - Input 7											
Z	Z	Z	Z	Unsigned 12 Bit Magnitude - Input 8											
Z	Z	Z	Z	Unsigned 12 Bit Magnitude - Input 9											
Z	Z	Z	Z	Unsigned 12 Bit Magnitude - Input 10											
Z	Z	Z	Z	Unsigned 12 Bit Magnitude - Input 11											
Z	Z	Z	Z	Unsigned 12 Bit Magnitude - Input 12											
Z	Z	Z	Z	Unsigned 12 Bit Magnitude - Input 13											
Z	Z	Z	Z	Unsigned 12 Bit Magnitude - Input 14											
Z	Z	Z	Z	Unsigned 12 Bit Magnitude - Input 15											
Z	Z	Z	Z	Unsigned 12 Bit Magnitude - Input 16											
Z	Z	Z	Z	Unsigned 12 Bit Magnitude - Input 17											
Z	Z	Z	Z	Unsigned 12 Bit Magnitude - Input 18											
Z	Z	Z	Z	Unsigned 12 Bit Magnitude - Input 19											
Z	Z	Z	Z	Unsigned 12 Bit Magnitude - Input 20											
Z	Z	Z	Z	Unsigned 12 Bit Magnitude - Input 21											
Z	Z	Z	Z	Unsigned 12 Bit Magnitude - Input 22											
Z	Z	Z	Z	Unsigned 12 Bit Magnitude - Input 23											
Z	Z	Z	Z	Unsigned 12 Bit Magnitude - Input 24											
Z	Z	Z	Z	Unsigned 12 Bit Magnitude - Input 25											
Z	Z	Z	Z	Unsigned 12 Bit Magnitude - Input 26											
Z	Z	Z	Z	Unsigned 12 Bit Magnitude - Input 27											
Z	Z	Z	Z	Unsigned 12 Bit Magnitude - Input 28											
Z	Z	Z	Z	Unsigned 12 Bit Magnitude - Input 29											
Z	Z	Z	Z	Unsigned 12 Bit Magnitude - Input 30											
Z	Z	Z	Z	Unsigned 12 Bit Magnitude - Input 31											
Z	Z	Z	Z	Unsigned 12 Bit Magnitude - Input 32											
Z	Z	Z	Z	Unsigned 12 Bit Magnitude - Input 33											

TABLE I.3.8.7.4.3.5-1 RACK ANALOG AND DISCRETE DATA (2 PAGES)

Z	Z	Z	Z	Unsigned 12 Bit Magnitude - Input 34
Z	Z	Z	Z	Unsigned 12 Bit Magnitude - Input 35
Z	Z	Z	Z	Unsigned 12 Bit Magnitude - Input 36
Z	Z	Z	Z	Unsigned 12 Bit Magnitude - Input 37
Z	Z	Z	Z	Unsigned 12 Bit Magnitude - Input 38
Z	Z	Z	Z	Unsigned 12 Bit Magnitude - Input 39
Z	Z	Z	Z	Unsigned 12 Bit Magnitude - Input 40
Z	Z	Z	Z	Unsigned 12 Bit Magnitude - Input 41
Z	Z	Z	Z	Unsigned 12 Bit Magnitude - Input 42
Z	Z	Z	Z	Unsigned 12 Bit Magnitude - Input 43
Z	Z	Z	Z	Unsigned 12 Bit Magnitude - Input 44
Z	Z	Z	Z	Unsigned 12 Bit Magnitude - Input 45
Z	Z	Z	Z	Unsigned 12 Bit Magnitude - Input 46
Z	Z	Z	Z	Unsigned 12 Bit Magnitude - Input 47
Z	Z	Z	Z	Unsigned 12 Bit Magnitude - Input 48
Z	Z	Z	Z	Unsigned 12 Bit Magnitude - Input 49
Z	Z	Z	Z	Unsigned 12 Bit Magnitude - Input 50
Z	Z	Z	Z	Unsigned 12 Bit Magnitude - Input 51
Z	Z	Z	Z	Unsigned 12 Bit Magnitude - Input 52
Z	Z	Z	Z	Unsigned 12 Bit Magnitude - Input 53
Z	Z	Z	Z	Unsigned 12 Bit Magnitude - Input 54
Z	Z	Z	Z	Unsigned 12 Bit Magnitude - Input 55
Z	Z	Z	Z	Unsigned 12 Bit Magnitude - Input 56
Z	Z	Z	Z	Unsigned 12 Bit Magnitude - Input 57

[1] EXPRESS Header shown for clarity.
[2] SSPCM Discrete Status - 4 words:

FE = 15v AAA Fan Enable : 0 b = Reset, 1 b = Set
Number = Bit I/O Discrete Number : 0 b = Reset, 1 b = Set
Z = always zero

[3] For specific drawer to analog/discrete usage, reference Table I.3.8.7.4.3.5-2

TABLE I.3.8.7.4.3.5-2 PAYLOAD IDENTIFIER/LOCATION ASSIGNMENT

PAYLOAD NOMENCLATURE	LOCATION (HEXADECIMAL)	DISCRETE	ANALOG
Locker 1	11 h	1, 2, 4	0, 1
Locker 2	12 h	5, 7, 8	2, 3
Locker 3	13 h	10, 11, 13	4, 5
Locker 4	14 h	14, 16, 17	6, 7
Locker 5	15 h	19, 20, 22	8, 9
Locker 6	16 h	23, 25, 26	10, 11
Locker 7	17 h	28, 29, 31	12, 13
Locker 8	18 h	32, 34, 35	14, 15
SIR Drawer 1	19 h	37, 38, 39	16, 17
SIR Drawer 2	1A h	40, 41, 42	18, 19

I.3.8.7.5 FILE MAINTENANCE

File maintenance features include file rename, changing file attributes and file deletion.

All subrack payload-developed software applications **shall** include file maintenance features including file rename, changing file attributes and file deletion on EMU/ELC PLD (Payload) and SWL (Software Load) directory.

I.3.8.7.6 PAYLOAD DATA MONITORING

A. All subrack payload hardware using parameter monitoring, when powered on, **shall** output Health and Status data including payload service request, payload ECW word, and other PD Health and Status sensor information at 1 Hz continuously per Section I.3.8.7.3.6.2.

B. The subrack payload **shall** meet the requirement in N.3.10.1.2.1.

C. The subrack payload **shall** meet the requirement in Paragraph I.3.4.1.4.

I.4.0 VERIFICATION

I.4.1 RESPONSIBILITIES

The PD is responsible for providing verification for all applicable requirements in this appendix, as allocated to the payload through the payload unique ICD. The ISS Program is responsible for review and approval of the submitted verification.

I.4.2 VERIFICATION METHODS

Compliance with the requirements stated in Section I.3.0 are proven using one or more of the methods described in Paragraph 4.2.

I.4.3 COMMAND AND DATA HANDLING INTERFACE VERIFICATION REQUIREMENTS

I.4.3.1 C&DH GENERAL REQUIREMENTS

I.4.3.1.1 SCHEMATIC DATA REQUIREMENT

<u>Data Deliverable</u>

I.4.3.1.2 DISPLAYS

Payload Laptop displays **shall** be verified by demonstration. Verification **shall** be considered successful when the demonstration to the Payload Display Review Team (PDRT) shows the requirements in SSP 50313 have been met.

Verification Submittal: CoC

I.4.3.2 WORD/BYTE NOTATIONS, TYPES AND DATA TRANSMISSIONS

NVR. Information only.

I.4.3.2.1 WORD/BYTE NOTATIONS

Verification of the word/byte notations **shall** be by test. The test **shall** be conducted with the PRCU, RAPTR or equivalent. Verification **shall** be considered successful when test data shows that the word/byte notations comply with SSP 52050, Paragraph 3.1.1.

Verification Submittal: CoC

I.4.3.2.2 DATA TYPES

Verification of the data types **shall** be by inspection. The inspection **shall** consist of a review of the data types against SSP 52050, paragraph 3.2.1 and subparagraphs. Verification **shall** be considered successful when it is shown that the data types in the unique payload software ICD conform with SSP 52050, Paragraph 3.2.1 and subparagraphs.

Verification Submittal: CoC

I.4.3.2.3 DATA TRANSMISSIONS

A. Verification of the MRDL transmissions *should* be by inspection. The inspection *should* consist of a review of the MRDL data transmissions against SSP 52050, paragraph 3.3.4.1. Verification *should* be considered successful when it is shown that the word/byte notations in the unique payload software ICD conforms with SSP 52050, paragraph 3.3.4.1.

Verification Submittal: CoC

B. Verification of the HRDL transmissions *should* be by inspection. The inspection *should* consist of a review of the HRDL data transmissions against CCSDS 701.0-B-3, paragraph 1.6. Verification *should* be considered successful when it is shown that the word/byte notations in the unique payload software ICD conforms with CCSDS 701.0-B-3, paragraph 1.6.

Verification Submittal: CoC

C. Verification that the payload is designed to accept commands resulting in a variable downlink rate *should* be by test. The verification *should* be considered successful when the test results show that the payload is designed to accept commands resulting in a variable downlink rate.

Verification Submittal: Test Report

I.4.3.3 CONSULTATIVE COMMITTEE FOR SPACE DATA SYSTEMS

NVR

I.4.3.3.1 CCSDS DATA

Verification of the CCSDS data for I.3.3.1.A, B, and C **shall** be by analysis or test. The analysis **shall** consist of a review of the CCSDS data in the software design documentation. The test **shall** consist of a data transmission with the PRCU, RAPTR, or equivalent and inspection of the transmitted data against the SSP 52050 formats. The analysis **shall** be considered successful when it is shown that in the software design documentation the payload data which is transmitted space to ground is either CCSDS data packets or Bitstream and the payload data which is transmitted ground to space or to the payload MDM is CCSDS data packets. Test **shall** be considered successful when the PRCU, RAPTR, or equivalent correctly receives the CCSDS data.

Verification Submittal: Test Report or Analysis Report

I.4.3.3.1.1 CCSDS DATA PACKETS

Verification of the CCSDS data packet **shall** be by test. The test **shall** consist of a data transmission with the PRCU, RAPTR, or equivalent and inspection of the transmitted data against the SSP 52050 formats. Test **shall** be considered successful when the PRCU, RAPTR, or equivalent correctly receives the CCSDS data packets.

Verification Submittal: Test Report

I.4.3.3.1.1.1 CCSDS PRIMARY HEADER

Verification of the CCSDS primary header **shall** be by test. The test **shall** consist of a data transmission with the PRCU, RAPTR, or equivalent and inspection of the transmitted data against the SSP 52050 formats. Test **shall** be considered successful when the PRCU, RAPTR, or equivalent correctly receives the CCSDS primary header.

Verification Submittal: Test Report

I.4.3.3.1.1.2 CCSDS SECONDARY HEADER

Verification of the CCSDS secondary header **shall** be by test. The test **shall** consist of a data transmission with the PRCU, RAPTR, or equivalent and inspection of the transmitted data against the SSP 52050 formats. Test **shall** be considered successful when the PRCU, RAPTR, or equivalent correctly receives the CCSDS secondary header.

Verification Submittal: Test Report

I.4.3.3.1.2 CCSDS DATA FIELD

Verification of the CCSDS data field **shall** be by test. The test **shall** consist of a data transmission with the PRCU, RAPTR, or equivalent and inspection of the transmitted data against the SSP 52050 formats. Test **shall** be considered successful when the PRCU, RAPTR, or equivalent correctly receives the CCSDS data field.

Verification Submittal: Test Report

I.4.3.3.1.3 CCSDS DATA BITSTREAM

Verification of the CCSDS bitstream *should* be by test. The test *should* consist of a transmission of a known set of bits and an inspection of the received data with the transmitted data. The test *should* be considered successful when the PRCU, RAPTR, or equivalent correctly receives the CCSDS bitstream.

Verification Submittal: CoC

I.4.3.3.1.4 CCSDS APPLICATION PROCESS IDENTIFICATION FIELD

NVR

I.4.3.3.1.5 COMMAND PACKET CHECKSUM

Verification of command packet checksum **shall** be by test or analysis. The test or analysis **shall** be considered successful when it is shown that the payload validates the received command packets by computing the checksum of the packet and comparing it to the received packet's checksum.

Verification Submittal: CoC

I.4.3.3.2 CCSDS TIME CODES

I.4.3.3.2.1 CCSDS UNSEGMENTED TIME

Verification of the CCSDS unsegmented time **shall** be by test. The test **shall** consist of a data transmission with the PRCU, RAPTR, or equivalent and inspection of the transmitted data per CCSDS 301.0-B-2 as tailored by SSP 52050 formats. Verification **shall** be to test the payload with the PRCU, RAPTR, or equivalent, for correct test CCSDS unsegmented time.

Verification Submittal: Test Report

I.4.3.3.2.2 CCSDS SEGMENTED TIME

NVR

I.4.3.4 MIL-STD-1553B LRDL

Verification of the MIL-STD-1553B LRDL **shall** be by test. The test **shall** consist of a Payload Bus Remote Terminal and RT Validation Test Set, provided by ISS, used in the performance of a complete RT Validation in accordance with MIL-HDBK-1553, Multiplex Application Handbook, Notice 1, Appendix A, RT Validation Test Plan, to verify the design. The test **shall** be considered successful when the payload's Payload Bus Remote Terminal meets the RT Validation test as specified.

Verification Submittal: Test Report

I.4.3.4.1 MIL-STD-1553B PROTOCOL

I.4.3.4.1.1 STANDARD MESSAGES

A. Verification of the standard messages **shall** be by test. The test **shall** consist of the PRCU, RAPTR, or equivalent transmitting and receiving standard messages with the payload. Test **shall** be considered successful when the PRCU, RAPTR, or equivalent correctly receives the standard messages.

Verification Submittal: Test Report

B. Verification of the payload subaddress assignments **shall** be by inspection and test. Inspection **shall** be considered successful when it is shown that the CCSDS data packets in the unique payload software ICD conforms with Table 3.2.3.2.1.4-1 of SSP 52050. Tests **shall** be considered successful when the PRCU, RAPTR, or equivalent correctly receives the payload CCSDS data packets.

Verification Submittal: Test Report

I.4.3.4.1.2 COMMANDING

Verification of the commanding **shall** be by test. The test **shall** consist of the PRCU, RAPTR, or equivalent issuing commands to the payload. Test **shall** be considered successful when the payload correctly responds to the commands issued by the PRCU, RAPTR, or equivalent.

Verification Submittal: Test Report

I.4.3.4.1.3 HEALTH AND STATUS DATA

A. Verification of the format for the H&S data **shall** be by test. The payload health and status data **shall** be tested during checkout with the PRCU, RAPTR, or equivalent. The payload health and status data **shall** be transmitted into the PRCU, RAPTR, or equivalent and logged. Subsequent inspection of the logged data **shall** verify that it exists as defined in the unique payload software ICD. The test **shall** be considered successful when the PRCU, RAPTR, or equivalent correctly receives the health and status data as it is defined in the unique payload software ICD, and in a format that complies with paragraph I.3.4.1.3.A.

Verification Submittal: Test Report

B. NVR

C. Verification that payloads respond to their respective PL MDM polls for H&S data with updated data at a 1 Hz or 0.1 Hz rate **shall** be by test. The payload H&S data **shall** be tested during checkout with the PRCU, RAPTR, or equivalent. The payload H&S data **shall** be transmitted into the PRCU, RAPTR, or equivalent and logged. The test **shall** be considered successful when the PRCU, RAPTR, or equivalent correctly receives the updated data at a 1 Hz or 0.1 Hz rate.

Verification Submittal: Test Report

D. Verification that payload RTs update H&S data such that the data is ready to be read at the appropriate time within the 100 millisecond processing frame as the 32 word messages are requested **shall** be by test. The payload H&S data **shall** be tested during checkout with the PRCU, RAPTR, or equivalent. The payload H&S data **shall** be transmitted into the PRCU, RAPTR, or equivalent and logged. The test **shall** be considered successful when the PRCU, RAPTR, or equivalent correctly receives the PL H&S data per paragraph I.3.4.1.3.D.

Verification Submittal: Test Report

E. Verification that the payload request data embedded in the H&S data provided by a Subset ID is only set for a single collection cycle for each request **shall** be by test. The payload H&S data **shall** be tested during checkout with the PRCU, RAPTR, or equivalent. The payload H&S data **shall** be transmitted into the PRCU, RAPTR, or equivalent and logged. The test **shall** be considered successful when the PRCU, RAPTR, or equivalent correctly receives the PL H&S data per paragraph I.3.4.1.3.E.

Verification Submittal: Test Report

F. Verification that the Request ID for payload Request Data is per Table I.3.4.1.3-1 **shall** be by test. The payload H&S data **shall** be tested during checkout with the PRCU, RAPTR, or equivalent. The payload H&S data **shall** be transmitted into the PRCU, RAPTR, or equivalent and logged. The test **shall** be considered successful when the PRCU, RAPTR, or equivalent correctly receives the PL H&S data per paragraph I.3.4.1.3.F.

Verification Submittal: Test Report

G. Verification that payloads (which the ISRP have determined cannot cause a condition as described in paragraph I.3.4.1.3.G) zero fill the C&W word **shall** be by test. The payload H&S data **shall** be tested during checkout with the PRCU, RAPTR, or equivalent. The payload H&S data **shall** be transmitted into the PRCU, RAPTR, or equivalent and logged. The test **shall** be considered successful when the PRCU, RAPTR, or equivalent correctly receives the PL H&S data per paragraph I.3.4.1.3.G.

Verification Submittal: Test Report

H. Verification that subset IDs which have multiple C&W events occurring simultaneously set their C&W word to the value representing the most severe even occurring at that time **shall** be by test. The payload H&S data **shall** be tested during checkout with the PRCU, RAPTR, or equivalent. The payload H&S data **shall** be transmitted into the PRCU, RAPTR, or equivalent and logged. The test **shall** be considered successful when the PRCU, RAPTR, or equivalent correctly receives the PL H&S data per paragraph I.3.4.1.3.H.

Verification Submittal: Test Report

I. Verification that the C&W word is placed as word #4 of H&S data for each Subset ID **shall** be by test. The payload H&S data **shall** be tested during checkout with the PRCU, RAPTR, or equivalent. The payload H&S data **shall** be transmitted into the PRCU, RAPTR, or equivalent and logged. The test **shall** be considered successful when the PRCU, RAPTR, or equivalent correctly receives the PL H&S data per paragraph I.3.4.1.3.I.

Verification Submittal: Test Report

J. Verification that for each Subset ID that is reporting H&S Data, a H&S Cycle Counter is proved with the characteristics per paragraph I.3.4.1.3.J **shall** be by test. The payload H&S data **shall** be tested during checkout with the PRCU, RAPTR, or equivalent. The payload H&S data **shall** be transmitted into the PRCU, RAPTR, or equivalent and logged. The test **shall** be considered successful when the PRCU, RAPTR, or equivalent correctly receives the PL H&S data per paragraph I.3.4.1.3.J.

Verification Submittal: Test Report

K. Verification that payloads which require messages to be displayed on a PCS onboard the ISS or displayed by Payload Operations personnel on the ground include those messages in their H&S Data per paragraph I.3.4.1.3.K **shall** be by test. The payload H&S data **shall** be tested during checkout with the PRCU, RAPTR, or equivalent. The payload H&S data **shall** be transmitted into the PRCU, RAPTR, or equivalent and logged. The test **shall** be considered successful when the PRCU, RAPTR, or equivalent correctly receives the PL H&S data per paragraph I.3.4.1.3.K.

Verification Submittal: Test Report

L. Verification that payload messages are formatted per paragraph I.3.4.1.3.L **shall** be by test. The payload H&S data **shall** be tested during checkout with the PRCU, RAPTR, or equivalent. The payload H&S data **shall** be transmitted into the PRCU, RAPTR, or equivalent and logged. The test **shall** be considered successful when the PRCU, RAPTR, or equivalent correctly receives the PL H&S data per paragraph I.3.4.1.3.L.

Verification Submittal: Test Report

M. Verification that the Message Counter has the characteristics per paragraph I.3.4.1.3.M **shall** be by test. The payload H&S data **shall** be tested during checkout with the PRCU, RAPTR, or equivalent. The payload H&S data **shall** be transmitted into the PRCU, RAPTR, or equivalent and logged. The test **shall** be considered successful when the PRCU, RAPTR, or equivalent correctly receives the PL H&S data per paragraph I.3.4.1.3.M.

Verification Submittal: Test Report

N. Verification that the Message Identifier is an 8-bit unsigned integer in the range of 0 to 255 **shall** be by test. The payload H&S data **shall** be tested during checkout with the PRCU, RAPTR, or equivalent. The payload H&S data **shall** be transmitted into the PRCU, RAPTR, or equivalent and logged. The test **shall** be considered successful when the PRCU, RAPTR, or equivalent correctly receives the PL H&S data per paragraph I.3.4.1.3.N.

Verification Submittal: Test Report

I.4.3.4.1.4 SAFETY DATA

A. The verification of safety data parameters contained within the payload Health and Status packet and defined by the payload unique software ICD **shall** be by test and inspection. The test **shall** consist of a transmission of the payload safety-related parameters as identified in software ICD, Table A-3 to a PRCU, RAPTR, or equivalent and confirmation that the correct number of words were received as documented in Table A-23 of the software ICD. Inspection **shall** consist of a comparison of the received parameters against the format defined in SSP 52050, paragraph 3.2.3.5 and payload unique software ICD, Table A-3 and Table A-23. Inspection and test **shall** be considered successful when there is a one-to-one correlation between the safety data received by the PRCU, RAPTR, or equivalent and the data defined by the payload unique software ICD.

If the ISRP has not identified any safety data parameters and the PD has not identified any safety-related parameters, then this requirement verification is not applicable.

Verification Submittal: Test Report

B. Verification that payloads or subrack payloads set their summary C&W word to the values per paragraph I.3.4.1.4.B **shall** be by test and inspection. The test **shall** consist of a transmission of the payload safety-related parameters as identified in software ICD, Table A-3 to a PRCU, RAPTR, or equivalent and confirmation that the correct number of words were received as documented in Table A-23 of the software ICD. Inspection **shall** consist of a comparison of the received parameters against the format defined in SSP 52050, paragraph 3.2.3.5 and payload unique software ICD, Table A-3 and Table A-23. Inspection and test **shall** be considered successful when there is a one-to-one correlation between the safety data received by the PRCU, RAPTR, or equivalent and the data defined by the payload unique software ICD.

If the ISRP has not identified any safety data parameters and the PD has not identified any safety-related parameters, then this requirement verification is not applicable.

Verification Submittal: Test Report

I.4.3.4.1.4.1 CAUTION AND WARNING

NVR

I.4.3.4.1.4.1.1 CLASS 1 - EMERGENCY

NVR

I.4.3.4.1.4.1.2 CLASS 2 - WARNING

Verification that the payload formats the C&W word for the listed warning events **shall** be by inspection and test. Inspection of the payload safety hazard reports and payload safety review data **shall** identify the types of events identified as warnings that are being monitored. The test **shall** use the PRCU, RAPTR, or equivalent to determine whether or not the C&W word in the payload's health and status is formatted as a warning for the events identified as warnings. Verification **shall** be considered successful when the inspection shows the C&W word is formatted in accordance with SSP 52050, paragraph 3.2.3.5 as a warning for events that are defined as a warning.

Verification Submittal: Test Report

I.4.3.4.1.4.1.3 CLASS 3 - CAUTION

Verification that the payload formats the C&W word for the listed caution events **shall** be by inspection and test. Inspection of the payload safety hazard reports and payload safety review data **shall** identify the types of events identified as cautions that are being monitored. The test **shall** use the PRCU, RAPTR, or equivalent to determine whether or not the C&W word in the payload's health and status is formatted as a caution for the events identified as cautions. Verification **shall** be considered successful when the inspection shows the C&W word is formatted in accordance with SSP 52050, paragraph 3.2.3.5 as a caution for events that are defined as a caution.

Verification Submittal: Test Report

I.4.3.4.1.4.1.4 CLASS 4 - ADVISORY

Verification that the payload requiring advisories format the C&W word for the listed advisory events **shall** be by inspection and test. Inspection of proposed payload advisories **shall** identify the types of events identified as advisories. The test **shall** use the PRCU, RAPTR, or equivalent to determine whether or not the C&W word in the payload's health and status is formatted as an advisory for the events identified as advisories. Verification **shall** be considered successful when the inspection shows the C&W word is formatted in accordance with SSP 52050, paragraph 3.2.3.5 as a advisory for events that are defined as an advisory.

Verification Submittal: Test Report

I.4.3.4.1.5 SERVICE REQUESTS

Verification of the service requests *should* be by test. The test *should* involve connecting the payload to the PRCU, RAPTR, or equivalent. Verification *should* be considered successful when the PRCU, RAPTR, or equivalent receives the payload's service request.

Verification Submittal: CoC

I.4.3.4.1.6 ANCILLARY DATA

A. The UAD request *should* be verified by test. This test *should* be considered successful when it has been shown that the payload receives 32 words of UAD from subaddress 7 after requesting UAD from H&S.

Verification Submittal: Test Report

B. The BAD request *should* be verified by test. This test *should* be considered successful when it has been shown that the payload receives 32 words of BAD from subaddress 7 after requesting BAD from H&S.

Verification Submittal: Test Report

I.4.3.4.1.7 FILE TRANSFER

Verification of the file transfer data for those payloads requiring file transfer *should* be by test. Verification *should* be to test the payload with the PRCU, RAPTR, or equivalent for correct file transfer. The test *should* consist of a test for both the request to transfer and the actual transfer of a file with the PRCU. The verification *should* be considered successful when the transmitted file is shown to be the same as the received file.

Verification Submittal: CoC

I.4.3.4.1.8 LOW RATE TELEMETRY

Verification of low rate telemetry for those payloads requiring file transfer *should* be by test. Verification *should* be to test the payload with the PRCU, RAPTR, or equivalent for correct low rate telemetry. The test *should* consist of a test of both the request to transmit and the transmission of low rate telemetry with the PRCU. The verification *should* be considered successful when the low rate telemetry received is shown to be the same as the low rate telemetry transmitted.

Verification Submittal: CoC

I.4.3.4.1.9 DEFINED MODE CODES

I.4.3.4.1.9.1 IMPLEMENTED MODE CODES

Verification of the implemented mode codes **shall** be by test. The test **shall** consist of the reception by the test equipment of the payload's Payload Bus Remote Terminal's response to an implemented mode code transmitted by the test equipment. The test **shall** be considered successful when the payload's Payload Bus Remote Terminal correctly responds to the implemented mode codes in a RT validation test as defined in MIL-HDBK-1553, Notice 1, Appendix A, RT Validation Test Plan.

Verification Submittal: Test Report

I.4.3.4.1.9.2 UNIMPLEMENTED/UNDEFINED MODE CODES

If a RT is designed to monitor for unimplemented and undefined modes codes, verification of the unimplemented and undefined mode codes *should* be test. The test *should* consist of the reception by the test equipment of the payload's Payload Bus Remote Terminal's response to an unimplemented/undefined mode code transmitted by the test equipment. Verification *should* be to test that the payload's Payload Bus Remote Terminal correctly responds to the unimplemented and undefined mode codes produce by setting the message error bit in the status word response in a RT validation test as defined in MIL-HDBK-1553, Notice 1, Appendix A, RT Validation Test Plan.

Verification Submittal: Test Report

I.4.3.4.1.10 ILLEGAL COMMANDS

If a RT is designed to monitor for illegal commands, verification of the illegal commands *should* be by test. Verification *should* be to test that the payload's Payload Bus Remote Terminal correctly responds to the illegal commands by setting the message error bit in the status word response in a RT validation test as defined in MIL-HDBK-1553, Notice 1, Appendix A, RT Validation Test Plan. Verification *should* be considered successful when the payload's Payload Bus Remote Terminal sets the message error bit when the test equipment sends an illegal command.

Verification Submittal: Test Report

I.4.3.4.2 MIL-STD-1553B LRDL INTERFACE CHARACTERISTICS

I.4.3.4.2.1 LRDL REMOTE TERMINAL ASSIGNMENT

I.4.3.4.2.1.1 LRDL CONNECTOR/PIN ASSIGNMENTS

I.4.3.4.2.1.2 MIL-STD-1553B BUS A AND B CONNECTOR/PIN ASSIGNMENT

A. NVR. Physical mating verification requirements are specified in paragraphs N.4.3.1.1.7.A and N.4.3.1.1.7.B.

B. Verification of P3 and P4 appropriate pin assignments **shall** be by inspection. The inspection **shall** be a comparison of the appropriate payload design drawings with the UIP J3 and J4 pin assignments. The verification **shall** be considered successful when the inspection shows that the payload P3 and P4 connector pin assignments match the J3 and J4 pin assignments shown respectively in Figure N.3.1.1.8-2 and Figure N.3.1.1.8-3.

Verification Submittal: CoC

C. NVR. Physical mating verification requirements are specified in paragraphs G.4.3.1.1.A and G.4.3.1.1.B.

D. Verification of P3 and P4 appropriate pin assignments **shall** be by inspection. The inspection **shall** be a comparison of the appropriate payload design drawings with the UOP J3 and J4 pin assignments. The verification **shall** be considered successful when the inspection shows that the payload P3 and P4 connector pin assignments match the J3 and J4 pin assignments shown respectively in Figure G.3.1.1.1-1 and Figure G.3.1.1.1-2.

Verification Submittal: CoC

E. NVR. Physical mating verification requirements are specified in paragraphs G.4.3.1.1.A and G.4.3.1.1.B.

F. Verification of P2 appropriate pin assignments **shall** be by inspection. The inspection **shall** be a comparison of the appropriate payload design drawings with the SUP J2 pin assignments. The verification **shall** be considered successful when the inspection shows that the payload P2 connector pin assignments match the J2 pin assignments shown in Figure G.3.1.1.2-6.

Verification Submittal: CoC

I.4.3.4.2.1.3 REMOTE TERMINAL ADDRESS CODING

A. Unique RT addressing for a payload **shall** be verified by test. The RT validation test performed for LRDL verification per paragraph I.4.3.4 **shall** be sufficient to demonstrate that the RT responds to each assigned RT hardwired address for all of the payload locations. The test **shall** be considered successful when the RT validation test per paragraph I.4.3.4 is correctly completed.

Verification Submittal: Test Report

B. Verification that decimal values are mapped in 5 bit representation with bit 0 = Least Significant Bit (LSB) **shall** be verified by test. The RT validation test performed for

LRDL verification per section I.4.3.4 **shall** be sufficient to demonstrate that the decimal values are mapped in 5 bit representation with bit 0 = LSB. The test **shall** be considered successful when the RT validation test per paragraph I.4.3.4 is correctly completed.

Verification Submittal: Test Report

C. Odd-parity **shall** be verified by test. The RT validation test performed for LRDL verification per paragraph I.4.3.4 **shall** be sufficient to demonstrate that the RT does not respond to an RT address with even parity. The test **shall** be considered successful when the RT validation test per paragraph I.4.3.4 is correctly completed.

Verification Submittal: Test Report

D. Verification that address line jumpers to ground are tied to logic 0 **shall** be verified by inspection. Inspection **shall** be considered successful when a review of payload and/or component documentation shows that the appropriate RT address lines are tied to logic 0.

Verification Submittal: CoC

E. Unique RT addressing for a UOP/SUP **shall** be verified by test. The RT validation test performed for LRDL verification per section I.4.3.4 **shall** be sufficient to demonstrate that the RT responds to the assigned RT address for any UOP/SUP location. The test **shall** be considered successful when the RT validation test per section I.4.3.4 is correctly completed.

Verification Submittal: Test Report

I.4.3.4.2.2 LRDL SIGNAL CHARACTERISTICS

Verification of the Terminal Characteristics **shall** be by test of the MIL-STD-1553B bus A and bus B. The test **shall** consist of measuring the LRDL signal characteristics with the RT Validation Test Set per MIL-HDBK-1553 section 100 or appendix A of MIL-HDBK-1553 Notice 1, including exceptions documented in SSP 50342, MIL-STD-1553 Remote Terminal Test Exceptions Report. Verification **shall** be considered successful when the Remote Terminal meets all conditions of MIL-STD-1553B, Notice 2, section 4.5.2.

Verification Submittal: Test Report

I.4.3.4.2.3 LRDL CABLING

A. Verification **shall** be by inspection of the integrated rack LRDL cable. The inspection **shall** be considered successful when it is shown the LRDL cable meets the requirements of SSQ 21655, Cable, Electrical, MIL-STD-1553 DataBus, Space Quality, General Specifications for 75 ohms.

Verification Submittal: CoC

B. Verification **shall** be by inspection that the payload internal wiring stub length does not exceed 12 feet (3.65 meters).

Verification Submittal: CoC

I.4.3.4.2.4 MULTI-BUS ISOLATION

If a payload's Payload Bus RT utilizes multiple ISS Payload MIL-STD-1553B data buses, verification of the isolation between the various ISS Payload MIL-STD-1553B data buses **shall** be by test. The test **shall** consist of the measurement of the signal isolation between the multiple ISS Payload MIL-STD-1553B data buses of the payload's Payload Bus Remote Terminal in a RT validation test as defined in MIL-HDBK-1553, Notice 1, Appendix A, RT Validation Test Plan. Verification **shall** be considered successful when the measurement of the signal isolation between the payload's Payload Bus Remote Terminal's multiple ISS Payload MIL-STD-1553B data buses is no less than 58 dB.

Verification Submittal: Test Report

I.4.3.5 ETHERNET

NVR

I.4.3.5.1 SUBRACK SPECIFIC ETHERNET REQUIREMENTS

EXPRESS and WORF Subrack payloads are referred to section I.4.3.8.3 for Ethernet interface verification requirements.

I.4.3.5.2 GENERAL PAYLOAD ETHERNET REQUIREMENTS

NVR

I.4.3.5.2.1 IEEE 802.3 REQUIREMENTS

I.4.3.5.2.1.1 IEEE 802.3 10/100 BASETX INTERFACE

Verification that the integrated rack or non-rack payload (including U.S. payloads on the COL EPF or the JEM EF) use the proper IEEE 802.3 (ISO/IEC/IEEE 8802-3) protocols **shall** be by inspection if the payload purchased a 802.3 (8802-3) chip. The inspection of the payload **shall** consist of a comparison of the payload unique software ICD against SSP 52050, paragraph 3.3. The verification **shall** be considered successful when the unique software ICD shows conformance with the IEEE 802.3 (ISO/IEC/IEEE 8802-3) protocol.

Verification Submittal: CoC

I.4.3.5.2.1.2 ETHERNET SIGNAL CHARACTERISTICS

Verification of the Ethernet LAN-1 and LAN-2 signal characteristics **shall** be by inspection. Verification **shall** be by inspection of the payload drawings to determine if an 802.3 (8802-3) chip set was used. The verification **shall** be considered successful if an 802.3 (8802-3) chip set was used.

Verification Submittal: CoC

I.4.3.5.2.1.3 MAC ADDRESSES

I.4.3.5.2.1.3.1 PAYLOAD MAC ADDRESSES

A. Verification of the payload Ethernet LAN-1 and LAN-2 unique address **shall** be by analysis and test. The analysis **shall** verify that the unique numbers were issued by IEEE, their representative, or ISS PSE&I. Verification **shall** be considered successful when traceability of addresses to IEEE or ISS PSE&I has been shown. The test **shall** verify that the payload correctly implements the Ethernet protocol with the PRCU, RAPTR, or equivalent. The verification **shall** be considered successful when the protocol meets the requirements of IEEE 802.3 (ISO/IEC/IEEE 8802-3) for 10BASE-T or 100BASE-T, using an Ethernet network analyzer.

Verification Submittal: CoC

B. Verification that the MAC address is set prior to the Ethernet terminal going active *should* be by test. The test *should* verify that the integrated rack, subrack, or non-rack payload correctly implements the Ethernet protocol with an Ethernet network analyzer. The verification *should* be considered successful when the protocol meets the requirements of IEEE 802.3 (ISO/IEC/IEEE 8802-3) for 10BASE-T or 100BASE-T, using an Ethernet network analyzer. This test may be combined with tests for part A.

Verification Submittal: CoC

I.4.3.5.2.1.3.2 MAC-LAYER MULTICAST

MAC-Layer Multicast *should* be verified by demonstration. A demonstration of the device's ability utilizing multicast addressing *should* be performed. The verification *should* be considered successful when the demonstration shows that the device implements multicast addressing as specified per IEEE 802.3 (ISO/IEC/IEEE 8802-3).

Verification Submittal: Data Cert

I.4.3.5.2.1.4 FRAME CHECK SEQUENCE FIELD

Verification that a packet generated by a payload includes the CRC *should* be by test. Verification *should* be considered successful when analysis of the test results show that a packet generated by a payload includes the CRC.

Verification Submittal: CoC

I.4.3.5.2.1.5 PORT CONFIGURATION

Verification that the integrated rack or non-rack payload (including U.S. payloads on the COL EPF or the JEM EF) communicates via the Ethernet *should* be by test. If the payload is installed in the USL or COL or, for U.S. payloads, COL EPF, then the test *should* be conducted using the PRCU, RAPTR, or equivalent to show compatibility with the IEEE 802.3 (ISO/IEC/IEEE 8802-3) protocol. If the payload is installed in the JEM or, for U.S. payloads, JEM EF, then the test *should* be conducted using the LEHX ground unit or equivalent to show compatibility with the IEEE 802.3 (ISO/IEC/IEEE 8802-3) protocol. If the payload is installed in any other USOS module, then the test *should* be conducted using the appropriate infrastructure device (Edge Router or Ethernet Switching Hub, or equivalent) to show compatibility with the IEEE 802.3 (ISO/IEC/IEEE 8802-3) protocol. The test will include the PRCU, RAPTR, or equivalent, or the LEHX ground unit, or equivalent or the Edge Router or Ethernet Switching Hub, or equivalent port configuration selected from one or more of the following:

(1) The port is configured for Auto-Negotiation

(2) The port is configured for a fixed 10BASE-T signaling rate.

(3) The port is configured for a fixed 100BASE-T signaling rate.

(4) The port is configured for fixed half-duplex operation.

(5) The port is configured for fixed full-duplex operation.

The test *should* be considered successful when the payload successfully communicates with the PRCU, RAPTR, or equivalent, or the LEHX ground unit, or equivalent, or the Edge Router or Ethernet Switching Hub, or equivalent per the IEEE 802.3 (ISO/IEC/IEEE 8802-3) protocol, using an Ethernet packet analyzer. Integrated racks utilizing an EXPRESS RIC and PEHB, or EXPRESS derivatives thereof, are already compliant with this requirement and no additional verification is required.

Note: LEHX does not accept 10/100 Base-TX fixed full-duplex operation from the user.

Verification Submittal: Test Report

I.4.3.5.2.1.6 ETHERNET CABLE CHARACTERISTICS

A. Verification of the Ethernet cables *should* be by inspection. An inspection of the drawings *should* be conducted. Verification of the cables *should* be considered successful when it is shown that the new cables are twisted pair and meet the EIA/TIA 568-B.2 specification.

Verification Submittal: CoC

B. Verification of the Category 5e cables *should* be by inspection. An inspection of the drawings *should* be conducted. Verification of the cables *should* be considered successful when it is shown that the new cables meet the 2 pair Category 5e specification.

Verification Submittal: CoC

I.4.3.5.2.1.7 LINK TRANSMISSION PARAMETERS

Verification of the end-to-end Ethernet cable link transmission parameters *should* be by analysis and test. The test *should* be conducted using the Fluke DTX 1800 Cable Analyzer or equivalent cable analyzer. The cable analyzer *should* be configured to test to the IEEE 802.3 100BaseT limits. An analysis of the test results *should* be performed. The verification *should* be considered successful when the analysis of the test results shows that cable passed the IEEE 802.3 100BaseT cable characteristics.

Verification Submittal: Analysis and Test Report

I.4.3.5.2.1.8 ISOLATION AND GROUNDING

Verification of isolation and grounding **shall** be by inspection. An inspection of drawings **shall** be conducted. Verification of isolation and grounding **shall** be considered successful when it is shown that Ethernet received and transmitted signals are per IEEE 802.3 (ISO/IEC/IEEE 8802-3).

Verification Submittal: CoC

I.4.3.5.2.1.9 CONNECTORS

I.4.3.5.2.1.9.1 IEEE 10 BASE-T, 100 BASE-TX, AND 1000 BASE-T 8-PIN MODULAR CONNECTOR (RJ-45)

Verification of this requirement *should* be by inspection. The verification *should* be considered successful when data for the Ethernet link confirms the use of an RJ-45 connector as specified per EIA/TIA 568-B.2.

Verification Submittal: CoC

I.4.3.5.2.1.9.2 MIL-STD CIRCULAR CONNECTORS

NVR

I.4.3.5.2.1.9.3 RACK UIP AND UOP CONNECTOR/PIN ASSIGNMENTS

A. NVR. Physical mating verification requirements are specified in paragraphs N.4.3.1.1.7.A and N.4.3.1.1.7.B.

B. Verification of P46 and P47 appropriate pin assignment **shall** be by inspection. The inspection **shall** be a comparison of the appropriate payload design drawings with the UIP J46 and J47 pin assignments. The verification **shall** be considered successful when the inspection shows that the payload P46 and P47 connector pin assignments match the J46 and J47 pin assignments shown respectively in Figure N.3.1.1.8-4 and Figure N.3.1.1.8-5.

Verification Submittal: CoC

C. NVR. Physical mating verification requirements are specified in paragraphs G.4.3.1.1.A and G.4.3.1.1.B.

D. Verification of P4 appropriate pin assignments **shall** be by inspection. The inspection **shall** be a comparison of the appropriate payload design drawings with the UOP J4 pin assignments. The verification **shall** be considered successful when the inspection shows that the payload P4 connector pin assignments match the J4 pin assignments shown in Figure G.3.1.1.1-2.

Verification Submittal: CoC

E. NVR. Physical mating verification requirements are specified in paragraphs G.4.3.1.1.A and G.4.3.1.1.B.

F. Verification of P3 appropriate pin assignments **shall** be by inspection. The inspection **shall** be a comparison of the appropriate payload design drawings with the SUP J03 pin assignments. The verification **shall** be considered successful when the inspection shows that the payload P3 connector pin assignments match the J03 pin assignments shown in Figure G.3.1.1.2-7.

Verification Submittal: CoC

I.4.3.5.2.2 WIRELESS (RADIO) PHYSICAL LAYER

NVR

I.4.3.5.2.2.1 ETHERNET WIRELESS STANDARDS

Verification of this requirement *should* be by inspection and demonstration. Inspection of vendor data and regulatory submittals *should* be used to confirm the device implements wireless Ethernet as specified per IEEE 802.11 B/G or N. Demonstration *should* be considered successful when the device communicates wirelessly with a WAP using IEEE 802.11 B/G or N protocols.

Verification Submittal: CoC

I.4.3.5.2.2.2 WIRELESS LOCAL AREA NETWORK

I.4.3.5.2.2.2.1 2.4 GHZ SPECTRUM

Verification of this requirement *should* be by inspection and demonstration. The inspection *should* be considered successful when a review of vendor data and regulatory submittals confirm the device implements wireless Ethernet using the spectrum specified. The demonstration *should* be considered successful when the device communicates wirelessly in the spectrum specified.

Verification Submittal: CoC

I.4.3.5.2.2.2.2 INTERNAL 5 GHZ SPECTRUM

Verification of this requirement *should* be by inspection and demonstration. The inspection *should* be considered successful when a review of vendor data and regulatory submittals confirm the device implements wireless Ethernet using the spectrum specified. The demonstration *should* be considered successful when the device communicates wirelessly in the spectrum specified.

Verification Submittal: CoC

I.4.3.5.2.2.2.3 EXTERNAL 5 GHZ SPECTRUM

Verification of this requirement *should* be by inspection and demonstration. The inspection *should* be considered successful when a review of vendor data and regulatory submittals confirm the device implements wireless Ethernet using the spectrum specified. The demonstration *should* be considered successful when the device communicates wirelessly in the spectrum specified.

Verification Submittal: CoC

I.4.3.5.2.2.2.4 WIRELESS SECURITY

Verification of the external wireless link security **shall** be by inspection and demonstration. The inspection **shall** be considered successful when a review of vendor data confirms the wireless device can be configured to use WPA2 – PSK [AES] wireless communications and demonstration that the wireless device communicates with a BelAir 100N WAP using WPA2 – PSK [AES].

Verification Submittal: CoC

I.4.3.5.2.2.2.5 WIRELESS PROFILES

Wireless profiles *should* be verified by inspection and demonstration. Verification *should* be considered successful when inspection and demonstration show that the wireless user device can be configured with multiple profiles as specified.

Verification Submittal: Data Cert

I.4.3.5.2.2.2.6 SSIDS

SSIDs *should* be verified by inspection and demonstration. Verification *should* be considered successful when inspection and demonstration show that the user device that supports roaming has the capability to be configured for multiple SSIDs as specified.

Verification Submittal: Data Cert

I.4.3.5.2.2.2.7 MANUAL WIRELESS CONNECTION

Manual wireless connection *should* be verified by inspection and demonstration. Verification *should* be considered successful when inspection and demonstration show that the wireless user device can be manually configured to connect to a specified WAP.

Verification Submittal: Data Cert

I.4.3.5.2.2.2.8 DYNAMIC WIRELESS CONNECTIONS

Dynamic connection *should* be verified by inspection and demonstration. Verification *should* be considered successful when inspection and demonstration show that the user device that supports roaming has the capability to dynamically detect and connect to the strongest WAP signal from the device's list of pre-configured profiles.

Verification Submittal: Data Cert

I.4.3.5.2.3 NETWORK/INTERNET LAYER REQUIREMENTS

I.4.3.5.2.3.1 IPV4

IPv4 **shall** be verified by inspection, and demonstration or test. A test of the device's ability to meet protocol requirements **shall** be performed. The verification **shall** be considered successful when an inspection of the documentation shows the device is compliant with IETF RFCs 791 and 6864, and the demonstration or test shows the device successfully functions as a host as defined by IETF RFC 791 and IETF RFC 6864.

Verification Submittal: Test Report

I.4.3.5.2.3.1.1 IPV4 ADDRESSING

A. Addressing *should* be verified by inspection and demonstration. A demonstration *should* be conducted with the device to verify that its IPv4 addresses are configurable. Verification *should* be considered successful when a demonstration shows that the device provides the capability to configure IPv4 addresses, for each of its Ethernet interfaces, in accordance with IETF RFC 950.

Verification Submittal: Data Cert

B. Configurable Device IPv4 Address *should* be verified by inspection and demonstration. An inspection of the vendor documents *should* be performed. A demonstration *should* be conducted with the device to verify that its IPv4 addresses are configurable. Verification *should* be considered successful when the inspection and the demonstration show that the device provides the capability to configure IPv4 addresses, for each of its Ethernet interfaces, in accordance with IETF RFC 950.

Verification Submittal: Data Cert

I.4.3.5.2.3.1.2 DEFAULT GATEWAY/GATEWAY OF LAST RESORT

This requirement **shall** be verified by demonstration. A demonstration of the device's ability to meet protocol requirements **shall** be performed. The verification **shall** be considered successful when data is routed to the default route per IETF RFCs 1122, 6298, 6633, 6864.

Verification Submittal: Data Cert

I.4.3.5.2.3.2 ICMP

ICMP *should* be verified by demonstration. A demonstration of the device's ability to meet protocol requirements *should* be performed. The verification *should* be considered successful when the device responds correctly per IETF RFC 792 and IETF 6633.

Verification Submittal: Data Cert

I.4.3.5.2.3.3 ARP

ARP *should* be verified by demonstration. A demonstration of the gateway *should* be performed, whereby an ARP message is sent to the gateway address and a proper ARP response is received by the sender. The verification *should* be considered successful when the demonstration shows that a proper ARP response message is returned by the gateway per IETF RFCs 826 and 5227.

Verification Submittal: Data Cert

I.4.3.5.2.3.4 STATIC ROUTING

Static Routing *should* be verified by demonstration. A demonstration of the ability to meet protocol requirements *should* be performed. The verification *should* be considered successful when data is routed correctly per RFC 1812 Section 7.4, RFC 2644, and RFC 6633.

Verification Submittal: Data Cert

I.4.3.5.2.3.5 LICKLIDER TRANSMISSION PROTOCOL

Licklider Transmission Protocol *should* be verified by demonstration. A demonstration of the ability to meet protocol requirements *should* be performed. The verification *should* be considered successful when data is transmitted correctly per IETF RFCs 5325, RFC 5326, and RFC 5327.

Verification Submittal: CoC

I.4.3.5.2.4 TRANSPORT LAYER REQUIREMENTS

I.4.3.5.2.4.1 TRANSMISSION CONTROL PROTOCOL

TCP *should* be verified by demonstration. A demonstration of the ability to meet protocol requirements *should* be performed. The verification *should* be considered successful when data is transmitted correctly per IETF RFC 793.

Verification Submittal: Data Cert

I.4.3.5.2.4.2 USER DATAGRAM PROTOCOL

A. UDP *should* be verified by inspection and demonstration. The verification *should* be considered successful when the inspection of documentation shows that each of the device's interfaces are compliant with IETF RFC 768 and the demonstration shows that each of the Ethernet interfaces can transfer data to/from other devices using the UDP (unicast) protocol.

Verification Submittal: Data Cert

B. UDP-Multicast *should* be verified by demonstration. The verification *should* be considered successful when a demonstration shows that each of the Ethernet interfaces can transfer data to the Edge Router using the UDP (multicast) protocol in accordance with IETF RFC 5771.

Verification Submittal: Data Cert

I.4.3.5.2.4.3 BUNDLE PROTOCOL

Bundle Protocol *should* be verified by inspection and demonstration. The verification *should* be considered successful when inspection of documentation shows that each of the device's interfaces are compliant with CCSDS 734.2-B-1 and a demonstration shows that each of the Ethernet interfaces can transfer data to/from other devices using the Bundle Protocol.

Verification Submittal: Data Cert

I.4.3.5.2.5 APPLICATION, PRESENTATION, AND SESSION LAYERS REQUIREMENTS

NVR

I.4.3.5.2.5.1 APPLICATION PROTOCOLS

I.4.3.5.2.5.1.1 FTP

NVR

I.4.3.5.2.5.1.2 NTP

NTP *should* be verified by inspection and demonstration. The verification *should* be considered successful when inspection of vendor documentation and a demonstration show that the device correctly provides NTP service in accordance with RFC 5905.

Verification Submittal: Data Cert

I.4.3.5.2.5.1.3 RTP

RTP *should* be verified by inspection and demonstration. An inspection of documentation and a demonstration with the device *should* be conducted to demonstrate the capability to support RTP. Verification *should* be considered successful when inspection of documentation shows that each of the Ethernet interfaces is compliant with IETF RFCs 3550, 5506, 5761, and 6051 and a demonstration shows that each of the Ethernet interfaces can transfer RTP audio data to/from another device.

Verification Submittal: Data Cert

I.4.3.5.2.5.1.4 SNMP VERSION 3

SNMP version 3 **shall** be verified by demonstration. Verification **shall** be considered successful when the demonstration shows that the device can provide SNMP v3 status data to a SNMP Network Management Computer using the SNMP protocol.

Verification Submittal: Data Cert

I.4.3.5.2.5.1.5 SECURE FILE TRANSFER

Secure File Transfer **shall** be verified by inspection and demonstration. An inspection of documentation and a demonstration **shall** be conducted to show the device supports secure file transfer. Verification **shall** be considered successful when inspection of documentation shows that the device is compliant with one or more of the standards listed in paragraph I.3.5.2, and the demonstration shows that the files are secure.

Verification Submittal: Data Cert

I.4.3.5.2.5.1.6 CCSDS FILE DELIVERY PROTOCOL (CFDP)

CFDP *should* be verified by inspection and demonstration. Verification *should* be considered successful when inspection of documentation shows that the device is compliant with CCSDS 727.0-B-4, and a demonstration shows that a file can be transferred using the CCSDS File Delivery Protocol.

Verification Submittal: Data Cert

I.4.3.5.2.6 KUIP COMMUNICATION

Verification that the payload is using the approved Internet Protocol Suite for KuIP communication links *should* be by inspection and demonstration.

The inspection *should* consist of a comparison of vendor-provided data and the unique payload software ICD against SSP 52050, paragraph 3.3.7 and Table 3.3.7-1. The verification *should* be considered successful when the vendor-provided data and the unique software ICD shows conformance to the approved IP protocol and packet format per SSP 52050, Table 3.3.7-1.

The demonstration *should* be conducted using ETS, RAPTR, or equivalent to show compatibility with the Internet Protocol and packet format.

The demonstration *should* include transmit and receipt of a payload IP packet sequence using real-time data. The demonstration *should* be considered successful when the payload packet sequence is observed to successfully communicate per SSP 52050 paragraph 3.3.7 and Table 3.3.7-1.

Verification Submittal: CoC

I.4.3.5.2.7 PEHG HRDL GATEWAY DOWNLINK PROTOCOLS

A. Verification that the integrated rack or non-rack payload in the USL or COL or U.S. payloads on the COL EPF uses proper HRDL gateway (see Glossary of Terms) protocols and packet format *should* be by inspection and analysis and test.

   The inspection *should* consist of a comparison of the unique payload software ICD against SSP 52050, paragraph 3.3.4.6 and SSP 52050, paragraph 3.3.5.1. The verification *should* be considered successful when the unique software ICD shows conformance to the gateway protocol and packet format.

   The analysis *should* consist of a comparison of the content of a payload packet Ethernet header and CCSDS header against SSP 52050, paragraph 3.3.4.6, and SSP 52050, paragraph 3.3.5.1. The data *should* be captured and documented in report format using packet capture software such as Wireshark or equivalent. The verification *should* be considered successful when the packet header contents conform to the Ethernet and CCSDS packet format.

   The test *should* be conducted using the PRCU, RAPTR, or equivalent to show compatibility with the HRDL gateway protocol and packet format. The test *should* be considered successful when the payload successfully communicates with the PRCU, RAPTR, or equivalent per SSP 52050 paragraph 3.3.4.6 and SSP 52050, paragraph 3.3.5.1.

Integrated racks utilizing an EXPRESS RIC and PEHB, or EXPRESS derivatives thereof, are already compliant with this requirement and no additional verification is required.

Verification Submittal: Data Cert

B. Verification that the integrated rack or non-rack payload in the JEM or U.S. payload on the JEM EF uses proper HRDL gateway protocols and packet format *should* be by inspection and analysis and test.

The inspection *should* consist of a comparison of the unique payload software ICD against SSP 52050, paragraph 3.3.4.6, SSP 52050, paragraph 3.3.5.1, and SSP 52050, paragraph 3.3.6. The verification *should* be considered successful when the unique software ICD shows conformance to the HRDL gateway protocol and packet format.

The analysis *should* consist of a comparison of the content of a payload packet Ethernet header and CCSDS header against SSP 52050, paragraph 3.3.4.6, SSP 52050, paragraph 3.3.5.1, and SSP 52050, paragraph 3.3.6. The data *should* be captured and documented in report format using packet capture software such as Wireshark or equivalent. The verification *should* be considered successful when the packet header contents conform to the Ethernet and CCSDS packet format.

Tests *should* be conducted using the PRCU, RAPTR, or equivalent, and the LEHX ground unit, or equivalent to show compatibility with their respective gateway protocol and packet formats. The test with the PRCU, RAPTR, or equivalent *should* be considered successful when the payload successfully communicates with the PRCU, RAPTR, or equivalent per SSP 52050 paragraph 3.3.4.6 and SSP 52050, paragraph 3.3.5.1. The test with the LEHX ground unit or equivalent *should* be considered successful when the payload successfully communicates with the LEHX ground unit or equivalent per SSP 52050, paragraph 3.3.6.

Integrated racks utilizing an EXPRESS RIC and PEHB, or EXPRESS derivatives thereof, are already compliant with this requirement and no additional verification is required.

Verification Submittal: Data Cert

I.4.3.5.2.8 INTEGRATED RACK ETHERNET CONNECTIVITY

A. Verification of the payload Ethernet connectivity **shall** be by inspection. Inspection **shall** be considered successful when it is shown that the payload drawings in the unique hardware ICD conform to paragraph I.3.5.2.1.9.3.

Verification Submittal: CoC

B. Verification of Ethernet data routing **shall** be by test. The test **shall** be accomplished with the PRCU or equivalent. The test **shall** be considered successful when it is shown that Ethernet data can be successfully routed to the proper ISS LAN with the correct Ethernet address without simultaneously transmitting the same message to both ISS LANs.

Verification Submittal: CoC

C. For payloads with an internal Ethernet LAN, verification **shall** be by test. The test **shall** be accomplished with the PRCU or equivalent. The test **shall** be considered successful when it is shown that isolation exists between the payload internal LAN and the ISS LAN.

Verification Submittal: CoC

D. Verification of compatibility with the PEHG and/or LEHX and/or Edge Router using payload-to-payload communications *should* be by analysis and/or test. The test *should* be considered successful when it is shown that the payload is compatible with the PEHG and/or LEHX and/or Edge Router.

Verification Submittal: CoC

I.4.3.6 HIGH RATE DATA LINK (HRDL)

I.4.3.6.1 PAYLOAD TO ICU PROTOCOLS

I.4.3.6.1.1 CCSDS PACKET PROTOCOL

NVR

I.4.3.6.1.1.1 PACKET DATA FRAMES

Verification of packet data frames *should* be by test and inspection. Verification *should* be to test the integrated rack with the PRCU. Verification *should* be by inspection of the integrated rack HRDL protocol against SSP 50184, sections 3.3.3.1.1, 3.3.3.1.1.1, and 3.3.3.1.1.2. Verification *should* be considered successful when it is shown that the packet data frames comply with the requirements of SSP 50184.

Verification Submittal: CoC

I.4.3.6.1.1.2 PACKET DATA RATES

Verification of packet data rates *should* be by test and inspection. Verification *should* be to test the integrated rack with a TAXI Analyzer or equivalent. Verification *should* be by inspection of the integrated rack HRDL protocol against SSP 50184, sections 3.3.3.1.2, 3.3.3.1.2.1, 3.3.3.1.2.2, and 3.3.3.1.2.2.1. Verification *should* be considered successful when it is shown that the data rates comply with the requirements of SSP 50184.

NOTE: If the structure of the packet data rate provided in SSP 50184 is not followed, there is a possibility that data could be lost.

Verification Submittal: CoC

I.4.3.6.1.1.3 PACKET FORMAT

Verification of packet format *should* be by test and inspection. Verification *should* be to test the integrated rack with the PRCU. Verification *should* be by inspection of the integrated rack HRDL protocol against SSP 50184, sections 3.3.3.1.3.1 and 3.3.3.1.3.2. Verification *should* be considered successful when it is shown that the packet format complies with the requirements of SSP 50184.

Verification Submittal: CoC

I.4.3.6.1.2 BITSTREAM PROTOCOL

NVR

I.4.3.6.1.2.1 DATA FRAMES

Verification of data frames *should* be by test and inspection. Verification *should* be to test the integrated rack with a TAXI Analyzer or equivalent. Verification *should* be by inspection of the integrated rack HRDL protocol against SSP 50184, section 3.3.3.2.1 and Figure 3.3.3-3, sections 3.3.3.2.1.1 and 3.3.3.2.1.2. Verification *should* be considered successful when it is shown that the data frames comply with the requirements of SSP 50184.

Note: If the structure of the packet data rate provided in SSP 50184 is not followed, there is a possibility that data could be lost.

Verification Submittal: CoC

I.4.3.6.1.2.2 DATA RATES

Verification of data rates *should* be by test and inspection. Verification *should* be to test the integrated rack with a TAXI Analyzer or equivalent. Verification *should* be by inspection of the integrated rack HRDL protocol against SSP 50184, sections 3.3.3.2.2, 3.3.3.2.2.1, 3.3.3.2.2.2, and 3.3.3.2.2.2.1. Verification *should* be considered successful when it is shown that the data rates comply with the requirements of SSP 50184.

Note: If the structure of the packet data rate provided in SSP 50184 is not followed, there is a possibility that data could be lost.

Verification Submittal: CoC

I.4.3.6.2 HRDL INTERFACE CHARACTERISTICS

I.4.3.6.2.1 PHYSICAL SIGNALING

Verification of the HRDL physical signaling *should* be by test and analysis. Verification of the fiber optic transmitted waveform at the fiber optic transmitter component *should* be by test. This test may be conducted at fiber optic component subassembly.

Verification of the integrated rack fiber optic transmitted waveform *should* be by analysis. Verification of the fiber optic receiver fiber optic sensitivity and bit error rate *should* be by test of the fiber optic receiver component.

Verification of the bit error rate (per ANSI X3.255, Fibre Distributed Data Interface (FDDI) - Abstract Test Suite for FDDI Physical Medium Dependent Conformance Testing (PMD ATS), test) and the integrated rack fiber optic receiver sensitivity *should* be by test.

Verification by test and analysis *should* be considered successful when the results meet the applicable requirements in SSP 50184, sections 3.1.1 and 3.1.2, and the bit error rate test section in ANSI X3.255. Integrated racks utilizing an EXPRESS RIC or its derivatives are compliant with this requirement.

Verification Submittal: Data Cert providing rates, signal coding, and control signals.

I.4.3.6.2.1.1 PHYSICAL SIGNALING DATA RATES

A. Verification of the payload data rates *should* be by test. The test *should* be considered successful when the HRDL data rate is less than or equal to the integrated rack assigned data rate. All selectable data rates are to be recorded.

Verification Submittal: CoC

B. Verification of transmitted data *should* be by test and inspection. Verification *should* be to test the integrated rack with a TAXI Analyzer or equivalent. Verification *should* be by inspection of the integrated rack HRDL protocol against SSP 50184, section 3.3.1.2. Verification *should* be considered successful when it is shown that the transmitted data comply with the requirements of SSP 50184.

Note: If the structure of the packet data rate provided in SSP 50184 is not followed, there is a possibility that data could be lost.

Verification Submittal: Data Cert providing rates, signal coding, and control signals.

I.4.3.6.2.2 ENCODING

Verification of the HRDL encoding *should* be by test. Verification *should* be to test the integrated rack with the PRCU. Verification *should* be considered successful when it is shown that encoding complies SSP 50184, with section 3.1.3.

Verification Submittal: Data Cert providing rates, signal coding, and control signals.

I.4.3.6.3 HRDL OPTICAL POWER

I.4.3.6.3.1 HRDL TRANSMITTED OPTICAL POWER

Verification **shall** be to test the integrated rack with fiber optic power meter per ANSI X3.255, for correct optical power using the Halt symbol. The optical power perturbations from the test setup are not included in the stated power requirement. The perturbations from the test are to be documented. This test **shall** be considered successful when the requirement is met or exceeded after the test setup variations are removed from the result.

Verification Submittal: CoC

I.4.3.6.3.2 HRDL RECEIVED OPTICAL POWER

Verification *should* be to test the integrated rack with a calibrated fiber optic source using the Halt symbol, in accordance with SSP 50184, Table 3.1-3, 4B/5B NRZI Encoding, at the minimum power. The received optical power *should* be measured at the integrated rack P7 connector to the ISPR connector interface. The optical power perturbations from the test setup are not included in the stated power requirement. The perturbations from the test are to be documented. This test *should* be considered successful when the requirement is met or exceeded after the test setup variations are removed from the result.

Verification Submittal: CoC

I.4.3.6.4 HRDL FIBER OPTIC CABLE

Verification *should* be by inspection of the integrated rack HRDL cable. Verification *should* be considered successful when it is shown that the integrated rack HRDL cable meets SSQ 21654 or equivalent.

Verification Submittal: CoC

I.4.3.6.5 HRDL FIBER OPTIC CABLE BEND RADIUS

Verification *should* be by inspection of the integrated rack HRDL cable routing, installation and handling procedures. Verification *should* be considered successful when the inspection shows that the routing, installation and handling procedures do not cause the cable to be bent in a tighter radius than one half inch for bends of 90 degrees or less.

Verification Submittal: CoC

I.4.3.6.6 HRDL CONNECTORS

A. NVR. Physical mating verification requirements are specified in section N.3.1.1.7.

B. Verification of P7 appropriate pin assignment *should* be by inspection. The inspection *should* be an inspection of payload drawings to verify that the P7 pinout matches the corresponding J7 pinout. The verification *should* be considered successful when the inspection shows that the P7 connector pinout is appropriate.

Verification Submittal: CoC

I.4.3.6.7 HRDL STATE

Verification of HRDL State *should* be by analysis of the Lock-On State and Data Send State based on software/hardware algorithms. Verification *should* be considered successful when it is shown that the HRDL State has met the criteria within SSP 50184, sections 3.3.1.1.2 and 3.3.1.1.3.

Verification Submittal: CoC

I.4.3.7 LAPTOP COMPUTERS AND PORTABLE COMPUTING DEVICES

A. Verification **shall** be by inspection. The inspection **shall** consist of a review of final flight drawings. The inspection **shall** be considered successful when the final flight drawings are shown to show the laptop part number is as specified in I.3.7.A.

Verification Submittal: CoC

B. Verification *should* be by demonstration. The demonstration *should* involve running the operating system and all applications needed for the payload’s planned operations. The demonstration *should* be considered successful when the software runs properly per final flight configuration. Software load changes on-orbit require the re-submittal of verification if the on-orbit software changes the interface to the ISS. Verification Submittal: CoC

C. Verification **shall** be by demonstration. The demonstration **shall** involve running the virus scanning software. The demonstration **shall** be considered successful when the virus scanning software runs properly per final flight configuration and no virus is detected. The results of the demonstration will be documented and include the name and version of the virus scanning software, and date of virus definition files used.

Verification Submittal: Data Certification providing the name and version of the virus scanning software that is installed and date of the definition files used.

D. Verification **shall** be by demonstration. The demonstration **shall** involve updating the definition files for the virus scanning software while in operation. Verification that definition files can be periodically updated **shall** be considered successful when an initial ground demonstration shows that the virus scanning software can be updated using the Joint Station LAN Laboratory, portable media, or equivalent. The results of the demonstration will be documented and include the name and version of the virus scanning software, and date of virus definition files used.

Verification Submittal: Data Certification providing the name and version of the virus scanning software that is installed and date of the definition files used.

E. Verification **shall** be by demonstration. The demonstration **shall** consist of showing the non-functionality of each wireless communication function other than those required for a specific payload application that has been approved by the CRCP and is documented in their meeting minutes. The demonstration **shall** be considered successful when a wireless receiver configured for each non-functional wireless communication function detects no transmissions within the applicable communications protocol when the portable device is operating or when the function is manually selected by the user.

Verification Submittal: CoC

I.4.3.7.1 U.S. LAPTOP HARDWARE

A. Verification *should* be by inspection. The inspection *should* be of flight drawings or hardware. The verification *should* be considered successful when the inspection shows that each rack has no more than one U.S. Laptop computer per payload rack.

Verification Submittal: CoC

B. Verification **shall** be by inspection. For the T61p laptop, verification **shall** be considered successful when an inspection of the Laptop Certification Matrix shows the hardware has been added to the accepted hardware list.

Verification Submittal: CoC

Note: The Laptop Certification Matrix is described in the fourth paragraph of section I.3.7. NASA OD Computer Resources team will facilitate the acceptance of certification documentation with NASA NE. Necessary documentation will include toxic test data (off-gassing) and EMI test data for each interfacing item.

C. Verification **shall** be by demonstration. The demonstration **shall** consist of performing a virus scan in the system’s final flight configuration of the system’s nonvolatile memory. The demonstration **shall** be considered successful when the virus scan determines there is no virus or other malicious software present in the system's nonvolatile memory. The results of the demonstration to be documented in the verification report **shall** include the name and version of the virus scanning product, the date of definition files used, and the results of the scan.

Verification Submittal: Data Certification providing the name and version of the virus scanning software that is installed, the date of the definition files used, and the results of the scan.

I.4.3.8 EXPRESS SUBRACK C&DH INTERFACES

Data Deliverable

I.4.3.8.1 EXPRESS SUBRACK CONNECTOR/PIN INTERFACE

I.4.3.8.1.1 MLE/MLE REPLACEMENT PAYLOAD

Verification that the final design flight cable and wire drawings reflect the connector part numbers and pin assignments per Table I.3.8.1.1-1 **shall** be by inspection. The verification **shall** be successful when the inspection of the final design flight cable and wire drawings show the connector part numbers and pin assignments are per Table I.3.8.1.1-1.

Verification Submittal: CoC

I.4.3.8.1.2 ISIS DRAWERS

A. Verification that the final design flight cable and wire drawings reflect the connector part numbers and pin assignments per Table I.3.8.1.2-1 **shall** be by inspection. The verification **shall** be successful when the inspection of the final design flight cable and wire drawings show the connector part numbers and pin assignments are per Table I.3.8.1.2-1.

Verification Submittal: CoC

B. Verification that the ISIS drawer payload jumpers the Command/Telemetry connector (P2) pin contact 9 to pin contact 121 per Table I.3.8.1.2-1 **shall** be by inspection. The verification **shall** be considered successful when the inspection of the flight hardware or the final design cable and wire drawings show the ISIS drawer payload jumpers the Command/Telemetry connector (P2) pin contact 9 to pin contact 121 per Table I.3.8.1.2-1.

Verification Submittal: CoC

I.4.3.8.1.3 PPCB

Verification that the pin functions for the PPCB reflect the pin assignments per Table I.3.8.1.1-1 and Table I.3.8.1.2-1 *should* be by inspection. The verification *should* be considered successful when the inspection of the flight hardware or final design flight cable and wire drawings show the pin functions for the PPCB are per Table I.3.8.1.1-1 and Table I.3.8.1.2-1.

Verification Submittal: CoC

I.4.3.8.2 RS-422 COMMUNICATIONS

I.4.3.8.2.1 SIGNAL CHARACTERISTICS

Verification that the subrack payload RS-422 serial channel meets the interface and signal characteristics requirements of specification ANSI/TIA/EIA-422 *should* be by test. Verification *should* be considered successful when the test results show the subrack payload RS-422 serial channel interface and signal characteristics are compliant with ANSI/TIA/EIA-422. Use of vendor test data is acceptable.

Verification Submittal: CoC

I.4.3.8.2.2 REQUEST/COMMAND FORMAT

NVR

I.4.3.8.2.3 COMMAND PROCESSING REQUIREMENTS

Verification that the subrack payload is capable of receiving, verifying, and processing commands of the size described in the Message Byte Count in the EXPRESS header for up to a maximum of 52 16-big words, including second, third, and fourth EXPRESS header words and up to 49 command data words *should* be by test. The verification *should* be considered successful when the test, using a ScS (preferred) or subrack payload GSE, shows that the subrack payload is capable of receiving, verifying, and processing commands of the size described in the Message Byte Count in the EXPRESS Header for up to a maximum of 52 16-bit words, including second, third, and fourth EXPRESS header words per Table I.3.8.7.3.1-1 and up to 49 command data words per Figure I.3.8.7.3.7-1.

Verification Submittal: CoC

I.4.3.8.3 ETHERNET COMMUNICATIONS

I.4.3.8.3.1 SIGNAL CHARACTERISTICS

Verification that the subrack payload interfacing with the EXPRESS Rack PEHB meets the signal characteristics of IEEE 802.3 (10BASE-T section) **shall** be by test. The verification **shall** be considered successful when the test shows the subrack payload interfacing with the EXPRESS Rack PEHB meets the signal characteristics of IEEE 802.3 (10BASE-T section). Use of vendor test data is acceptable.

Verification Submittal: Test Report

I.4.3.8.3.2 COMMUNICATIONS PROTOCOL

Verification that the subrack payload communicating with the RIC and/or the laptop via the Ethernet PEHB uses software protocol TCP/IP *should* be by test. The verification *should* be considered successful when the test, using GSE or Remote Advanced Payload Test Rig (RAPTR), shows that the subrack payload communicating with the RIC and/or the laptop via the Ethernet PEHB uses software protocol TCP/IP.

Verification Submittal: CoC

I.4.3.8.3.3 REQUEST/COMMAND FORMAT

NVR

I.4.3.8.3.4 COMMAND PROCESSING REQUIREMENTS

Verification that the subrack payload is capable of receiving, verifying, and processing commands of the size described in the Message Byte Count in the EXPRESS header for up to a maximum of 52 16-bit words, including second, third, and fourth EXPRESS header words and up to 49 command data words *should* be by test. The verification *should* be considered successful when the test, using a ScS (preferred), RAPTR or subrack payload GSE, shows that the subrack payload is capable of receiving, verifying, and processing commands of the size described in the Message Byte Count in the EXPRESS Header for up to a maximum of 52 16-bit words, including second, third, and fourth EXPRESS header words per Table I.3.8.7.3.1-1 and up to 49 command data words per Figure I.3.8.7.3.7-1.

Verification Submittal: CoC

I.4.3.8.4 ANALOG COMMUNICATIONS

NVR

I.4.3.8.4.1 SIGNAL CHARACTERISTICS

Verification that the subrack payload analog signal input to the EXPRESS Rack is a **-**5 Vdc to +5 Vdc output signal (i.e., differential input to the SSPCM) **shall** be by test. The verification **shall** be considered successful when analysis of the test data shows that the subrack payload analog signal input to the EXPRESS Rack is a -5 Vdc to +5 Vdc output signal (i.e., differential input to the SSPCM). Use of vendor test data is acceptable.

Verification Submittal: Analysis test report

I.4.3.8.4.2 ANALOG DRIVER CHARACTERISTICS

Verification that the electrical characteristics of the subrack payload analog driver output circuit is compatible with the SSPCM receiver circuit per Figure I.3.8.4.2-1 **shall** be by test. The verification **shall** be considered successful when the analysis of the test data shows the subrack payload analog driver output circuit is compatible with the SSPCM receiver circuit per Figure I.3.8.4.2-1. Use of vendor test data is acceptable.

Verification Submittal: Analysis test report

I.4.3.8.5 DISCRETE COMMUNICATIONS

NVR

I.4.3.8.5.1 DISCRETE SIGNAL CHARACTERISTICS

NVR

I.4.3.8.5.1.1 DISCRETE OUTPUT LOW LEVEL

Verification that the PD hardware is compatible with a digital “zero” level output of -3.5 Vdc line-to-line *should* be by test. The verification *should* be considered successful when the analysis of the test data shows the PD hardware is compatible with a digital “zero” level output of -3.5 Vdc line-to-line.

Verification Submittal: CoC

I.4.3.8.5.1.2 DISCRETE OUTPUT HIGH LEVEL

Verification that the PD hardware is compatible with a digital “one” level output of +3.5 Vdc line-to-line *should* be by test. The verification *should* be considered successful when the analysis of the test data shows the PD hardware is compatible with a digital “one” level output of +3.5 Vdc line-to-line.

Verification Submittal: CoC

I.4.3.8.5.1.3 DISCRETE OUTPUT MAXIMUM FAULT CURRENT

Verification that the PD hardware is not damaged by indefinite exposure to a misconnection to -27 to 32 Vdc source or sustained short *should* be by analysis. The verification *should* be considered successful when the analysis shows the PD hardware is not damaged by indefinite exposure to a misconnection to -27 to 32 Vdc source or sustained short.

Verification Submittal: CoC

I.4.3.8.5.1.4 DISCRETE INPUT LOW LEVEL

Verification that the PD hardware provides a low level input (logic low level) within the voltage range of -0.5 Vdc to +2.0 Vdc *should* be by test. The verification *should* be considered successful when the analysis of test data shows the PD hardware provides a low level input (logic low level) within the voltage range of -0.5 Vdc to +2.0 Vdc.

Verification Submittal: CoC

I.4.3.8.5.1.5 DISCRETE INPUT HIGH LEVEL

Verification the PD hardware provides a high level input (logic high level) within the voltage range of +2.5 Vdc to +6.0 Vdc *should* be by test. The verification *should* be considered successful when the analysis of test data shows the PD hardware provides a high level input (logic high level) within the voltage range of +2.5 Vdc to +6.0 Vdc.

Verification Submittal: CoC

I.4.3.8.5.1.6 DISCRETE INPUT MINIMUM AND MAXIMUM FAULT VOLTAGE

Verification the PD hardware due to a fault is within the range of -27 to +32 Vdc **shall** be by analysis. The verification **shall** be considered successful when the analysis shows the PD hardware does not output any voltage outside the range of -27 to +32 Vdc.

Verification Submittal: Analysis Report

I.4.3.8.5.2 DISCRETE DRIVER AND RECEIVER CHARACTERISTICS

Verification that the electrical characteristics of the payload discrete driver circuit and receiver circuit are designed to match the SSPCM receiver circuit and driver circuit illustrated in Figure I.3.8.5.2-1 *should* be by analysis. The verification *should* be considered successful when the analysis shows the electrical characteristics of the payload discrete driver circuit and receiver circuit are designed to match the SSPCM receiver circuit and driver circuit illustrated in Figure I.3.8.5.2-1.

Verification Submittal: CoC

I.4.3.8.6 LAPTOP COMPUTERS AND SOFTWARE

A. Subrack payloads using the RIC bypass *should* meet the verification requirements in paragraph I.4.3.5.2.7.A or I.4.3.5.2.7.B

B. Subrack payloads using the KuIP *should* meet the downlink verification requirements listed in paragraph I.4.3.5.2.6.

I.4.3.8.6.1 LAPTOP COMPUTERS AND PORTABLE COMPUTING DEVICES

Verification that the subrack payload does not utilize/manifest its own laptop *should* be by inspection. The verification *should* be considered successful when the inspection of the final flight drawings shows the subrack payload does not utilize/manifest its own laptop.

Verification Submittal: CoC

I.4.3.8.7 EXPRESS RACK SOFTWARE

A. Verification that the subrack payload requiring data downlink via the RIC with a data rate greater than or equal to 1.2 Mbps for more than a 4 hour period per day or more than 600 Kbps for a period of more than 48 hours is designed to accept commands resulting in a variable downlink rate lower than 1.2 Mbps or less than 600 Kbps, which will meet payload criteria *should* be by analysis and test. The verification *should* be considered successful when the analysis of test results shows that the subrack payload requiring data downlink via the RIC with a data rate greater than or equal to 1.2 Mbps for more than a 4 hour period per day or more than 600 Kbps for a period of more than 48 hours is designed to accept commands resulting in a variable downlink rate lower than 1.2 Mbps or less than 600 Kbps, which will meet subrack payload criteria.

Verification Submittal: CoC

B. Verification that the keep-alive payload is designed to accept commands resulting in a variable downlink rate of less than 400 Kbps during the keep-alive period *should* be by analysis and test. The verification *should* be considered successful when the analysis of test results shows that the keep-alive payload is designed to accept commands resulting in a variable downlink rate of less than 400 Kbps during the keep-alive period.

Verification Submittal: CoC

C. Verification that the subrack payload using the RIC bypass capability and with a downlink data rate greater than or equal to 2.0 Mbps is designed to accept commands resulting in a variable downlink rate less than 2.0 Mbps *should* be by analysis and test. The verification *should* be considered successful when the analysis of test results shows that the payload using the RIC bypass capability and with a downlink data rate greater than or equal to 2.0 Mbps is designed to accept commands resulting in a variable downlink rate less than 2.0 Mbps.

Verification Submittal: CoC

I.4.3.8.7.1 EXPRESS RACK PEHB INTERFACE (ETHERNET)

Verification that the payload Ethernet connection conforms with IEEE 802.3, Type 10 BASE-T TCP/IP protocol format *should* be by analysis and test. The verification *should* be considered successful when the analysis of test results show that the payload Ethernet connection is compatible with IEEE 802.3, Type 10 BASE-T TCP/IP protocol format.

Verification Submittal: CoC

A. NVR

B. NVR

C. Verification that the data and files elements for the payload-to-RIC Ethernet interfaces are compliant with Table I.3.8.7.1-1 *should* be by analysis and test. The verification *should* be considered successful when the analysis of test results shows the payload-to-RIC Ethernet interfaces are compliant with Table I.3.8.7.1-1.

Verification Submittal: CoC

D. Subrack payloads using the payload-to-payload communication protocol between racks or to other payload locations *should* meet the verification requirement listed in paragraph I.4.3.5.2.7.A or B.

I.4.3.8.7.1.1 SUBRACK PAYLOAD USING DATA DOWNLINK VIA THE RIC BYPASS

A. The subrack payload **shall** meet the CCSDS Data verification requirements listed in Table I.4.3.8.7.1.1-1.

TABLE I.4.3.8.7.1.1-1 CCSDS REQUIREMENTS

SSP 57000 Requirement	Title/Subject
I.4.3.3.1.1	CCSDS DATA PACKETS
I.4.3.3.1.2	CCSDS DATA FIELD

B. The payload **shall** meet the MAC Address verification requirement I.4.3.5.2.1.3.1.A.

I.4.3.8.7.2 EXPRESS RACK RIC SERIAL INTERFACE (RS-422)

A. Verification that all subrack payload packets are separated by a minimum idle time equivalent to 5 data characters *should* be by analysis and test. The verification *should* be considered successful when the analysis of test data results show that all subrack payload packets are separated by a minimum idle time equivalent to 5 data characters.

Verification Submittal: CoC

B. Verification that all subrack payload messages are complete and never have idle time of more than two contiguous characters between sync word and message checksum word *should* be by analysis and test. The verification *should* be considered successful when the analysis of test results show that all payload messages are complete and never have idle time of more than two contiguous characters between sync word and message checksum word.

Verification Submittal: CoC

I.4.3.8.7.3 PAYLOAD INTERFACE DATA ELEMENTS

I.4.3.8.7.3.1 EXPRESS HEADER

Verification that the subrack payload uses the header word format defined in Table I.3.8.7.3.1-1, EXPRESS Header, during communications between the payload and the RIC CSCI across the physical ANSI/TIA/EIA-422 interface or across the logical Ethernet interface through the PEHB *should* be by analysis and test. The verification *should* be considered successful when the analysis of test results shows that that the payload uses the header word format defined in Table I.3.8.7.3.1-1, EXPRESS Header, during communications between the payload and the RIC CSCI across the physical ANSI/TIA/EIA-422 interface or across the logical Ethernet interface through the PEHB.

Verification Submittal: CoC

I.4.3.8.7.3.2 UNIQUE IDENTIFIER NUMBERS

Verification that the subrack payload uses the TCP port number, IP Address for TCP/IP, and Function Code assigned to the subrack payload in PDL **shall** be by analysis and test. The verification **shall** be considered successful when the analysis of test results show that the subrack payload uses the TCP port number, IP Address for TCP/IP, and Function Code assigned to the subrack payload in PDL.

Verification Submittal: CoC

I.4.3.8.7.3.3 EXPRESS TELEMETRY SECONDARY HEADER

Verification that the subrack payload uses the format of the EXPRESS telemetry secondary header per Table I.3.8.7.3.3-1 *should* be by analysis and test. Verification *should* be considered successful when the analysis of test results show that the subrack payload uses the format of the EXPRESS telemetry secondary header per Table I.3.8.7.3.3-1.

Verification Submittal: CoC

I.4.3.8.7.3.4 PAYLOAD TELEMETRY PACKET

Verification that all payload telemetry from the subrack payload to the RIC is packetized in accordance with the packet format shown in Table I.3.8.7-2 *should* be by analysis and test. The verification *should* be considered successful when the analysis of the test data shows that all payload telemetry from the subrack payload to the RIC is packetized in accordance with the packet format shown in Table I.3.8.7-2.

Verification Submittal: CoC

I.4.3.8.7.3.5 EXPRESS RIC INTERFACE REQUESTS AND RESPONSES

A. Verification that requests and messages initiated by the subrack payload when communicating with the RIC CSCI are per Table I.3.8.7.3.5-1 and Table I.3.8.7.3.5-2 *should* be by analysis and test. The verification *should* be considered successful when the analysis of test results show that requests and messages initiated by the subrack payload when communicating with the RIC CSCI are per Table I.3.8.7.3.5-1 and Table I.3.8.7.3.5-2.

Verification Submittal: CoC

B. Verification that request header/message/word definitions used by the subrack payload are in accordance with Tables I.3.8.7.3.5.1-1, I.3.8.7.3.5.2-1, I.3.8.7.3.5.3-1, I.3.8.7.3.5.4-1, I.3.8.7.3.5.5.1-1 and I.3.8.7.3.5.5.2-1 *should* be by analysis and test. The verification *should* be considered successful when the analysis of test results show that that request header/message/word definitions used by the subrackpayload are in accordance with Tables I.3.8.7.3.5.1-1, I.3.8.7.3.5.2-1, I.3.8.7.3.5.3-1, I.3.8.7.3.5.4-1, I.3.8.7.3.5.5.1-1 and I.3.8.7.3.5.5.2-1.

Verification Submittal: CoC

I.4.3.8.7.3.5.1 PEP BUNDLE REQUEST

NVR

I.4.3.8.7.3.5.2 PEP PROCEDURE EXECUTION REQUEST

NVR

I.4.3.8.7.3.5.3 RACK TIME REQUEST

Verification that the subrack payload sends a rack time request to the RIC if the subrack payload requires broadcast time updates more frequently than once every 30 seconds *should* be by analysis and test. The verification *should* be considered successful if the analysis of the test results show that the subrack payload sends a rack time request to the RIC if the subrack payload requires broadcast time updates more frequently than once every 30 seconds.

Verification Submittal: CoC

I.4.3.8.7.3.5.4 ANCILLARY DATA CONFIGURATION CONTROL

Verification that the subrack payload receiving the Broadcast Ancillary data frame checks the Frame ID (least 7 significant bits of the CCSDS header word eight (8)) before further processing *should* be by analysis and test. The verification *should* be considered successful when the analysis of test data shows that the subrack payload receiving the Broadcast Ancillary data frame checks the Frame ID (least 7 significant bits of the CCSDS header word eight (8)) before further processing.

Verification Submittal: CoC

I.4.3.8.7.3.5.5 FILE TRANSFER REQUEST

NVR

I.4.3.8.7.3.5.5.1 PAYLOAD FILE TRANSFER REQUEST

Verification that the subrack payload uses the correct format for the Payload File Transfer Request *should* be by analysis and test. The verification *should* be considered successful when the analysis of test data shows the subrack payload uses the format per Table I.3.8.7.3.5.5.1-1.

Verification Submittal: CoC

I.4.3.8.7.3.5.5.2 EMU FILE TRANSFER REQUEST

NVR

I.4.3.8.7.3.5.6 PAYLOAD RESPONSE

NVR

I.4.3.8.7.3.6 PAYLOAD HEALTH AND STATUS DATA

NVR

I.4.3.8.7.3.6.1 PAYLOAD HEALTH AND STATUS DATA – ECW (1ST WORD)

A. Verification that the powered subrack payload continuously provides H&S (including Safety) data in number of words to the RIC at a rate of 1.0 Hz *should* be by analysis and test. The verification *should* be considered successful when the analysis of test results shows that the powered subrack payload continuously provides H&S (including Safety) data in number of words to the RIC at a rate of 1.0 Hz per the format shown in Table I.3.8.7.3.6-1.

Verification Submittal: CoC

B. Verification that the powered subrack payload's H&S has a fixed length and a fixed measurement location *should* be by analysis and test. The verification *should* be considered successful when the analysis of test results shows that the powered subrack payload's H&S has a fixed length and a fixed measure location per MSFC-STD-1274, Volume 2, Paragraph 4.4.3.2 (Subset Sampling).

Verification Submittal: CoC

C. Verification that the subrack payload has reserved the first word of the subrack payload generated H&S data as the ECW word, and set the ECW word value to either zero (No Problem) or 1 (Advisory) **shall** be by analysis and test. The verification **shall** be considered successful when the analysis of test results shows that the subrack payload has reserved the first word of the subrack payload generated H&S data as the ECW word, and set the ECW word value to either zero (No Problem) or 1 (Advisory).

Verification Submittal: Analysis Report or Test Data/Report

I.4.3.8.7.3.6.2 PAYLOAD HEALTH AND STATUS DATA – H&S CYCLE COUNTER (2ND WORD)

A. Verification that the subrack payload provides as the second word of H&S data an H&S Cycle Counter that is an unsigned 16-bit integer in the range of zero to 65,535 **shall** be by analysis and test. The verification **shall** be considered successful when the analysis of test results shows that the subrack payload provides as the second word of H&S data an H&S Cycle Counter that is an unsigned 16-bit integer in the range of zero to 65,535.

Verification Submittal: Analysis Report or Test Data/Report

B. Verification that the subrack payload provides as the second word of H&S data an H&S Cycle Counter that is set to zero for the first H&S packet that the subrack payload transmits **shall** be by analysis and test. The verification **shall** be successful when the analysis of test results shows that the subrack payload provides as the second word of H&S data an H&S Cycle Counter that is set to zero for the first H&S packet that the subrack payload transmits.

Verification Submittal: Analysis Report or Test Data/Report

C. Verification that the subrack payload provides as the second word of H&S data an H&S Cycle Counter that increments by a value of one for each packet transmitted **shall** be by analysis and test. The verification **shall** be considered successful when the analysis of test results shows that the subrack payload provides as the second word of H&S data an H&S Cycle Counter that increments by a value of one for each packet transmitted.

Verification Submittal: Analysis Report or Test Data/Report

D. Verification that the subrack payload provides as the second word of H&S data an H&S Cycle Counter that once the value 65,535 is reached, the counter resets to a value of zero and continues renumbering **shall** be by analysis and test. The verification **shall** be considered successful when the analysis of test results shows that the subrack payload provides as the second word of H&S data an H&S Cycle Counter that once the value 65,535 is reached, the counter resets to a value of zero and continues renumbering per paragraphs I.3.8.7.3.6.2.A, B and C.

Verification Submittal: Analysis Report or Test Data/Report

I.4.3.8.7.3.6.3 PAYLOAD HEALTH AND STATUS DATA – PAYLOAD MESSAGE (3RD TO 92ND WORD)

Verification that subrack payloads that require advisory messages to be displayed on a PCS onboard the ISS or displayed by payload operations personnel on the ground, include those messages in their H&S data *should* be by analysis and test. The verification *should* be considered successful when the analysis of test results shows that subrack payloads that require advisory messages to be displayed on a PCS onboard the ISS or displayed by payload operations personnel on the ground, include those messages in their H&S data per Figure I.3.4.1.3-3.

Verification Submittal: CoC

I.4.3.8.7.3.6.3.1 PAYLOAD MESSAGE COUNTER (FIRST BYTE OF PAYLOAD MESSAGE)

A. Verification that the subrack payload provides as the first byte of the Payload Message a Payload Message Counter that is an unsigned eight (8)-bit integer in the rate of zero to 255 *should* be by analysis and test. The verification *should* be considered successful when the analysis of test results shows that the subrackpayload provides as the first byte of the Payload Message a Payload Message Counter that is an unsigned eight (8)-bit integer in the rate of zero to 255.

Verification Submittal: CoC

B. Verification that the subrack payload provides as the first byte of the Payload Message a Payload Message Counter that initially contains a value of zero *should* be by analysis and test. The verification *should* be considered successful when the analysis of test results shows that the subrack payload provides as the first byte of the Payload Message a Payload Message Counter that initially contains a value of zero.

Verification Submittal: CoC

C. Verification that the subrack payload provides as the first byte of the Payload Message a Payload Message Counter that increments by a value of one with each message issued by the subrack payload *should* be by analysis and test. The verification *should* be considered successful when the analysis of test results shows that the subrack payload provides as the first byte of the Payload Message a Payload Message Counter that increments by a value of one with each message issued by the subrack payload.

Verification Submittal: CoC

D. Verification that the Payload Message Counter resets to a value of zero and continues incrementing *should* be by analysis. The verification *should* be considered successful when the analysis shows that the Payload Message Counter resets to a value of zero and continues incrementing per paragraphs I.3.8.7.3.6.3.1.A, B and C.

Verification Submittal: CoC

I.4.3.8.7.3.6.3.2 PAYLOAD MESSAGE IDENTIFIER

Verification that the payload message identifier is an 8-bit unsigned integer in the range of zero to 255 *should* be by analysis and test. The verification *should* be considered successful when the analysis of tests results shows that the payload message identifier is an 8-bit unsigned integer in the range of zero to 255.

Verification Submittal: CoC

I.4.3.8.7.3.7 EXPRESS PAYLOAD COMMANDING

Verification that payload uplink commands meet the payload input S-Band minimum 13 word requirement (including the EXPRESS Header) *should* be by analysis or test. The verification *should* be considered successful when the analysis or test (using ScS, preferred, RAPTR, or payload GSE) shows payload uplink commands via EHS zero fill to meet the payload input S-Band minimum size requirement of 13 words (including the EXPRESS Header).

Verification Submittal: CoC

I.4.3.8.7.4 LAPTOP CSCI INTERFACES

Verification that the subrack payload interfaces to the laptop CSCI are IEEE 802.3, CSMA/CD Local Area Network Specification, Type 10BASE-T TCP/IP protocol format compliant *should* be by analysis and test. The verification *should* be considered successful when the analysis of test results shows that the subrack payload interfaces to the laptop CSCI are IEEE 802.3, CSMA/CD Local Area Network Specification, Type 10BASE-T TCP/IP protocol format compliant.

Verification Submittal: CoC

I.4.3.8.7.4.1 PAYLOAD-PROVIDED SOFTWARE/PERIPHERALS

NVR

I.4.3.8.7.4.2 EXPRESS RACK LAPTOP DISPLAY REQUIREMENTS

Subrack payload displays **shall** meet the verification requirements in paragraph I.4.3.1.2.

I.4.3.8.7.4.3 PAYLOAD APPLICATION SOFTWARE (PAS) INTERFACES

NVR

I.4.3.8.7.4.3.1 PAS DIRECT COMMUNICATIONS WITH THE SUBRACK PAYLOAD

Verification that data packets sent between PAS on the ELC and the subrack payload do not exceed 100 kilobits per second **shall** be by analysis and test. The verification **shall** be considered successful when the analysis and test results show that all data packets sent between PAS on the ELC and the subrack payload do not exceed 100 kilobits per second.

Verification Submittal: CoC

I.4.3.8.7.4.3.2 SOFTWARE UPDATING PROCESS FOR LAPTOP

NVR

I.4.3.8.7.4.3.3 PAYLOAD APPLICATION PROCESS TO EXPRESS CSCI

Verification that the payload application message includes the EXPRESS Header andfirst word of the EXPRESS telemetry secondary header, telemetry Data Type, and up to 1,248 bytes of data *should* be by test. The verification *should* be considered successful when the test results show the payload application message is per Table I.3.8.7.4.3.3-1.

Verification Submittal: CoC

I.4.3.8.7.4.3.4 PAS COMPATIBILITY AND INSTALLATION FILES

A. Verification that PAS is compatible with the Lenovo T61P with Common Laptop Software Release 9.2 or greater (with Windows 7 Professional Service Pack 1, 32-bit Operating System) **shall** be by demonstration. The demonstration **shall** involve running the operating systems and all applications needed for a subrack payload's planned operations. The demonstration **shall** be considered successful when the software runs properly per final flight configuration on a ground EXPRESS Laptop Computer (Lenovo T61P) with Common Laptop Software Release 9.2 or greater (with Windows 7 Professional Service Pack 1, 32-bit Operating System).

Verification Submittal: Report

B. Verification that the subrack payload limits Write Files/data to the ELC partition assigned to the subrack payload **shall** be by analysis and test. The verification **shall** be considered successful when the analysis and test results show that all subrack payload Write Files are limited to the ELC partition assigned to the subrack payload.

Verification Submittal: Analysis Report and Test Report

C. Verification that the subrack payload provides a way to remove 'read only' files **shall** be by analysis and test. The verification **shall** be considered successful when the analysis and test results show that 'read only' files can be removed.

Verification Submittal: Analysis Report and Test Report

D. Verification that PAS installation programs are capable of being installed on any ELC partition without requiring additional editing to the PAS after installation is complete **shall** be by analysis and test. The verification **shall** be considered successful when the test results show that PAS installation programs are capable of being installed on any ELC partition without requiring additional editing to the PAS after installation is complete.

Verification Submittal: Analysis Report and Test Report

E. Verification that the PAS is compatible with the anti-virus software and definition files that run on the ELC **shall** be by test. The verification **shall** be considered successful when the PAS runs properly per final flight configuration while ELC virus scanning software is running normally in active scan mode. The test results will be documented and include the PAS version, name, and version and date of the anti-virus software and definition file.

Verification Submittal: Test Report

I.4.3.8.7.4.3.5 PAS PROCESS AT PSIVF

A. Verification that the PD has provided the latest flight version of PAS that has no load conflicts (including port number conflicts) and does not affect the configuration and/or performance of the ELC application whether the PAS product is active or inactive **shall** be by inspection. The verification **shall** be considered successful when the inspection results show that the PD has provided the latest flight version of PAS to the PSIVF for integrated functional testing and approval.

Verification Submittal: Test Report

B. Verification that PAS does not run and/or write files/data on the ELC system drive (C. partition) (except files required during PAS installation and updating) **shall** be by test. The verification **shall** be considered successful when the test results show that PAS does not run and/or write files/data on the ELC system drive (C. partition) (except files required during PAS installation and updating).

Verification Submittal: Test Report

C. Verification that the PD has supplied PAS that directly controls and allocates the amount of RAM available to the application is adjustable **shall** be by analysis and test. The verification **shall** be considered successful when the test results show that RAM allocation for the PAS that directly controls and allocates the amount of RAM available to the application is adjustable.

Verification Submittal: Analysis Report and Test Report

D. Verification that the PAS is delivered to PSIV virus-free **shall** be by inspection. The verification **shall** be considered successful when certification paperwork is received from the PD noting that their software was scanned and found to be virus-free prior to shipment. The certification will include the PAS name and version, date of the scan, and name, version, and release date of the anti-virus software and definition files used to scan the PAS before delivery.

Verification Submittal: Test Report

E. NVR

I.4.3.8.7.5 FILE MAINTENANCE

Verification that all subrack payload developed software applications include file maintenance features **shall** be by analysis or test. The verification **shall** be considered successful when the analysis or test results show that all payload developed software applications include file maintenance features which will rename files, change file attributes, and delete files on EMU/ELC PLD (Payload) and SWL (Software Load) directory.

Verification Submittal: CoC

I.4.3.8.7.6 PAYLOAD DATA MONITORING

A. Verification that all subrack payload hardware using parameter monitoring, when powered on, outputs Health and Status data including payload service request, payload

ECW word, and other PD Health and Status sensor information at 1 Hz continuously per Section I.3.8.7.3.6.2 **shall** be by analysis and test. The verification **shall** be considered successful when the analysis of the test results show that all subrack payload hardware using parameter monitoring, when powered on, outputs Health and Status data including payload service request, payload ECW word, and other PD Health and Status sensor information at 1 Hz continuously per Section I.3.8.7.3.6.2.

Verification Submittal: Analysis Report and Test Report

B. The subrack payload **shall** meet the verification requirement in paragraph N.4.3.10.1.2.1.

C. The subrack payload **shall** meet the verification requirement in paragraph I.4.3.4.1.4.B.

APPENDIX J

POWER INVERTER TO 120 VAC LOAD INTERFACE REQUIREMENTS

APPENDIX J - POWER INVERTER TO 120 VAC LOAD INTERFACE REQUIREMENTS

J.1.0 INTRODUCTION

J.1.1 PURPOSE

This appendix provides requirements, guidelines and data deliverables for payloads powered by the ISS Power Inverters. The inverters takes electrical energy from the 120 Vdc ISS power bus or a 28 Vdc power source and inverts the power into 120 Vac.

J.1.2 SCOPE

This appendix addresses payloads which are 120 Vac loads on the ISS Power Inverters listed in Table J.1.2-1.

TABLE J.1.2-1 ISS POWER INVERTERS

DESCRIPTION	OPSNOM	PART NUMBER	MAX. POWER LIMIT
120VDC ISS Power Inverter “Cobalt” Blue	120 Vdc to 120 Vac Inverter	SEG33123254-301	750 W
120VDC ISS Power Inverter “Cobalt” Blue	120 Vdc to 120 Vac Inverter	SEG33123254-303	750 W
28VDC ISS Power Inverter “Emerald” Green	28 Vdc to 120 Vac Inverter	SEG33123255-301	400 W

Note: None of the inverters provide any ground fault detection or interrupt function.

AC loads often do not have enough controls for shock hazard. Safety NCR-IPVR-001 identifies a Ground Fault Circuit Interrupt (GFCI) Cable as a possible shock hazard control for certain load configurations. In addition, NCR-IPVR-001 identifies connector non-compliances (lack of locking features) with the COTS NEMA 5-15 receptacles on the inverter that can be mitigated with the locking receptacle on the GFCI cable. This appendix includes requirements for the GFCI Cable shown in Table J.1.2-2.

TABLE J.1.2-2 ISS GROUND FAULT CIRCUIT INTERRUPT CABLE

DESCRIPTION	OPSNOM	PART NUMBER
Ground Fault Interrupter Cable	INVERTER GFCI CABLE, 3’	SEG33123662-301

J.1.3 USE

These requirements, guidelines and data deliverables are applied to payloads powered by the ISS Power Inverters in addition to the general requirements, guidelines and data deliverables in Section 3.0 and are allocated to a payload through the payload unique ICD. The PD and the ISS Program must jointly agree on the interfaces and identify requirements as applicable if the interface exists, and not applicable if the interface does not exist for the payload configuration documented in the ICD.

J.2.0 DOCUMENTATION

See Section 5.0.

J.3.0 POWER INVERTER TO 120 VAC LOAD INTERFACE REQUIREMENTS

J.3.1 AC INVERTER MECHANICAL INTERFACES

J.3.1.1 AC INVERTER CONNECTOR

All loads *should* have an electrical interface connection compatible with Figure J.3.1.1-1 or Figure J.3.1.1-2.

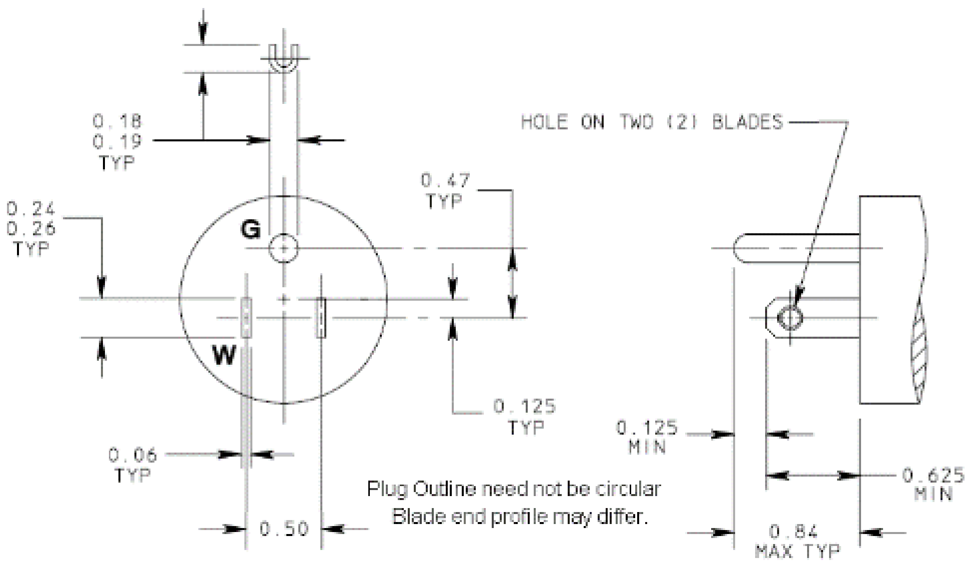


FIGURE J.3.1.1-1 125V, 15 AMPERES, 2 POLE 3 WIRE, GROUNDING TYPE PLUG

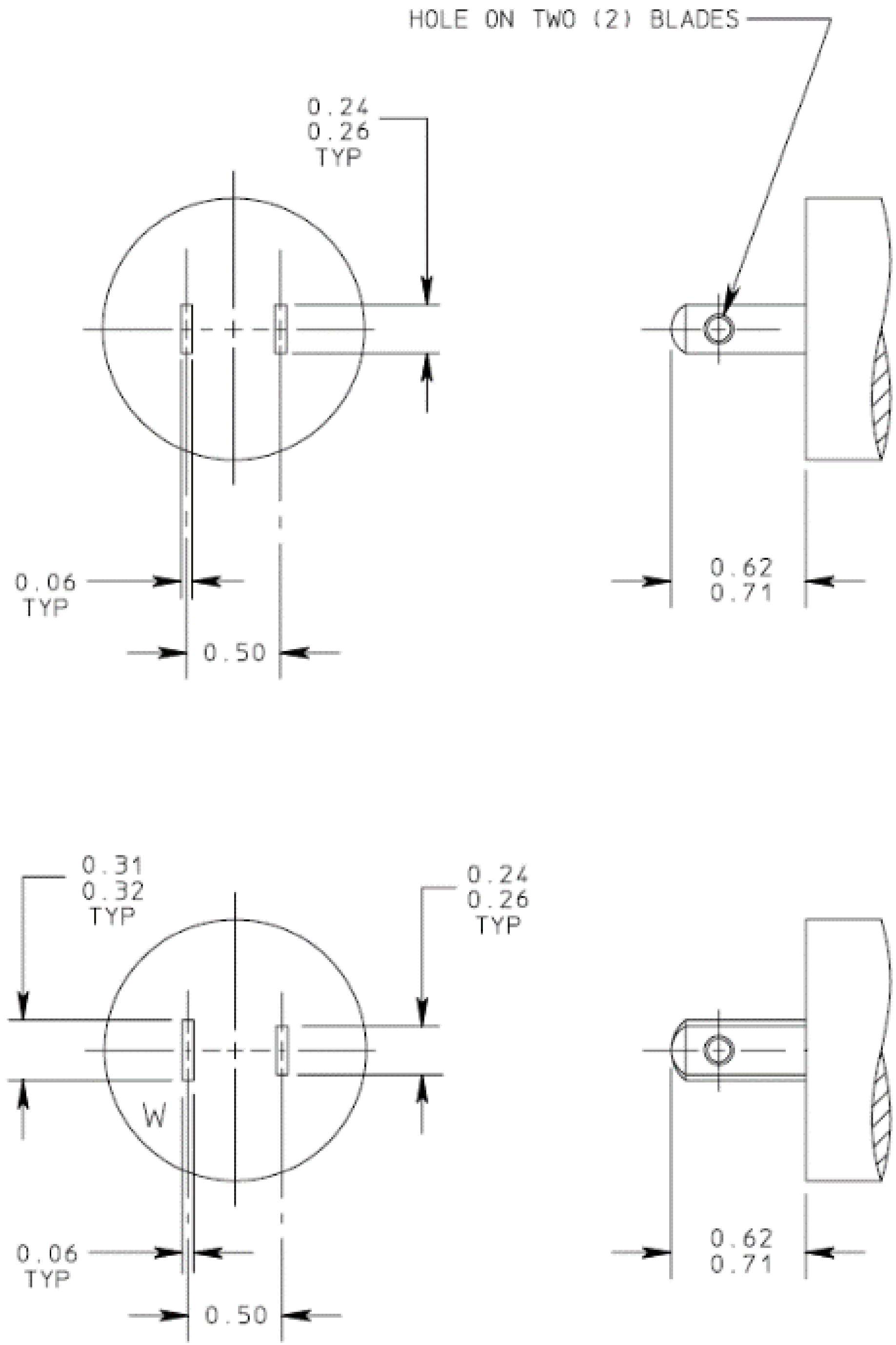


FIGURE J.3.1.1-2 125V, 15 AMPERES, 2 POLE 2 WIRE PLUG

J.3.1.2 AC INVERTER CONNECTOR COVER INTERFERENCE

The portion of the load that connects to the inverter *should* mate with the inverter receptacle so that it does not interfere with the connector cover as shown in Figure J.3.1.2-1.

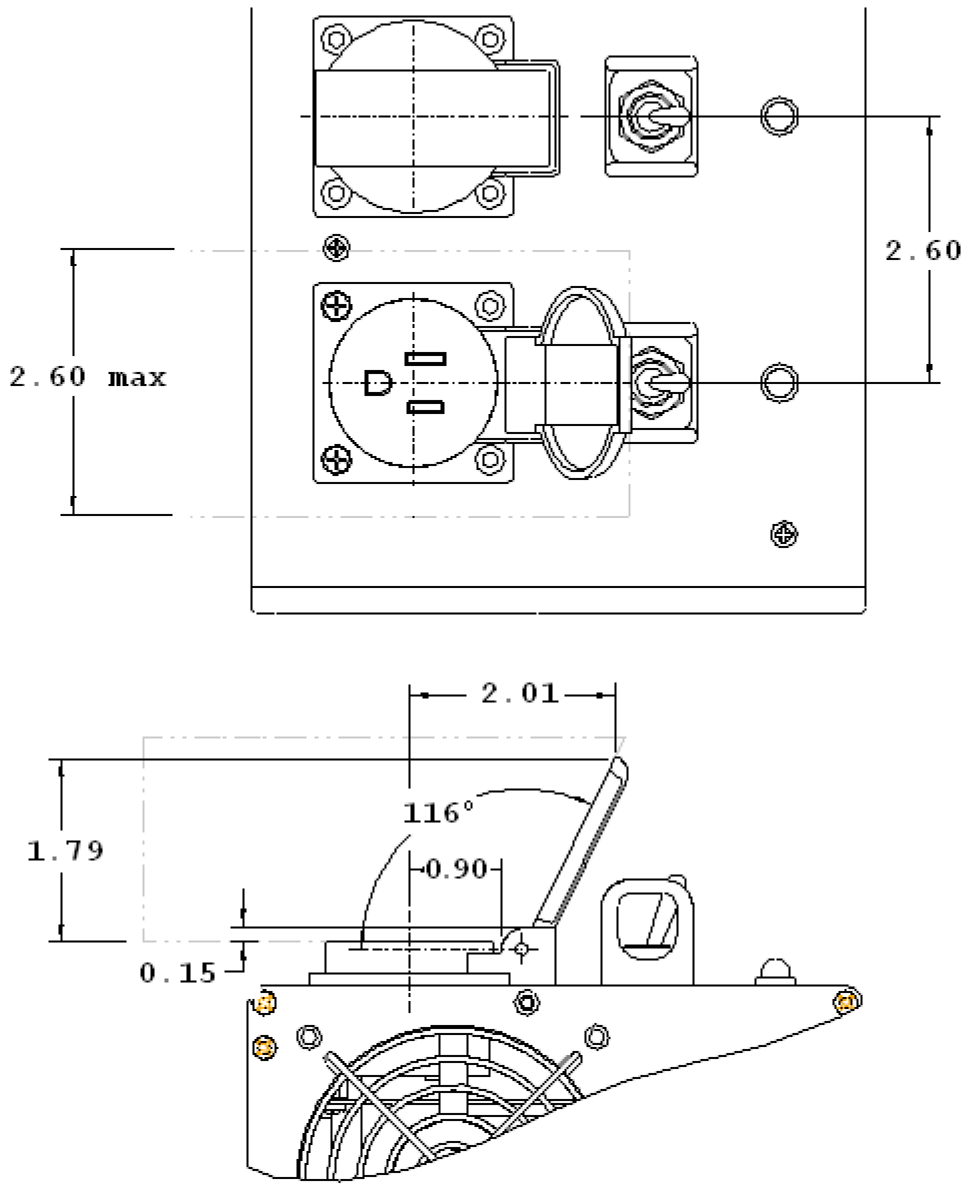


FIGURE J.3.1.2-1 CONNECTOR COVER KEEP-OUT ZONE

J.3.1.3 AC INVERTER CONNECTOR MECHANICAL ENVELOPE

The physical dimensions of the electrical connection to the inverter *should* fit within the mechanical envelope in Figure J.3.1.2-1.

J.3.1.4 AC INVERTER CABLE RESTRAINT

For long duration AC loads, the AC load project **shall** provide a cable restraint method such as a hook/loop strap or tie wrap.

J.3.1.5 AC INVERTER STRAIN RELIEF

All cables **shall** have adequate strain relief such as continuous molded plug/cable jacket, or other obvious strain relief, including any overwrap installed by the project.

J.3.1.6 AC INVERTER CABLE INSULATION

AC cables interfaced to the ISS Power Inverter output and other downstream cables with voltages greater than 32 V_{RMS} **shall** be double insulated or utilize a second layer of insulation over-wrap.

J.3.1.7 PAYLOAD HOUSING

Payloads *should* not have openings in their housing greater than 0.125 square inches.

J.3.2 AC INVERTER ELECTRICAL LOAD REQUIREMENTS

J.3.2.1 AC INVERTER REVERSE OUTPUT POWER

The load **shall** operate without supplying continuous reverse power to the inverter.

J.3.2.2 AC INVERTER REVERSE OUTPUT ENERGY

The load **shall** operate without supplying more than 2.7 watt second (Joule) of reverse energy to the inverter before drawing that energy back from the inverter.

J.3.2.3 AC INVERTER OPERATION AT 60HZ

The load *should* be capable of operating at 60 Hz ±1 Hz.

J.3.2.4 AC INVERTER USER CAPABLE OF RUNNING AT REDUCED VOLTAGE

The load *should* operate normally with an input voltage of 105 Vrms.

J.3.2.5 AC INVERTER USER CAPABLE OF UNDISTURBED OPERATION WHEN POWER SKIPS ONE CYCLE

The load *should* operate undisturbed when exposed to an interruption of AC power for one AC cycle.

Note that ‘undisturbed operation’ is defined by the user of the load. Certain loads, such as battery chargers or AC adapters for devices with batteries may be considered to operate undisturbed if the only result of skipped cycles is the ‘charge’ indication momentarily going out.

J.3.3 GFCI CABLE INTERFACE REQUIREMENTS

J.3.3.1 GFCI CABLE STARTUP OPERATIONAL COMPATIBILITY

The load *should* successfully start up when powered on by operating the RESET button on the GFCI cable.

J.3.3.2 GFCI CABLE CONTINUOUS LOAD LEAKAGE CURRENT

The leakage current through the ground or chassis connection, at the power frequency, *should* not exceed 2 mA rms.

J.3.4 LEAKAGE EMISSION LE01 LIMITS

Payloads connecting to 120 VAC power source **shall** limit leakage emissions (LE) LE01 to not exceed 0.5 mA AC (or 0.25 mA AC for double insulated devices) when referenced through an equivalent crew impedance as defined in Figure J.3.4-1.

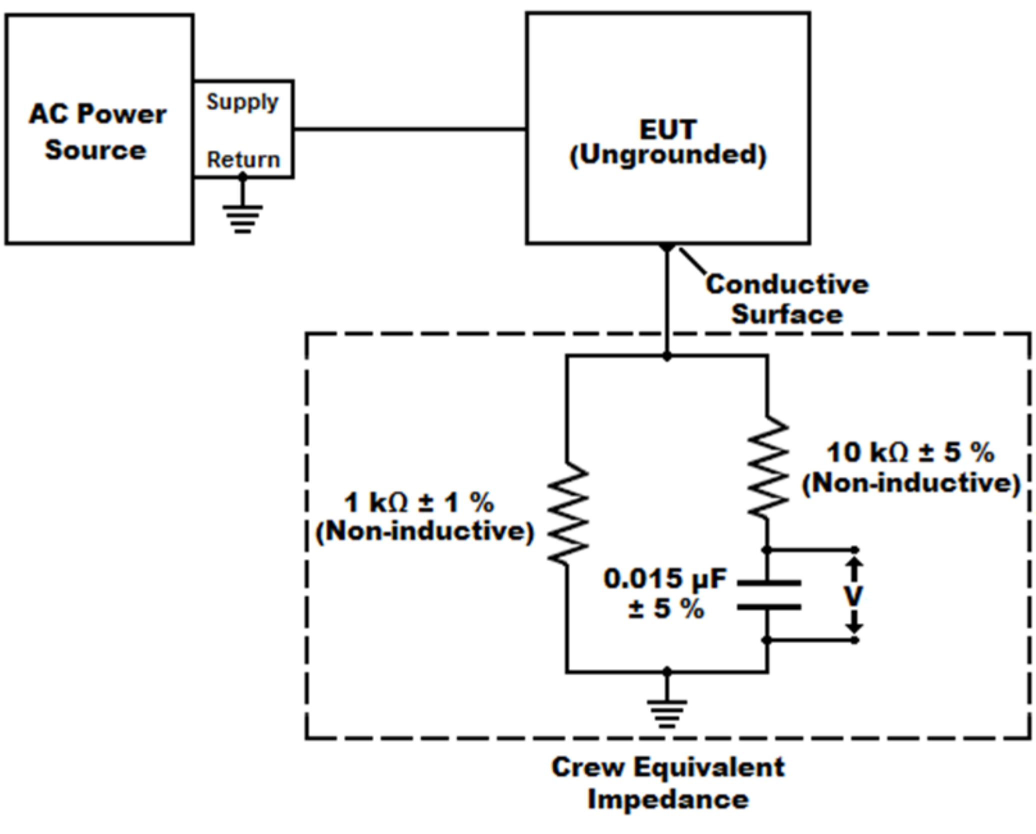


FIGURE J.3.4-1 LE01 MEASUREMENT SETUP

J.3.5 AC CONDUCTED EMISSIONS

Payloads connecting to 120 VAC power source **shall** limit AC conducted emissions (AC CE) per Table J.3.5-1.

TABLE J.3.5-1 AC CONDUCTED EMISSIONS LIMITS

Frequency Range	Limits
150 kHz – 500 kHz	Decreasing log linearly with increasing frequency from 66 to 56 dB above 1 microvolt
500 kHz – 5 MHz	56 db above 1 microvolt
5 MHz – 30 MHz	60 dB above 1 microvolt

Notes:
1) The lower limit applies at the transition frequencies.
2) The limit is in terms of quasi-peak detection mode. Peak detection mode may be used if all emissions are below the specified limits.

J.3.6 AC CONDUCTED SUSCEPTIBILITY

Payloads connecting to 120 VAC ISS power source **shall** not exhibit any malfunction, degradation of performance, or deviation from specified indications beyond the tolerances indicated in the individual equipment or subsystem specification when subjected to the values as shown in Table J.3.6-1. This limit is applicable between 150 kHz and 30 MHz for equipment and subsystem 120 VAC power leads.

TABLE J.3.6-1 AC CONDUCTED SUSCEPTIBILITY LIMITS

Frequency Range	Limits
150 kHz – 30 MHz	3 Vrms

Note: The test limit is the CW amplitude before modulation. During testing, the injected signal will be modulated with a 1 kHz, 80% amplitude modulation.

J.4.0 VERIFICATION

J.4.1 RESPONSIBILITIES

The PD is responsible for providing verification for all applicable requirements in this appendix, as allocated to the payload through the payload unique ICD. The ISS Program is responsible for review and approval of the submitted verification.

J.4.2 VERIFICATION METHODS

Compliance with the requirements stated in Section J.3.0 are proven using one or more of the methods described in paragraph 4.2.

J.4.3 POWER INVERTER TO 120 VAC LOAD INTERFACE VERIFICATION REQUIREMENTS

J.4.3.1 AC INVERTER MECHANICAL INTERFACES

J.4.3.1.1 AC INVERTER CONNECTOR

An inspection of the drawings or a demonstration *should* be performed to show that the plug interfacing with the receptacle of the inverter has an electrical connection compatible with a flight like inverter or NEMA socket equivalent. The verification *should* be considered successful with the inspection or demonstrations shows that the plug that interfaces with the inverters has an electrical connection compatible with Figure J.3.1.1-1 or Figure J.3.1.1-2. A plug that is U/L listed will be considered for successful verification of plug-inverter interface.

Verification Submittal: CoC documenting the evidence of connector compatibility.

J.4.3.1.2 AC INVERTER CONNECTOR COVER INTERFERENCE

An inspection of the drawings or a demonstration *should* be performed to show that the part of the load that interfaces with the inverter does not interfere with the receptacle cover as shown in Figure J.3.1.2-1. The verification *should* be considered successful when the inspection of drawings or the demonstration shows that the part of the load that interfaces with the inverter does not interfere with the receptacle cover shown in Figure J.3.1.2-1.

Verification Submittal: CoC documenting the evidence of connector compatibility.

J.4.3.1.3 AC INVERTER CONNECTOR MECHANICAL ENVELOPE

An inspection of the drawings or a demonstration *should* be performed to show that the physical dimensions of the electrical interface to the inverter meets the mechanical envelope shown in Figure J.3.1.2-1. The verification *should* be considered successful when the inspection of drawings or the demonstration shows that the physical dimensions of the electrical interface to the inverter meets the mechanical envelope shown in Figure J.3.1.2-1.

Verification Submittal: CoC documenting the evidence of connector compatibility.

J.4.3.1.4 AC INVERTER CABLE RESTRAINT

An inspection of the AC load project deliverables **shall** be performed showing that the list of deliverables include a cable restraint method that is commensurate with the AC load duration.

Note: The Power Inverter hazard report, UNQ-IPVR-17, initiated the OCAD (ID #102400) to cover the operational control required by the crew to restrain the AC cable loads depending upon the duration. No other operational control is required by the AC load.

Verification Submittal: CoC documenting the evidence of connector compatibility.

J.4.3.1.5 AC INVERTER STRAIN RELIEF

Verification **shall** be by inspection. The inspection **shall** be considered successful when inspection of vendor data or flight hardware shows that the cable has strain relief.

Verification Submittal: CoC documenting the evidence of connector compatibility.

J.4.3.1.6 AC INVERTER CABLE INSULATION

Verification **shall** be by inspection. The inspection **shall** be considered successful when inspection of vendor data or flight hardware shows that the cable is double insulated.

Verification Submittal: CoC documenting the evidence of connector compatibility

J.4.3.1.7 PAYLOAD HOUSING

Verification *should* be by inspection of drawings or flight hardware. The verification *should* be considered successful when the inspection shows that the payload housing has no openings greater than 0.125 square inches.

Verification Submittal: CoC

J.4.3.2 AC INVERTER ELECTRICAL LOAD REQUIREMENTS

J.4.3.2.1 AC INVERTER REVERSE OUTPUT POWER

A test **shall** be performed to show that the load does not supply continuous reverse power to the inverter. The verification **shall** be considered successful when the test data shows that the load does not supply continuous reverse power to the inverter.

Verification Submittal: Test Report documenting reverse output power test results or closed TPS as performed in ESTA.

J.4.3.2.2 AC INVERTER REVERSE OUTPUT ENERGY

For electromechanical devices, a test **shall** be performed to show that the load does not supply more than 2.7 W·s (Joules) of reverse energy to the inverter. For devices containing no electromechanical devices, analysis **shall** be performed to show that the load does not supply any reverse energy to the inverter. The verification **shall** be considered successful when the test data shows that the load does not supply more than 2.7 W·s (Joules) of reverse energy to the inverter, or analysis proves the load does not supply any reverse energy to the inverter.

Verification Submittal: Test Report documenting reverse output energy (or closed TPS as performed in ESTA) or analysis report.

J.4.3.2.3 AC INVERTER OPERATION AT 60 HZ

An inspection of the load specification or a test *should* be performed to show that the load can operate at 60 Hz ±1 Hz. The verification *should* be considered successful when the inspection of the load specification or a test shows that the load can operate at 60 Hz ±1 Hz.

Verification Submittal: Test Report or specification documenting the compliance of operating at 60 Hz ±1 Hz or closed TPS as performed in ESTA.

J.4.3.2.4 AC INVERTER USER CAPABLE OF RUNNING AT REDUCED VOLTAGE

An inspection of the load specification or data sheet or a test *should* be performed to show that the load can operate at 105 Vrms. The verification *should* be considered successful when the inspection of the load specification or the test shows that the load can operate at 105 Vrms.

Verification Submittal: Test Report or specification documenting the compliance of operating at reduced voltage of 105 Vrms or closed TPS as performed in ESTA.

J.4.3.2.5 AC INVERTER USER CAPABLE OF UNDISTURBED OPERATION WHEN POWER SKIPS ONE CYCLE

A test *should* be performed to show that the load can operate when power skips one cycle. The verification *should* be considered successful when the test shows that the load can operate when power skips one cycle.

Verification Submittal: Test Report documenting the power skip test or closed TPS as performed in ESTA.

J.4.3.3 GFCI CABLE INTERFACE REQUIREMENTS

J.4.3.3.1 GFCI CABLE STARTUP OPERATIONAL COMPATIBILITY

This requirement *should* be verified by test or demonstration on a qualification unit.

Verification Submittal: Test Report documenting the evidence of operational compatibility or closed TPS as performed in ESTA.

J.4.3.3.2 GFCI CABLE CONTINUOUS LOAD LEAKAGE CURRENT

This requirement *should* be verified by test or demonstration on a qualification unit. The test setup may be that used in LE01 (SSP 30238, 3.2.5.1) or equivalent.

Verification Submittal: Test Report documenting the evidence of the ground leakage or chassis connection or closed TPS as performed in ESTA.

J.4.3.4 LEAKAGE EMISSION LE01 LIMITS

Verification **shall** be by test or inspection. The test **shall** be conducted using the methods in SSP 30238. The verification by test **shall** be considered successful when test results shows that the equipment complies with the applicable emissions limits or has secured a TIA to except any non-compliances. Non-compliances may also require review by the ISS Safety Review Panel or Payload Safety Review Panel to ensure hazards to crew are properly managed. The inspection **shall** be of design data. The verification by inspection **shall** be successful when the inspection of design data shows that the procured parts comply with a commercial EMI safety standard.

Verification Submittal: EMI test reports along with any supporting analyses, or CoC with a commercial EMI safety standard may be submitted for verification in lieu of test data.

J.4.3.5 AC CONDUCTED EMISSIONS

The verification **shall** be by test. Tests **shall** be conducted with flight or flight-like cables. Flight-like cables have the same configuration with the same methods of shield termination. Bond EUT to the copper bench top in the same manner as it is bonded to vehicle structure during flight.

Verification **shall** be considered successful when test results shows that the equipment complies with the applicable emissions limits

Verification Submittal: EMI test reports along with any supporting analyses or a CoC with a commercial EMI conducted emissions standard may be submitted for verification in lieu of test data.

J.4.3.6 AC CONDUCTED SUSCEPTIBILITY

The verification **shall** be by test. The payload **shall** be monitored during susceptibility testing for indications of degradation or malfunction. This monitoring is normally accomplished through the use of built-in-test (BIT), visual displays, aural outputs, and other measurements of signal outputs and interfaces.

Monitoring of payload performance through installation of special circuitry in the payload is permissible; however, these modifications must not influence test results. Prior to testing, susceptible operation **shall** be defined; some anomalous behavior may be present but hardware may continue to meet operational and performance requirements despite anomaly. When susceptibilities are noted, the threshold of susceptibility **shall** be determined by reducing the interference signal below the level where the equipment recovers, and then slowly increasing the level until the susceptibility occurs. The threshold, frequency of occurrence and equipment response **shall** be recorded in the EMI test report.

Tests **shall** be conducted with flight or flight-like cables. Flight-like cables have the same configuration with the same methods of shield termination. EUT **shall** be bonded to the copper bench top in the same manner as it is bonded to vehicle structure during flight.

Verification **shall** be considered successful when the equipment meets its operational and performance requirements when exposed to the applicable susceptibility test levels.

Verification Submittal: EMI test reports along with any supporting analyses,or a CoC with a commercial EMI conducted immunity standard may be submitted for verification in lieu of test data.

APPENDIX K

POWER CONVERTER TO 28 VDC LOAD INTERFACE REQUIREMENTS

APPENDIX K - POWER CONVERTER TO 28 VDC LOAD INTERFACE REQUIREMENTS

K.1.0 INTRODUCTION

K.1.1 PURPOSE

This appendix includes power quality requirements, guidelines and data deliverables for 28 Vdc portable loads. A portable load is defined as a load which can be moved to and used in multiple ISS modules, utilizes a connector for power input (MS3475L14 12PN, MS3475L14 4PN, or equivalent), and is not mounted in a rack or middeck locker equivalent payload location during its operational use. The power interface for portable loads is defined at the power input connector of the cable leading to the portable load. This cable may be permanently attached to the payload (i.e., a "pigtail") or detachable. The 28Vdc interface for the PS-28Vdc Junction Box is shown in Figure K.1.1-1, Electrical Power Interface Through PS-28VDC Junction Box.

Portable payloads that meet all requirements in Appendix K will be compatible with all of the available ISS 28Vdc power sources except 28 Vdc power from the EXPRESS Rack connector panels. Although the requirements in this appendix envelope EXPRESS Rack power quality, the power connector and wire derating requirements for EXPRESS 28 Vdc loads are different and must be verified separately.

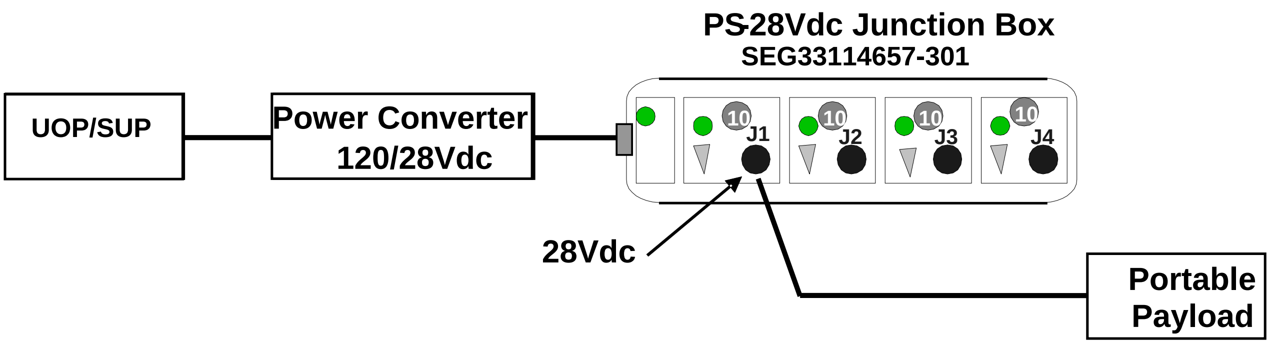


FIGURE K.1.1-1 ELECTRICAL POWER INTERFACE THROUGH PS-28VDC JUNCTION BOX

K.1.2 SCOPE

This appendix addresses payloads which are 28 Vdc portable loads on the ISS.

This appendix does not apply to payloads which are 28 Vdc on the Russian segment. For Russian Segment only: Portable 28V loads must operate with the potential difference from negative input power line (+) to chassis (-) between -28 and +5 volts, and with the potential difference from positive power line (+) to chassis (-) between -5 and +32 volts.

K.1.3 USE

These requirements, guidelines and data deliverables are applied to 28Vdc portable loads in addition to the general requirements, guidelines and data deliverables in Section 3.0 and are allocated to a payload through the payload unique ICD. The PD and the ISS Program must jointly agree on the interfaces and identify requirements as applicable if the interface exists, and not applicable if the interface does not exist for the payload configuration documented in the ICD.

K.2.0 DOCUMENTATION

See Section 5.0.

K.3.0 POWER CONVERTER TO 28 VDC LOAD INTERFACE REQUIREMENTS

K.3.1 STRUCTURAL/MECHANICAL INTERFACES

N/A

K.3.2 POWER INTERFACE TO ISS PORTABLE 28 VDC SOURCE

K.3.2.1 28VDC CONNECTOR PIN OUT

The PS-28Vdc junction box will have four output connectors (J1, J2, J3, and J4) that interface with plug MS3475L14-12P on portable equipment 28Vdc, 10 Amp. The payload connector for J1, J2, J3, and J4 **shall** be MS3470L14-12S with pin assignment shown in Table K.3.2.1-1.

TABLE K.3.2.1-1 28VDC CONNECTOR PIN OUT

DESCRIPTION	PART NUMBERS	PIN ASSIGNMENT
PS-28 Output connector (J1, J2, J3, J4)	Receptacle: MS3470L14-12S Plug w/Pins: MS3475L14-12P	J: +28 volt power K: Power return L: Ground

K.3.2.2 STEADY STATE VOLTAGE

The ISS will provide a steady-state voltage limits of 23 to 32 volts.

K.3.2.3 NORMAL TRANSIENT VOLTAGES

K.3.2.3.1 VOLTAGE SPIKES

Portable 28 V loads *should* operate with a normal transient input voltage spike with a peak of ±56 volts (measured differentially) and a base width of 10 microseconds. Pulse shape must be in accordance with that defined for the 10 microsecond CS-06 in SL-E-0002 or SSP 30237, Space Station Electromagnetic Emission and Susceptibility Requirements.

K.3.2.3.2 VOLTAGE DROPOUT

Portable 28 V loads *should* tolerate a normal transient input voltage of 0 volts for 100 milliseconds, either by operating through the transient, by automatic recovery to the pre-transient operating state, or by operation as specified in the applicable requirements documents.

K.3.2.4 ABNORMAL VOLTAGE

Portable 28 V loads *should* be capable of operation following exposure to abnormal voltages within the envelope shown in Figure K.3.2.4-1.

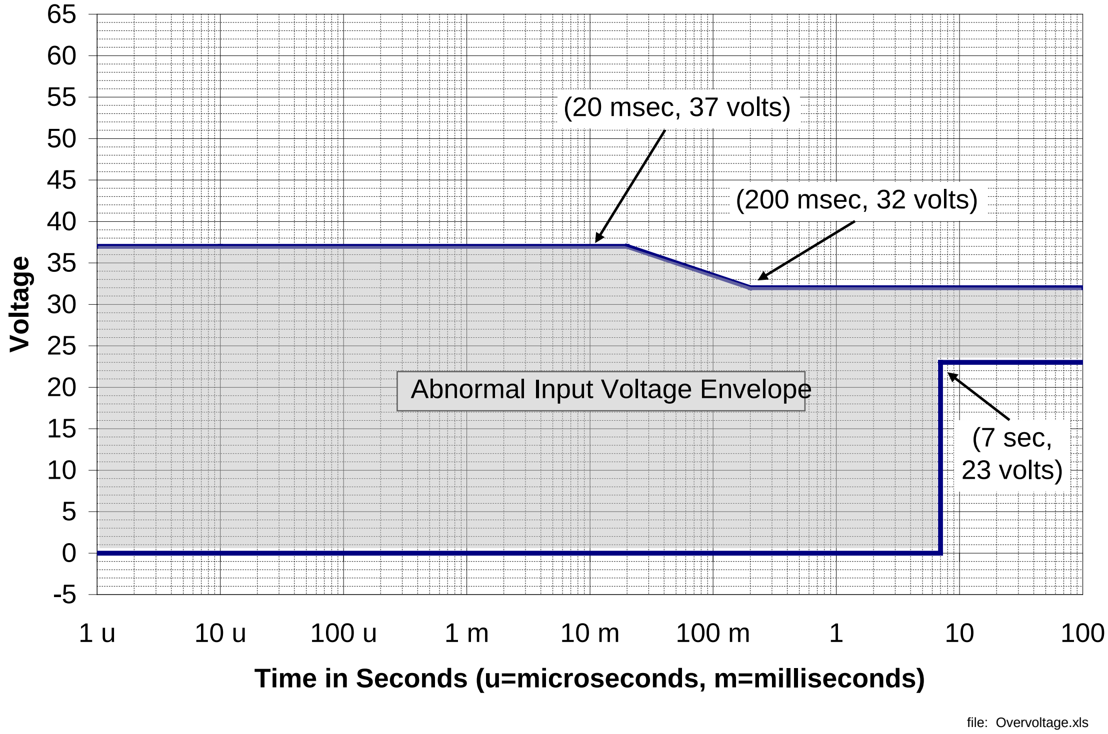


FIGURE K.3.2.4-1 ABNORMAL INPUT VOLTAGE ENVELOPE

K.3.2.5 STEADY STATE CURRENT

Portable 28 V loads **shall** have a maximum input current defined in their procuring documentation of from 0 to 7.0 amperes for all normal steady-state operating conditions.

K.3.2.6 INPUT IMPEDANCE

Portable 28 V loads **shall**, at each frequency between 200 Hz and 20 kHz, have either input impedance magnitude greater than the limit indicated or input impedance phase within the limits indicated in Figure K.3.2.6-1.

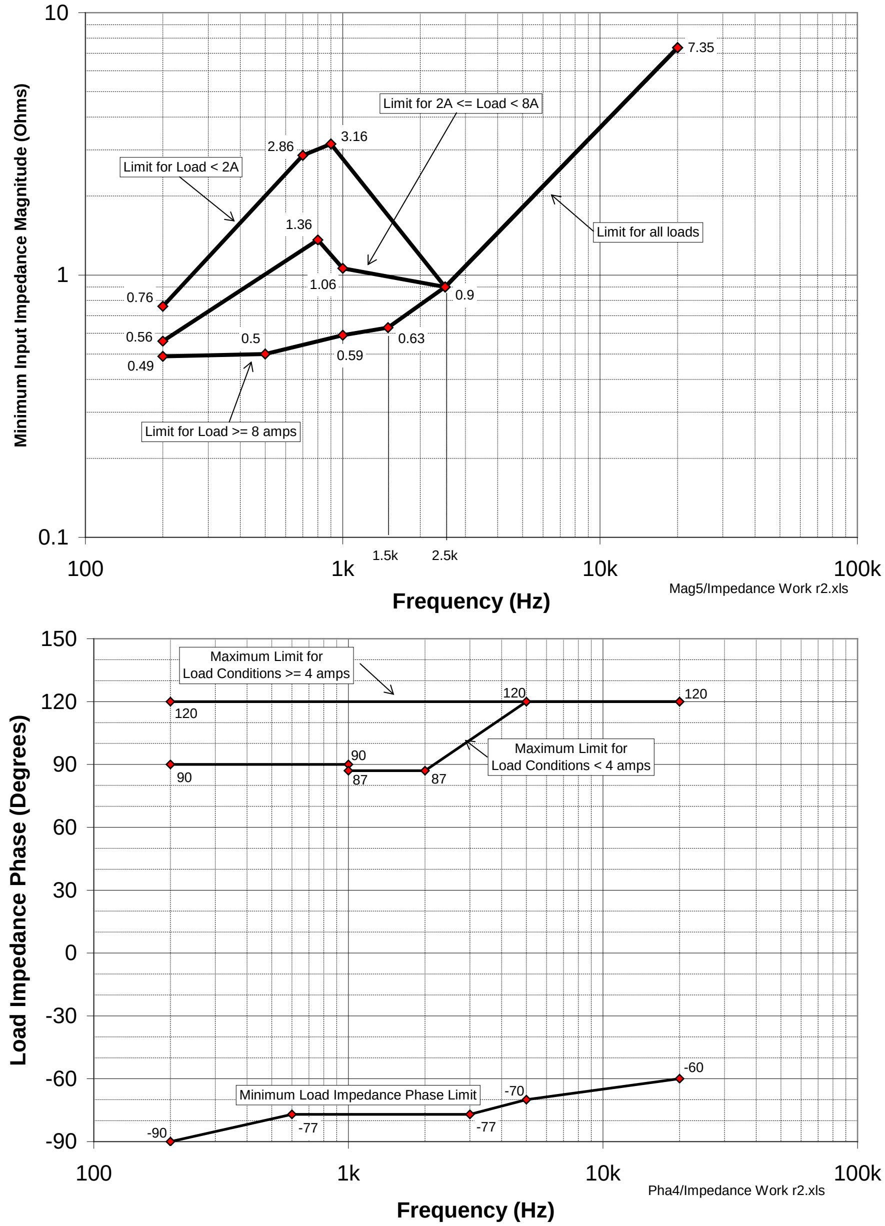


FIGURE K.3.2.6-1 INPUT IMPEDANCE ENVELOPE FOR 28 V PORTABLE LOADS

K.3.2.7 LOAD POWER-TO-CHASSIS AND RETURN-TO-CHASSIS ISOLATION

Portable 28 V loads **shall** provide 1 megohm isolation at ±100 volts between power lines and chassis and returns and chassis with an atmospheric relative humidity of 95% ±3% at an air temperature of 20 ±5 °C. This requirement is considered to be satisfied if the resistance is not less than 20 megohms with an atmospheric relative humidity of 45 to 80% at an air temperature of 15 to 35 °C.

K.3.2.8 LOAD CURRENT TRANSIENTS

Portable 28 V loads **shall** limit the transient input current such that the integral of the input current in excess of the load rating is less than 0.02 amp·seconds. This requirement can be expressed by the following equation:

$$\int[(\text{Load Input Current}) - (\text{Load Current Rating})]dt <= 0.02 \text{ amp}\cdot\text{seconds}$$

evaluated over the time interval that Load Input Current > Load Current Rating

K.3.2.9 POWER ON COMPATIBILITY

K.3.2.9.1 SLOW RATE-OF-RISE POWER ON COMPATIBILITY

Portable 28 V loads *should* power on as expected when the input voltage rate of rise is 5,000 volts per second and faster.

K.3.2.9.2 VOLTAGE BOUNCE POWER ON COMPATIBILITY

Portable 28 V loads **shall** power on as expected when the input bounces (e.g., source current drops to zero amperes for 100 microseconds) within the first 5 milliseconds of application of input power.

K.3.2.10 REVERSE ELECTROMAGNETIC FORCE

Portable 28 V loads **shall** limit the reverse EMF generated by the load and imposed on the upstream power system so that the voltage rise at the load input does not exceed 2 volts for more than 10 microseconds.

K.4.0 VERIFICATION

K.4.1 RESPONSIBILITIES

The PD is responsible for providing verification for all applicable requirements in this appendix, as allocated to the payload through the payload unique ICD. The ISS Program is responsible for review and approval of the submitted verification.

K.4.2 VERIFICATION METHODS

Compliance with the requirements stated in Section K.3 are proven using one or more of the methods described in paragraph 4.2.

K.4.3 POWER CONVERTER TO 28 VDC LOAD INTERFACE VERIFICATION REQUIREMENTS

K.4.3.1 STRUCTURAL/MECHANICAL INTERFACES

N/A

K.4.3.2 POWER INTERFACE TO ISS PORTABLE 28 VDC SOURCE

K.4.3.2.1 28VDC CONNECTOR PIN OUT

Verification of the 28Vdc connector pin out **shall** be by inspection. The verification **shall** be considered successful when the inspection of drawings shows that the payload connector meets the specified pin out per paragraph K.3.2.1.

Verification Submittal: CoC

K.4.3.2.2 STEADY STATE VOLTAGE

NVR

K.4.3.2.3 NORMAL TRANSIENT VOLTAGES

K.4.3.2.3.1 VOLTAGE SPIKES

Verification of the voltage spikes requirement *should* be verified by analysis. The verification *should* be considered successful when analysis shows the Payload is in compliance with CS06 requirements.

Verification Submittal: CoC

K.4.3.2.3.2 VOLTAGE DROPOUT

Verification of the voltage dropout voltage requirement *should* be verified by analysis or test. Verification by analysis or test *should* be performed to demonstrate that payload can tolerate a normal transient input voltage of 0 volts for 100 ms. Verification *should* be considered successful when analysis or test shows the Payload is designed to withstand a dropout to 0 volts for 100 ms.

Note: The impact during the voltage dropout to 0V for 100ms will be documented in the ICD.

Verification Submittal: CoC

K.4.3.2.4 ABNORMAL VOLTAGE

Verification of the abnormal voltage requirement *should* be verified by analysis. The verification *should* be considered successful when analysis shows the portable payload is not damaged (e.g., all parts are within rating) by sustained input voltage as defined in Figure K.3.2.4-1.

Verification Submittal: CoC

K.4.3.2.5 STEADY STATE CURRENT

Verification of the steady state current requirement **shall** be verified by inspection and test. The verification by inspection **shall** be considered successful when inspection of the appropriate document shows the portable payloads have a defined maximum current rating, and that the current rating is within 0 to 7.0 A. The verification by test **shall** be considered successful when portable payloads operate within their maximum current rating.

Verification Submittal: Test Report

K.4.3.2.6 INPUT IMPEDANCE

Verification of the input impedance requirement **shall** be verified by test. The portable payload input impedance **shall** be tested under conditions of high, 32 volts, and low, 23 volts, steady-state input voltage and with these conditions for the active converters directly downstream **shall** be exercised through the complete range of their loading. Selected combinations of portable payloads converters that can influence the measured input impedance **shall** be tested. The verification **shall** be considered successful when the test shows that all load impedance measured for high and low voltage conditions remain within specified limits.

Verification Submittal: Test Report

K.4.3.2.7 LOAD POWER-TO-CHASSIS AND RETURN-TO-CHASSIS ISOLATION

Verification of the load power-to-chassis and return-to-chassis requirement **shall** be verified by test. Verification test **shall** be performed on an unpowered unit with the positive and return input power lines tied together and 100 volts applied between the power lines and chassis. The test **shall** be repeated with the polarity reversed. The test **shall** be performed in one of the following two environments: atmospheric relative humidity within 92 to 98% at an air temperature within 15 to 25 Centigrade, or atmospheric relative humidity within 45 to 80% at an air temperature within 15 to 35 Centigrade. The verification **shall** be considered successful when the measured current through the 100 volt power source is no greater than the limit set for the test environment. This limit is 100 μA for the high-humidity environment, and 5 μA for the low-humidity test environment defined above.

Verification Submittal: Test Report

K.4.3.2.8 LOAD CURRENT TRANSIENTS

Verification of the load current transient requirement **shall** be verified by test. Verification test **shall** be performed to measure the load current transient at source power on, for an input voltage step from 0 to 32 volts DC. Verification test **shall** also be performed to measure the load current transients for all payload transitions from one operating mode to another with an input voltage at the low end of the steady-state voltage range (i.e., 23 volts). The verification **shall** be considered successful when the test shows the integral of the payload input current in excess of the load rating is less than 0.02 amp-seconds for source power on and for each tested load transition.

Verification Submittal: Test Report

K.4.3.2.9 POWER ON COMPATIBILITY

K.4.3.2.9.1 SLOW RATE-OF-RISE POWER ON COMPATIBILITY

Verification of the slow rate-of rise power on compatibility requirement *should* be verified by test. Verification test *should* be performed to demonstrate load initiation when the time for the input voltage to rise from 5 volts to 23 volts is less than 100 microseconds (fast), and when the time is at least 3.6 milliseconds (slow). Less comprehensive testing, such as only that necessary to verify other requirements like power-on inrush current, is acceptable if supported by analysis showing that the design is inherently insensitive to variations in external power application (e.g., a purely resistive load (heater) or a load with an internal power switch). The verification *should* be considered successful when the test shows the payload can power on as expected with both fast and slow voltage rise times for external power application.

Verification Submittal: CoC

K.4.3.2.9.2 VOLTAGE BOUNCE POWER ON COMPATIBILITY

Verification of the voltage bounce power on compatibility requirement **shall** be verified by analysis or test. Verification test or analysis **shall** be performed to demonstrate load initiation when the load is powered on using a mechanical relay that has some “bounce”, with at least one bounce having duration of at least 100 microseconds. A “bounce” occurs when the mechanical relay breaks contact for a short period of time after having briefly made contact. A mechanical relay may bounce several times before establishing a firm contact. Due to unpredictability of mechanical relays, this test may need to be repeated to achieve the desired bounce characteristic. Analysis supported by less comprehensive testing, such as only that necessary to verify other requirements like power-on inrush current, is acceptable if the design is inherently insensitive to variations in external power application (e.g., a purely resistive load (heater) or a load with an internal power switch). The verification **shall** be considered successful when the test or analysis shows the payload can power on as expected with external power application via a mechanical relay with “bounce” characteristics.

Verification Submittal: Analysis Report or Test Report

K.4.3.2.10 REVERSE ELECTROMAGNETIC FORCE

Verification of the reverse EMF requirement **shall** be verified by analysis or test. Verification test or analysis **shall** be performed to demonstrate that either the payload does not generate any reverse EMF or that the payload does not generate sufficient reverse EMF to raise the input voltage by more than two volts. The first test condition (no reverse EMF) is met if the measured input current of the load is always non-negative during the load current transient conditions in tests for payload operating mode transitions. If the negative input current exists during the load current transient conditions, test or analysis **shall** be performed to measure the input voltage increase caused by negative input current. If the test is performed, a diode **shall** be installed in the input power path to block reverse current. The voltage rise caused by the EMF generated by the payload is obtained by measuring the peak voltage across the diode (in the reverse direction from normal power flow), or by measuring the difference between the peak differential voltage and the steady state voltage. The verification **shall** be considered successful when the test or analysis shows the payload does not generate negative input current or the voltage generated by negative load input current generated is less than 2 volts.

Verification Submittal: Test Report or Analysis Report

APPENDIX L

EXCEPTIONS

APPENDIX L – EXCEPTIONS

L.1.0 OVERVIEW

Any non-compliance to requirements defined in this IRD must be submitted under specific procedures and guidelines to assure proper control, evaluation and approval. These non-compliances are referred to in this document as exceptions. This section describes how exceptions are processed and documented.

L.2.0 DEFINITIONS

An Exception is the general term used to identify the form processed for acceptance of payload-specific requirement violation(s). A payload exception is a condition of non-compliance with an IRD requirement. An ISS Program approved Exception may be used as the verification submittal for any requirement violation along with additional verification data that may be required to be submitted.

L.3.0 SUBMITTAL REQUESTS

The PD will be responsible for submitting any required exception requests, including any supporting rationale for acceptance and supporting data or analysis, if needed. Once the need for an exception is identified, the first step in submitting a request is to create an Exception in the Preliminary Interface Revision Notice (PIRN) database and provide the pertinent information on an Exception/PIRN form. The Exception/PIRN form and instructions for completion may be obtained from the PIRN database. The PD may create an Exception using Verification of Engineering Requirements – Interface for Tracking, Approval and Submission (VERITAS) if the payload verification is housed within VERITAS.

L.3.1 DATA SUBMITTAL RESPONSIBILITY

The PD is responsible for providing all data that is needed to evaluate the Exception request for approval. The subsystem engineer evaluating the Exception may require data beyond what was submitted with the exception request or contained in the unique ICD. The PD must supply the required additional data before the Exception request can be processed by the subsystem engineer.

If the Exception does not impact the integrated payload complement, the analysis can be performed upon receipt of the Exception request. If the Exception impacts the integrated payload complement, the exception must be analyzed as part of the standard element analysis process. The integrated analysis will identify any operational constraints that are required to approve the Exception. Any identified operational constraints will be documented in the Payload Operations Guidelines and Constraints document. At the discretion of the mandatory evaluators assigned to review and approve the Exception, a request may be made to review an exception at a technical or Program board, specific to the subsystem (i.e. Acoustics Working Group (AWG), Internal Volume Configuration Working Group (IVCWG), etc.). The PD may be asked to attend the board for technical backup.

Exceptions may require IP analysis. The PD is responsible for submitting any additional data that IPs may require to complete their analysis.

Once the evaluation is complete, the IPs will submit their recommendation to NASA.

In the case of EMI exceptions, the PD must submit a TIA to the EME Panel. The approved TIA, with all the EME Panel analysis, conclusions, and recommendations may be used in lieu of the exception.

L.3.2 CONTROL BOARDS

The Requirements and Verification Control Panel (RVCP), will approve the Exception or direct the PD to modify the payload to meet the IRD requirement in violation.

L.3.3 SAFETY EXCEPTIONS

NCRs define non-compliances to safety requirements and are handled by the ISS Safety Review Panel. The approved NCR, with all the Safety Panel analysis, conclusions, and recommendations may be used in lieu of the exception.

APPENDIX M

WORF RACK TO SUBRACK PAYLOAD INTERFACE REQUIREMENTS

APPENDIX M - WORF RACK TO SUBRACK PAYLOAD INTERFACE REQUIREMENTS

M.1.0 INTRODUCTION

M.1.1 PURPOSE

This appendix identifies unique requirements, guidelines and data deliverables for payloads interfacing with the WORF Rack.

M.1.2 SCOPE

This appendix addresses payloads interfacing with the WORF rack.

M.1.3 USE

The listed unique requirements in this appendix are applied in addition to the EXPRESS rack requirements contained within the EXPRESS rack Appendix F and the general requirements in Section 3.0. WORF Rack payloads must address all EXPRESS requirements which are listed in the EXPRESS rack Appendix F as well as those in this appendix. These requirements, guidelines and data deliverables are allocated to a payload through the payload unique ICD. The PD and the ISS Program must jointly agree on the interfaces and identify requirements as applicable if the interface exists, and not applicable if the interface does not exist for the payload configuration documented in the ICD.

M.2.0 DOCUMENTATION

See Section 5.0.

M.3.0 WORF RACK TO SUBRACK PAYLOAD INTERFACE REQUIREMENTS

M.3.1 STRUCTURAL/MECHANICAL INTERFACES

M.3.1.1 PAYLOAD VOLUME

The maximum WORF Rack volume available for the payload and crew use is approximately 22.6 ft3 (0.64 m3). The WORF payload *should* not exceed the payload envelope shown in Figure M.3.1.1-1.

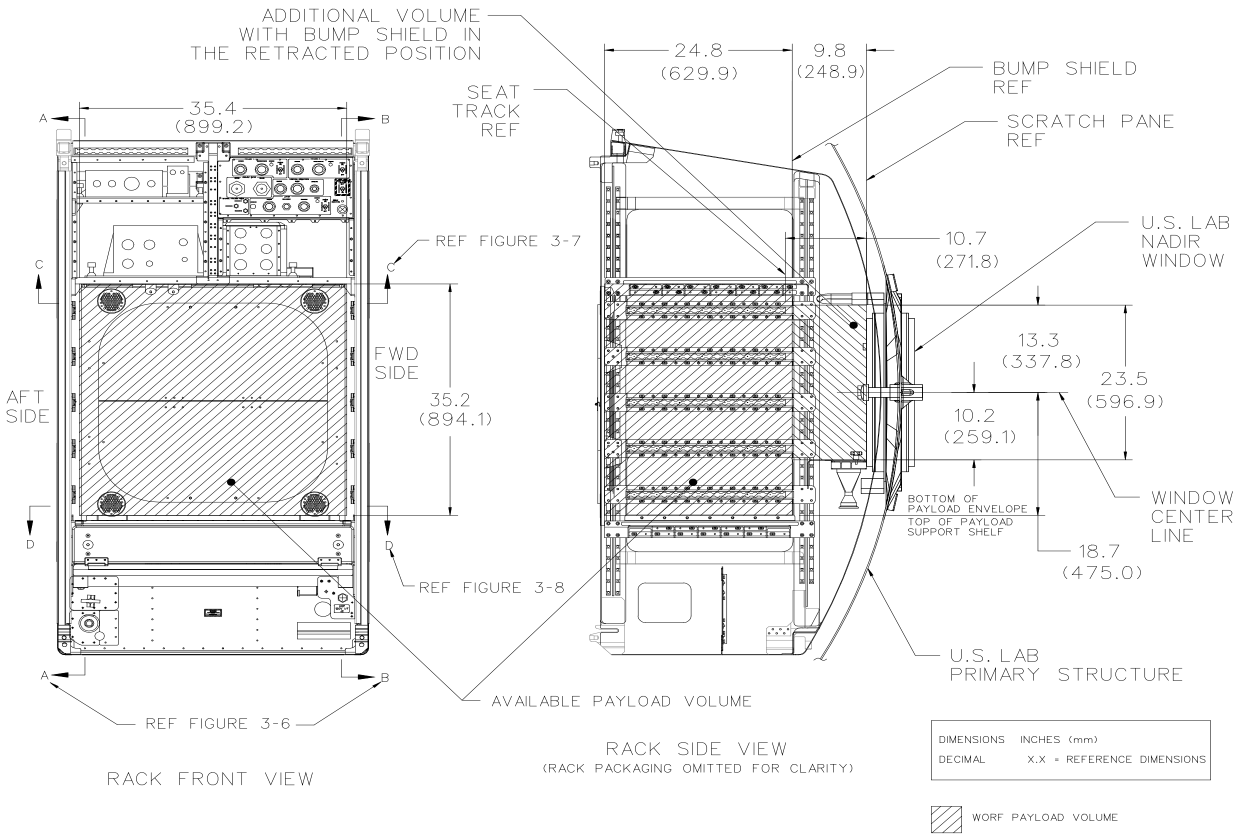
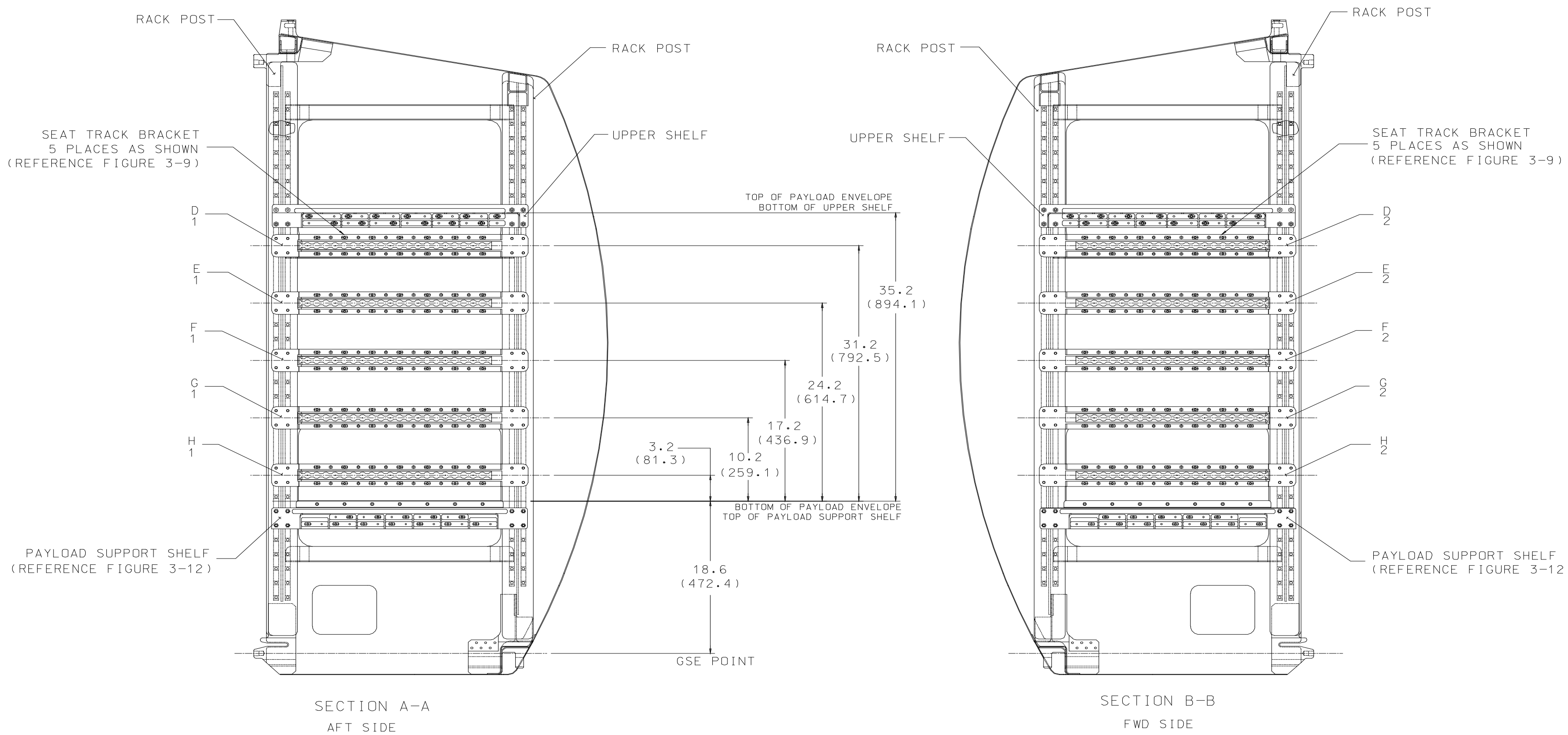


FIGURE M.3.1.1-1 WORF PAYLOAD VOLUME

M.3.1.2 SEAT TRACKS

Permanently mounted seat track brackets are located in five places on each side of the WORF payload volume as shown in Figure M.3.1.2-1. These brackets allow the mounting of payload hardware and can accommodate soft stowage, such as camera bags and lens containers. The moment of payload hardware attached to the seat tracks **shall** be no greater than 750 inch-pounds (in-lbs). The details of the seat track brackets are shown in Figure M.3.1.2-2 and the details of the seat track extrusions are shown in Figure M.3.1.2-3. The payload is responsible for providing attachment hardware for mounting to the seat tracks.

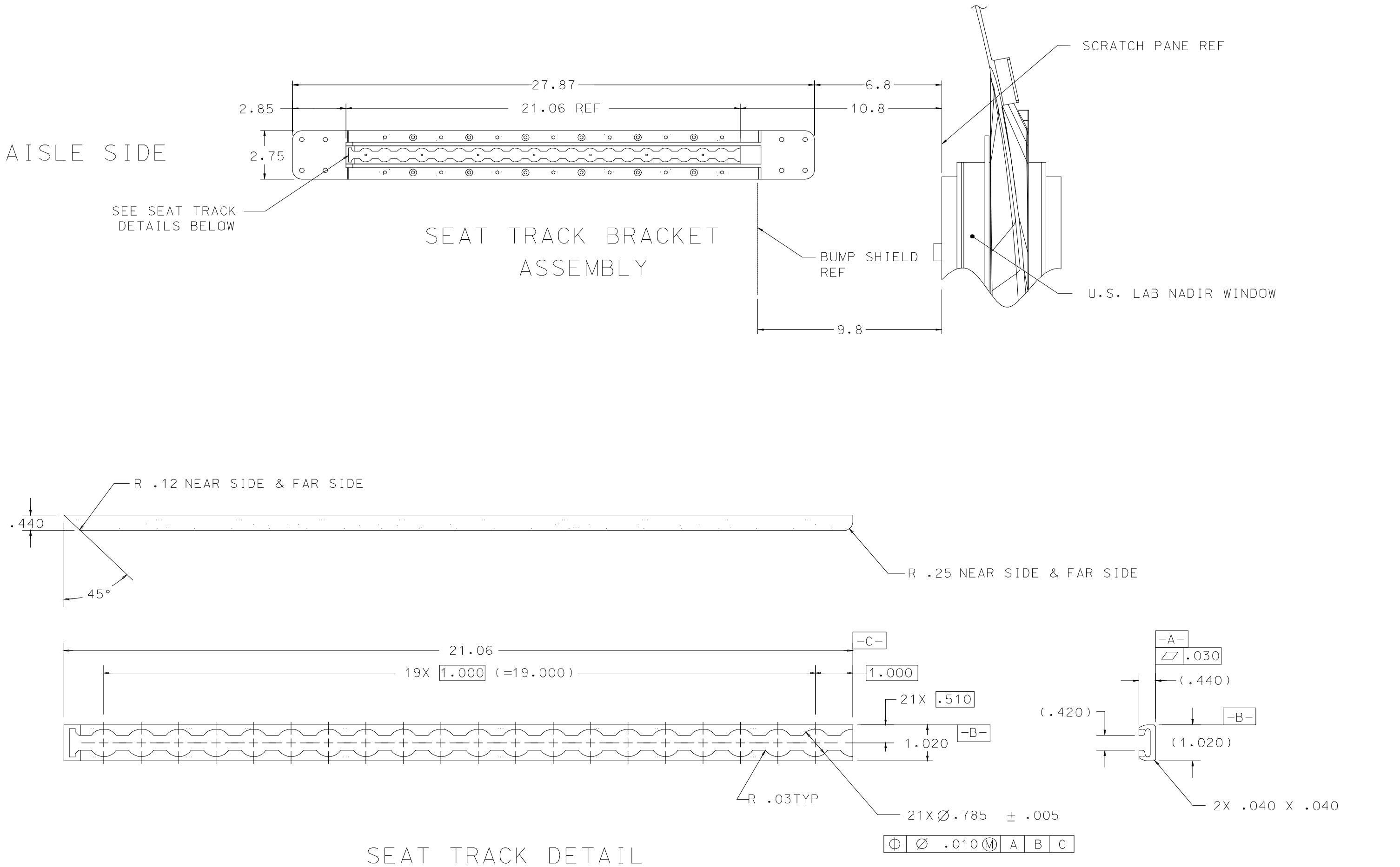


SEAT TRACK LOCATION NOMENCLATURE	
D2	D1
E2	E1
F2	F1
G2	G1
H2	H1

DIMENSIONS	INCHES (mm)
DECIMAL	X.X = REFERENCE DIMENSIONS

NOTES:
1. RACK PACKAGING OMITTED FOR CLARITY.
2. DIMENSIONS SHOWN THROUGH CENTER LINE OF SEAT TRACK BRACKETS.

FIGURE M.3.1.2-1 WORF SEAT TRACK LOCATIONS



NOTES:

1. DIMENSIONING & TOLERANCING PER ANSI Y14.5M-1982.
2. MATERIAL: 7075 ALUMINUM EXTRUSION.
3. FINISH: LUSTERLESS BLACK PAINT OVER BRUSH NICKEL.
4. EXTRUDED PER DIMENSIONS OF BAC1520-1636, REFERENCE FIGURE 3-10.
5. CROSS-SECTIONAL DIMENSIONAL TOLERANCES PER MS33601.

DIMENSIONS INCHES
DECIMAL X.X = REFERENCE DIMENSIONS
X.XX = +/- 0.03 inches
X.XXX = +/- 0.010 inches
(X.XXX) = REFERENCE DIMENSIONS

FIGURE M.3.1.2-2 SEAT TRACK BRACKET DETAIL

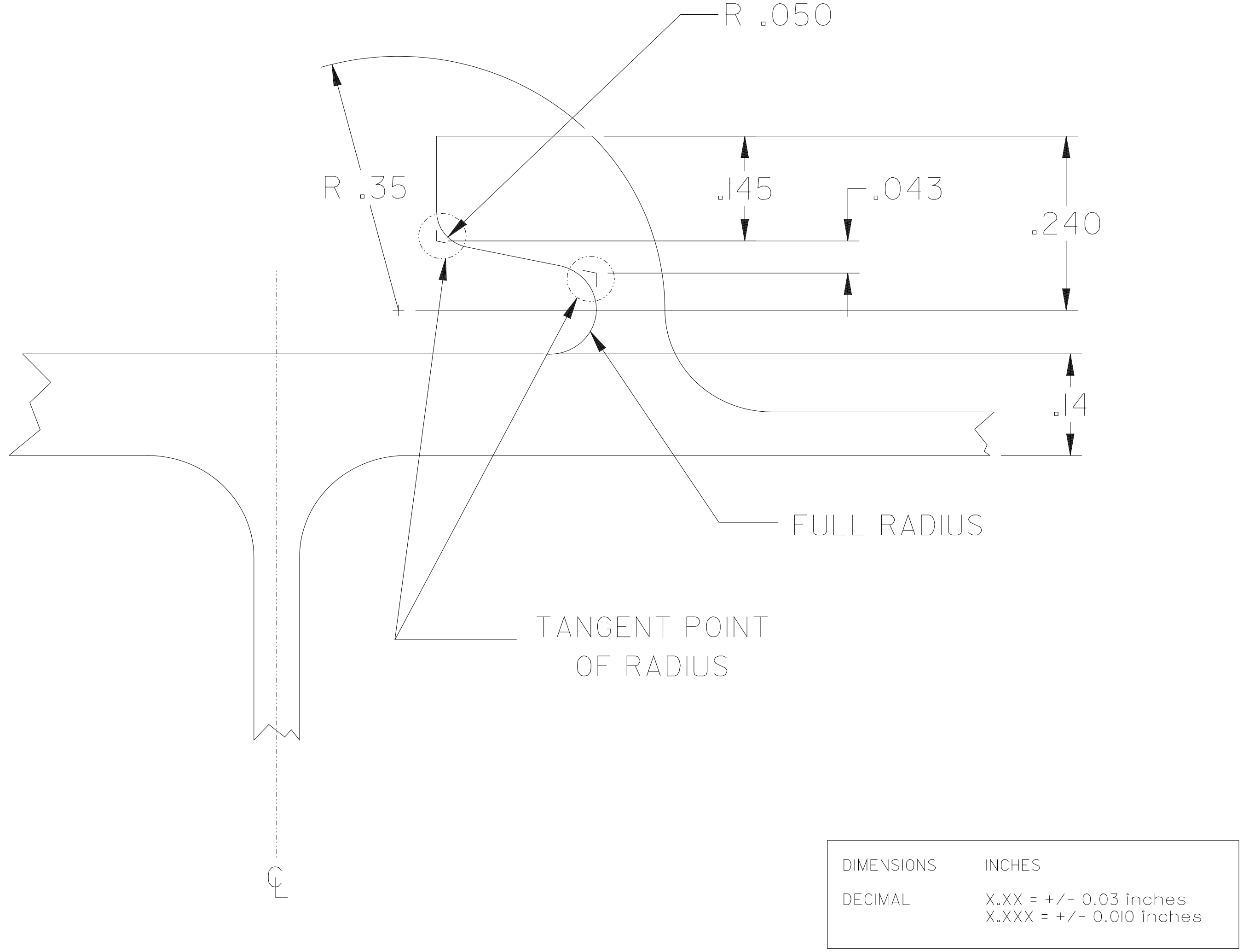


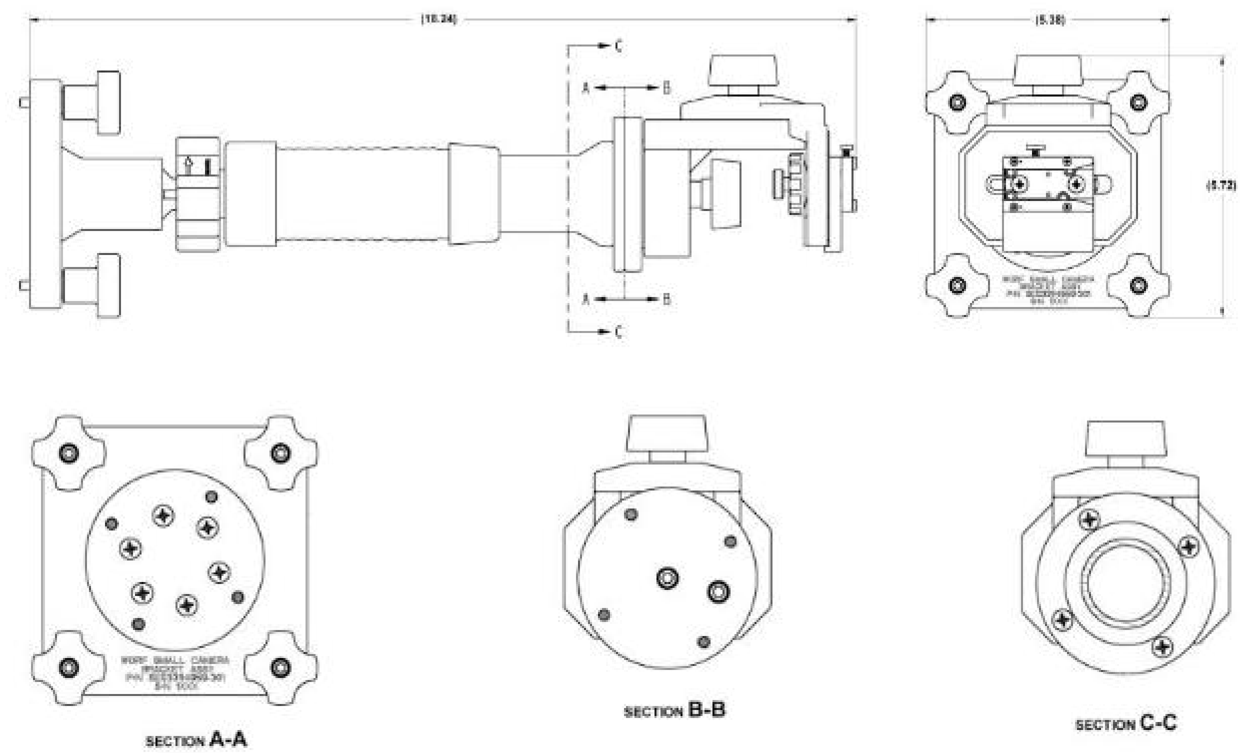
FIGURE M.3.1.2-3 SEAT TRACK EXTRUSION DETAIL (DETAIL 1 OF BOEING PART # BAC 1520-1636)

M.3.1.3 SMALL CAMERA BRACKET

Two camera brackets (Figure M.3.1.3-1) are provided for payload use. The camera bracket is used to stabilize and position payload equipment such as cameras or camcorders in front of the nadir window. The bracket can be mounted within the WORF payload volume without the use of tools. It provides adjustment and locking capability for a wide range of positions to accommodate different viewing distances. The bracket provides 6 Degrees of Freedom (DOF).

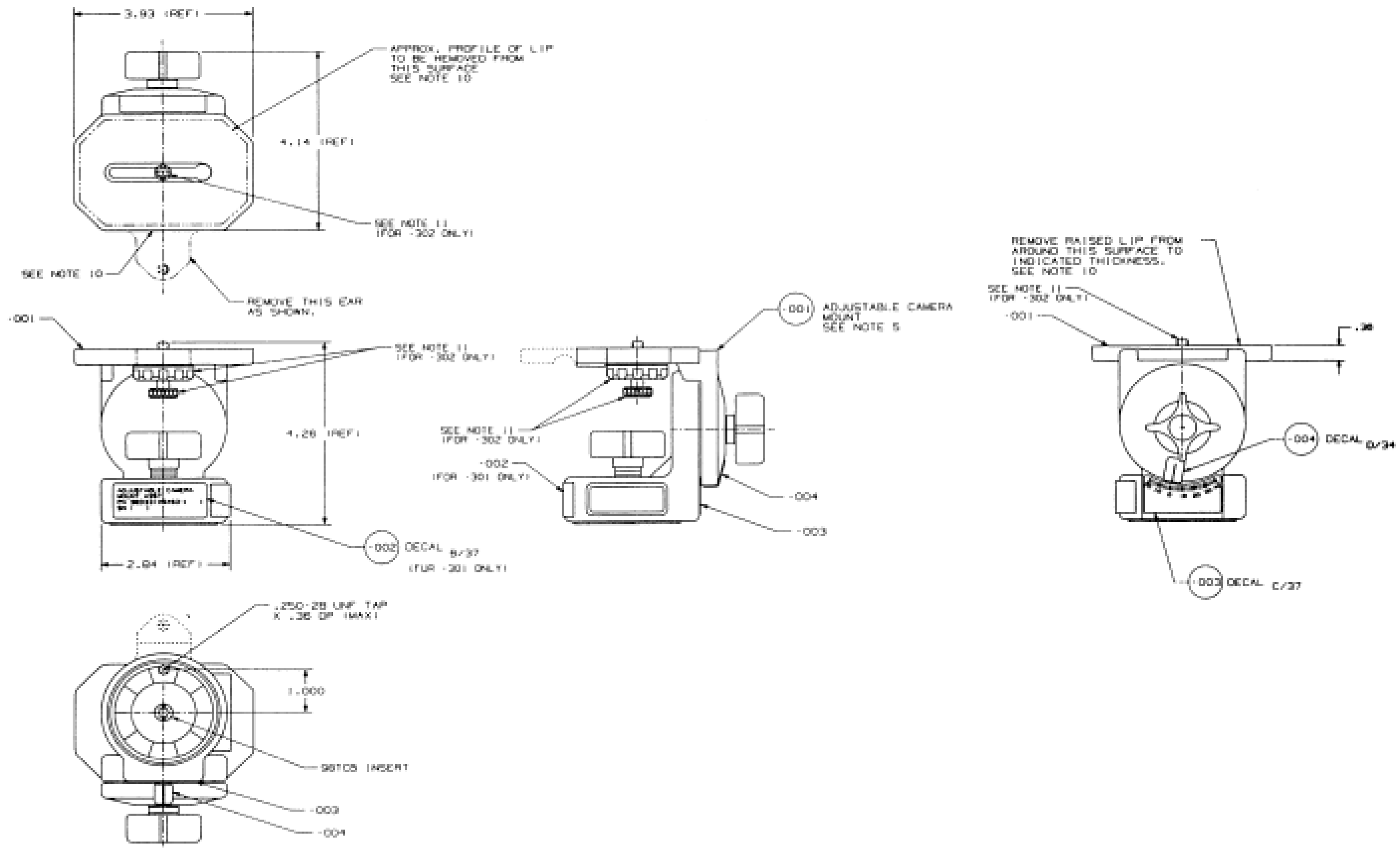
The payload using the small camera bracket *should* interface per Figure M.3.1.3-1. Generally, the payload will successfully interface with the small camera bracket by utilizing the mounting shoe specified in NASA JSC drawing SED33102474, Adapter Assembly Multiuse Bracket or equivalent. The mounting shoe is payload-provided.

An alternative method of mounting payload equipment to the small camera bracket is to remove the mounting shoe assembly from the adjustable camera mount. The payload hardware can be attached using the through hole that is drilled for a ¼-20 fastener.



SMALL CAMERA BRACKET DIMENSIONS
NOTE: Dimensions in inches.

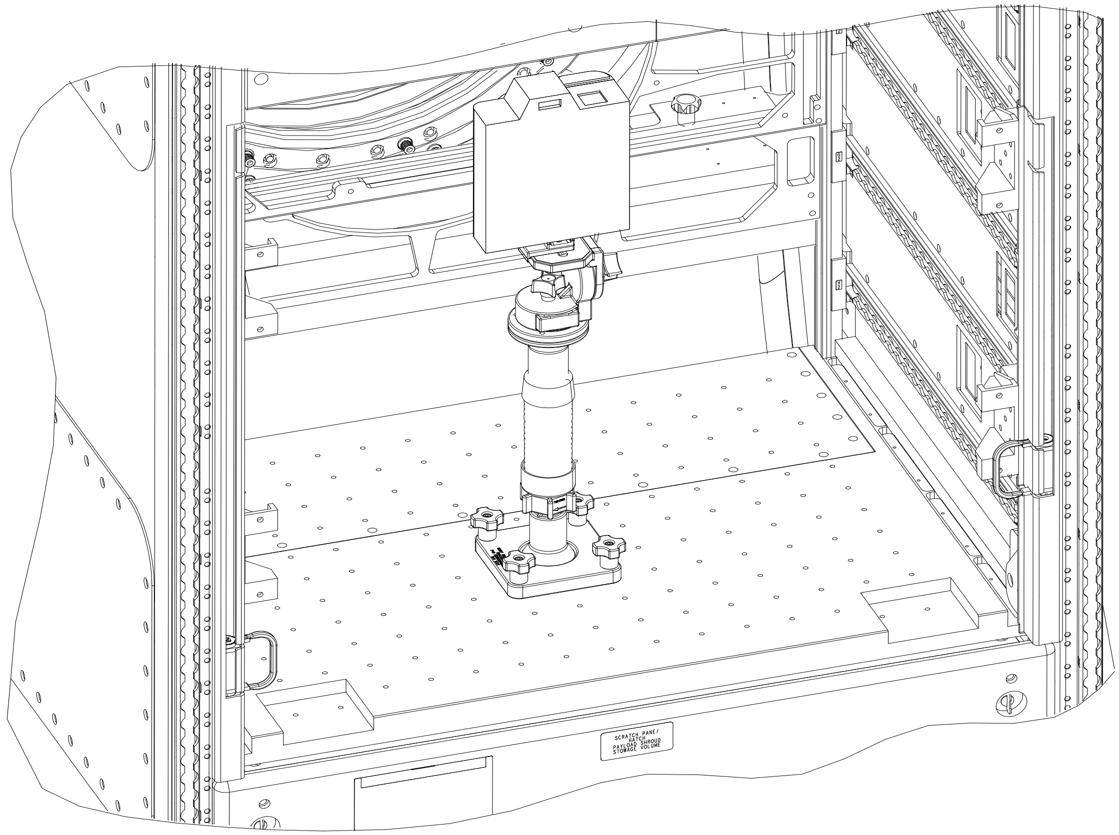
FIGURE M.3.1.3-1 SMALL CAMERA BRACKET (PAGE 1 OF 3)



NOTES:
Dimensions are in inches.
Reference NASA JSC drawing SED33105463 for definition of note references in figure.

Camera Mount Details

FIGURE M.3.1.3-1 SMALL CAMERA BRACKET (PAGE 2 OF 3)



SMALL CAMERA BRACKET WORF INSTALLATION EXAMPLE

FIGURE M.3.1.3-1 SMALL CAMERA BRACKET (PAGE 3 OF 3)

M.3.1.4 PAYLOAD SUPPORT SHELF

A payload support shelf is located at the bottom of the WORF payload volume as shown in Figure M.3.1.4-1. The payload support shelf has a mounting area of 6.1 ft2 (0.57 m2) and provides 161 threaded inserts in a 2-inch × 2-inch (51 mm × 51 mm) pattern for payload mounting as shown in Figure M.3.1.4-2. The payload is responsible for providing attachment hardware for mounting to the payload support shelf.

Payload mounting locations are identified using a labeled grid pattern on the payload support shelf surface. The grid labels can be used to identify and specify payload hardware mounting locations in the crew procedures. The grid pattern is shown in Figure M.3.1.4-2.

A. Payload support shelf attachment point provisions *should* be in accordance with Figure M.3.1.4-3.

B. The payload mounting across the gap between the payload support shelf and the removable section payload support shelf panel (i.e., AAA access panel) *should* use the following mating holes and tolerances for proper mounting of payload equipment:

   1. Mating Part Holes - Class 3, .219 - .233” (5.56 - 5.92 mm) diameter

   2. Positional Tolerance - ϕ.007” (0.178 mm) diameter in all directions

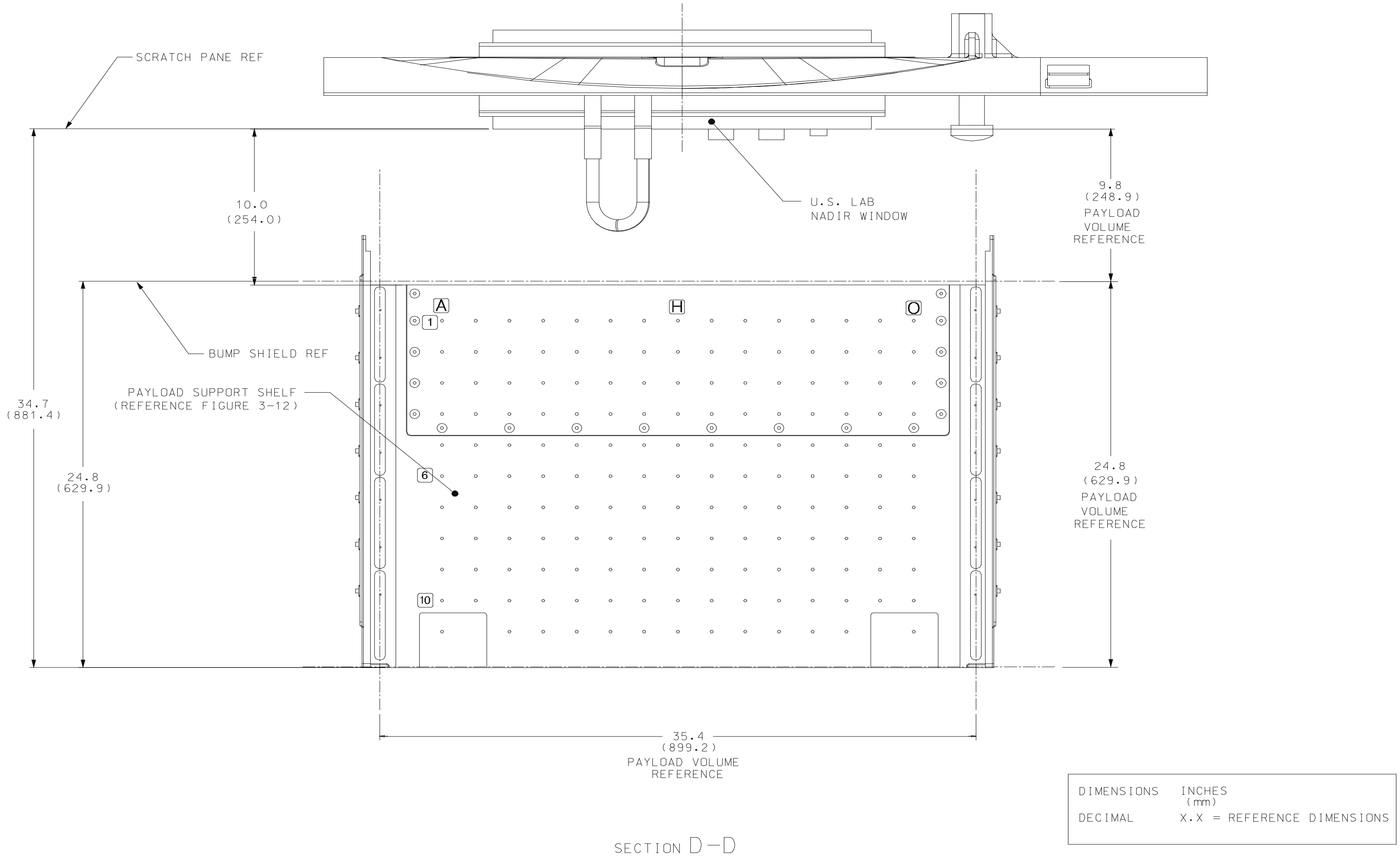
Informational note: Payload provided fasteners must be torqued 25 to 30 inch-pounds for payload attachment to the payload support shelf.

C. The payload **shall** use the following fastener to attach to the payload support shelf: thread size: 0.19-32 (#10-32).

D. The payload *should* prevent fastener seizing through dry film lubrication, silver plating, or application of approved anti-seize compound.

E. Payload fasteners *should* be self-retracting (i.e., spring loaded) and at least flush with the payload mounting flange.

F. Payload alignment guides are recommended. Payload alignment guides *should* be non-metallic, self-retracting, and not pose a damage hazard to the surface of the payload support shelf.



SECTION D-D
(FROM FIGURE 3-5)

FIGURE M.3.1.4-1 WORF PAYLOAD VOLUME BOTTOM VIEW

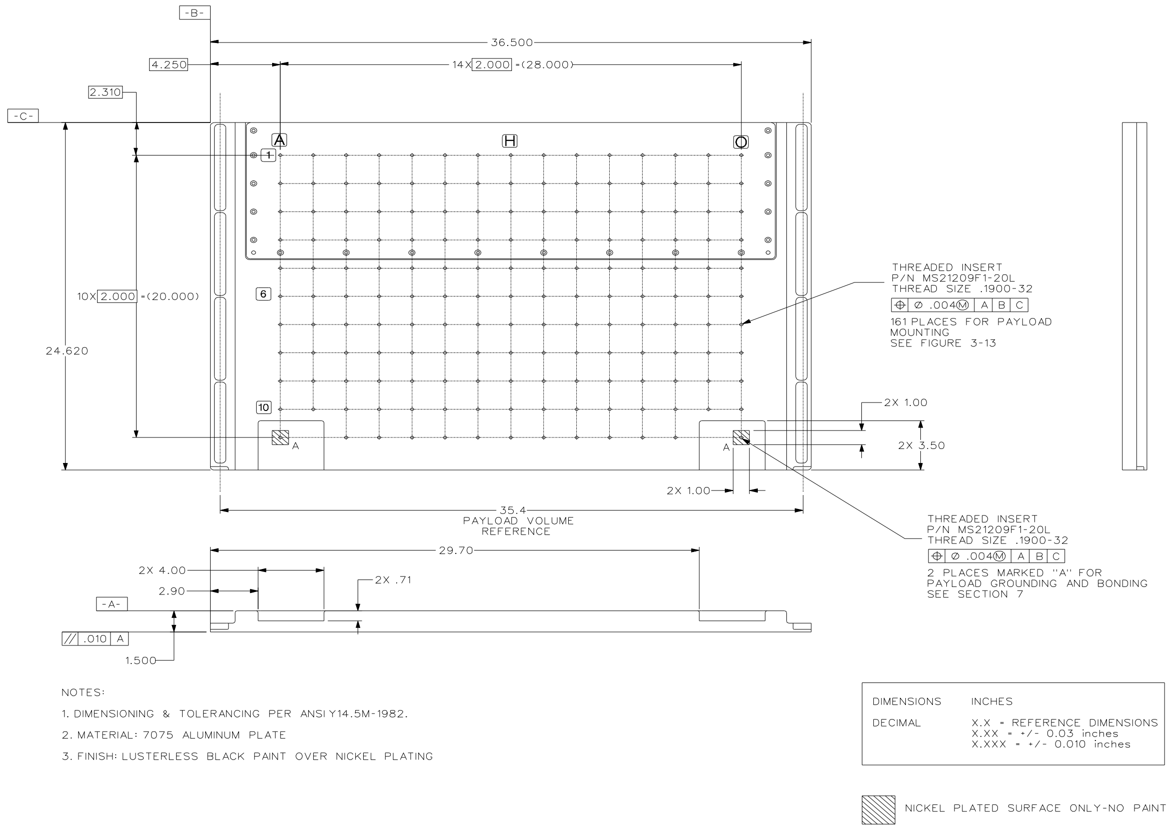


FIGURE M.3.1.4-2 PAYLOAD SUPPORT SHELF MOUNTING PROVISIONS

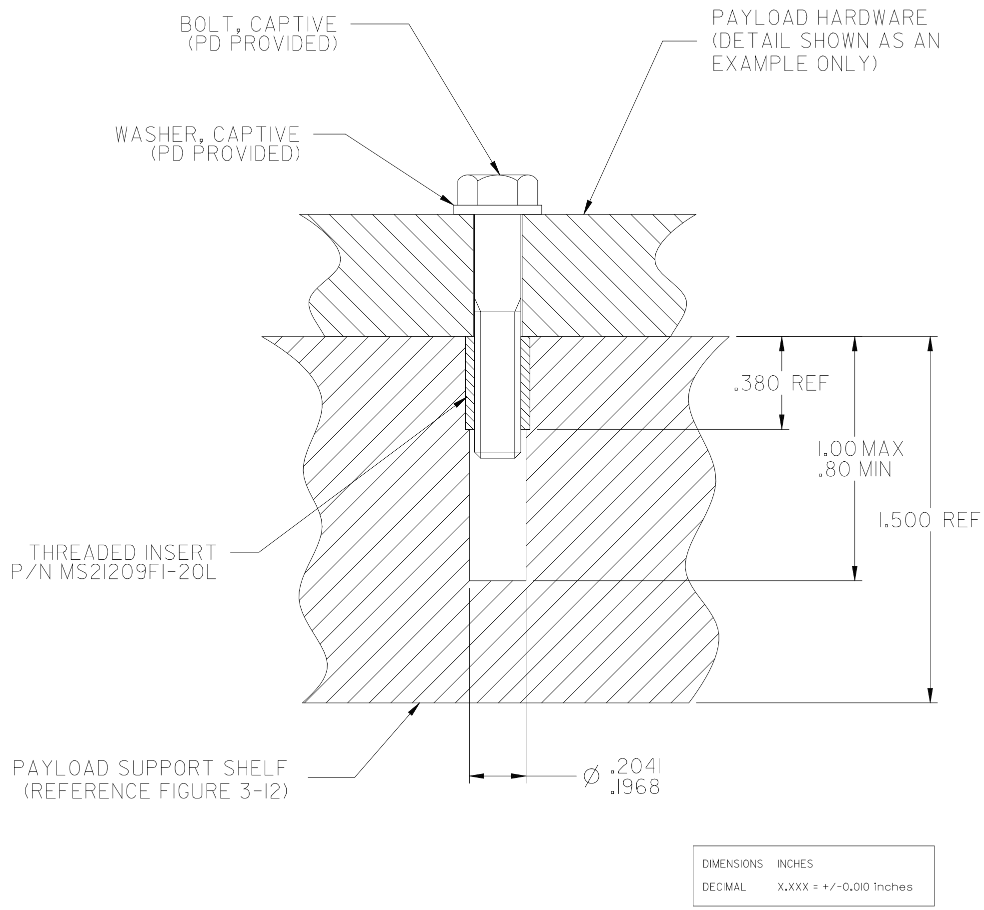


FIGURE M.3.1.4-3 PAYLOAD SUPPORT SHELF ATTACHMENT POINT DETAILS

M.3.1.5 LAB WINDOW

The payload at the U.S. Laboratory window location **shall** accommodate a keep−out zone as specified in Figure M.3.1.5-1.

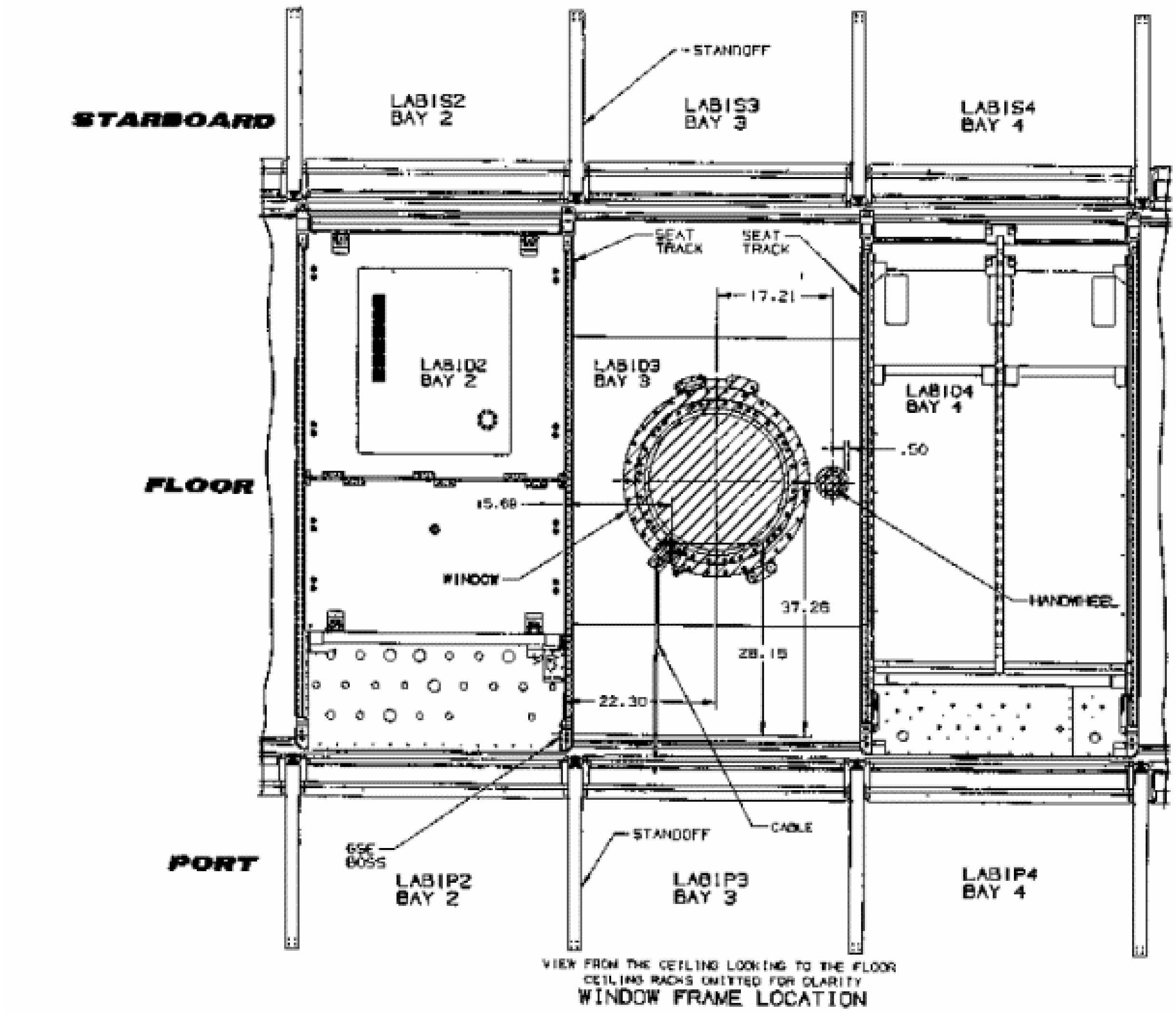


FIGURE M.3.1.5-1 LAB WINDOW KEEP-OUT ZONE (PAGE 1 OF 2)

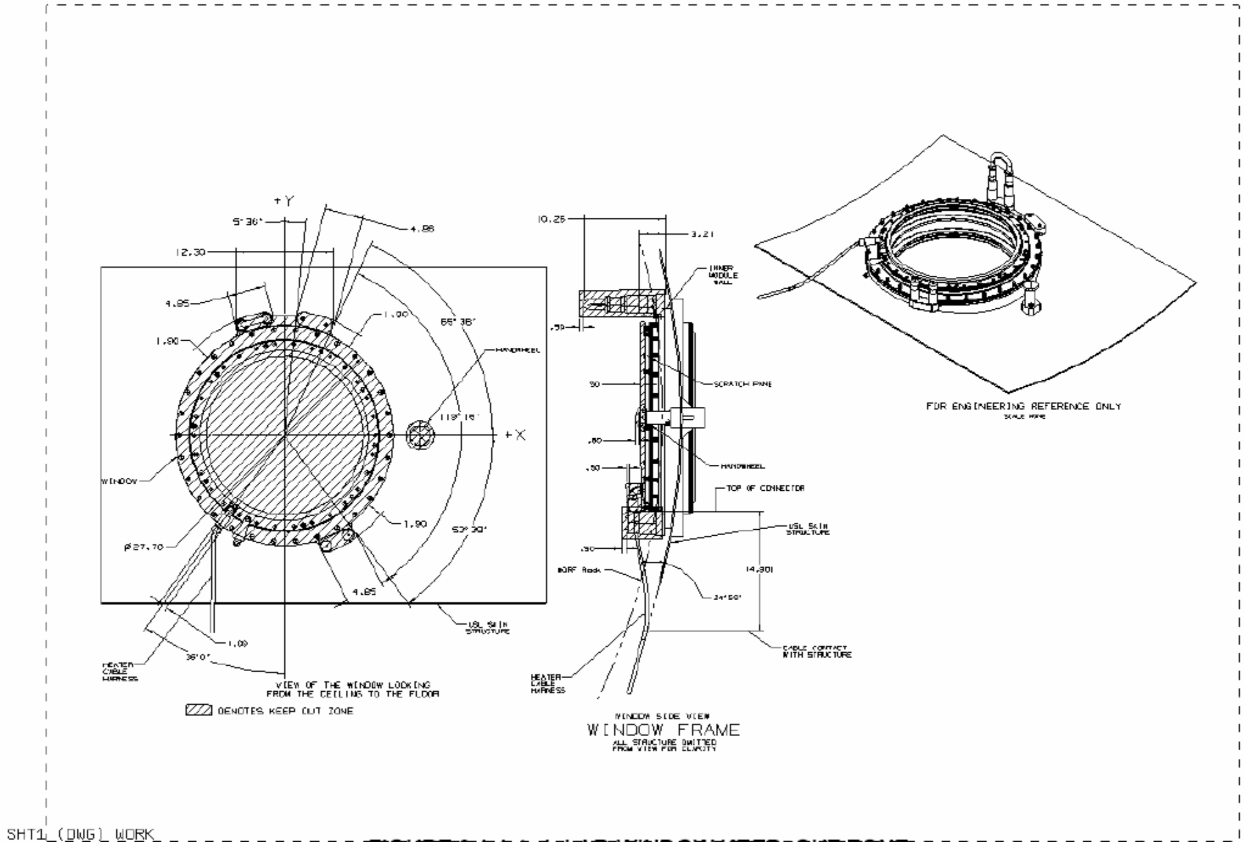


FIGURE M.3.1.5-1 LAB WINDOW KEEP-OUT ZONE (PAGE 2 OF 2)

M.3.1.6 ELECTRICAL POWER AND DATA CONNECTOR LOCATIONS

Electrical power and data provisions are available through the front connector and camera connector panel locations as shown in Figures M.3.1.6-1, M.3.1.6-2, M.3.1.6-3, M.3.1.6-4 and M.3.1.6-5. The WORF Rack payload integrator approves the payload power and data cable routing methodology.

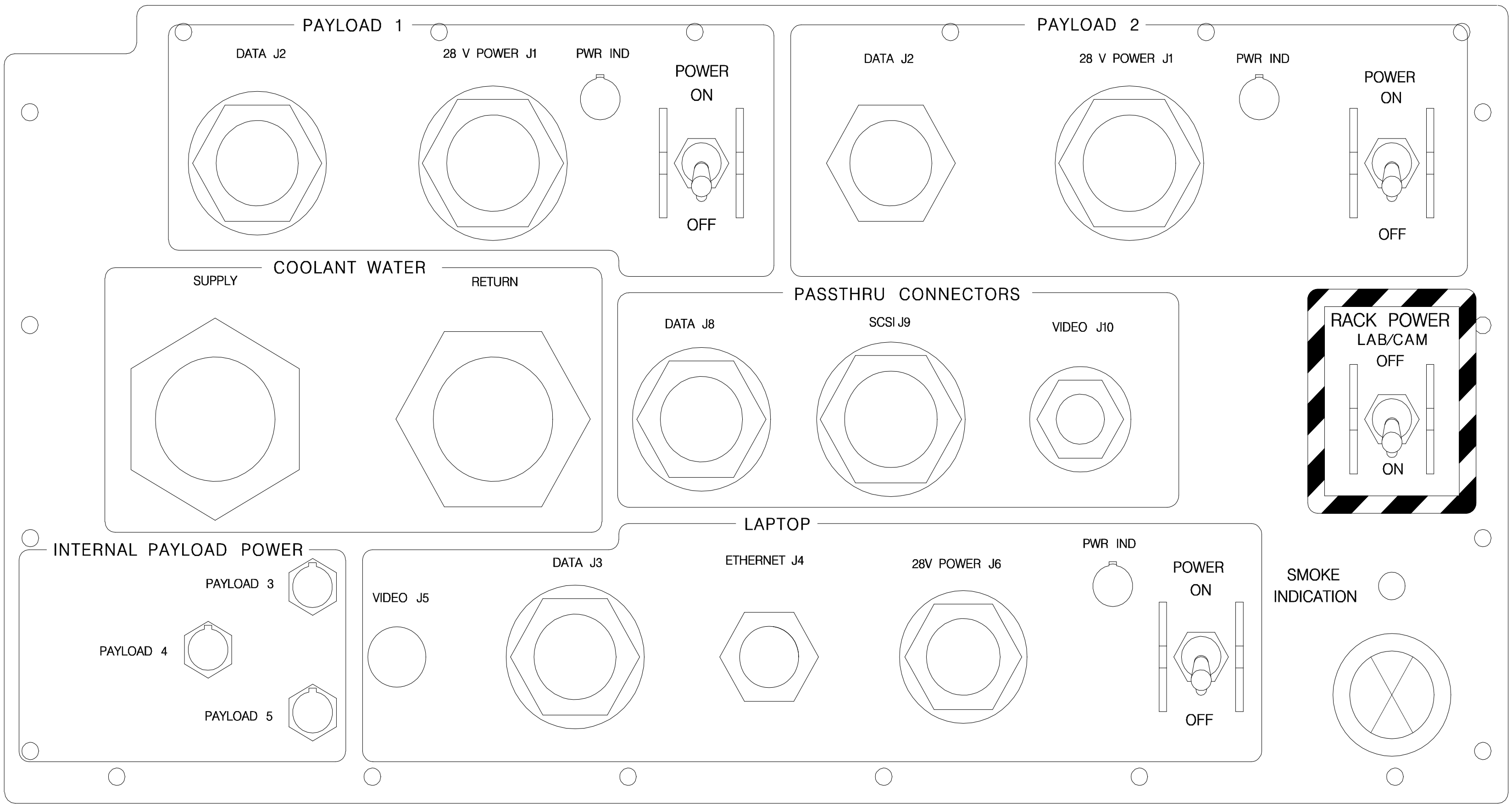
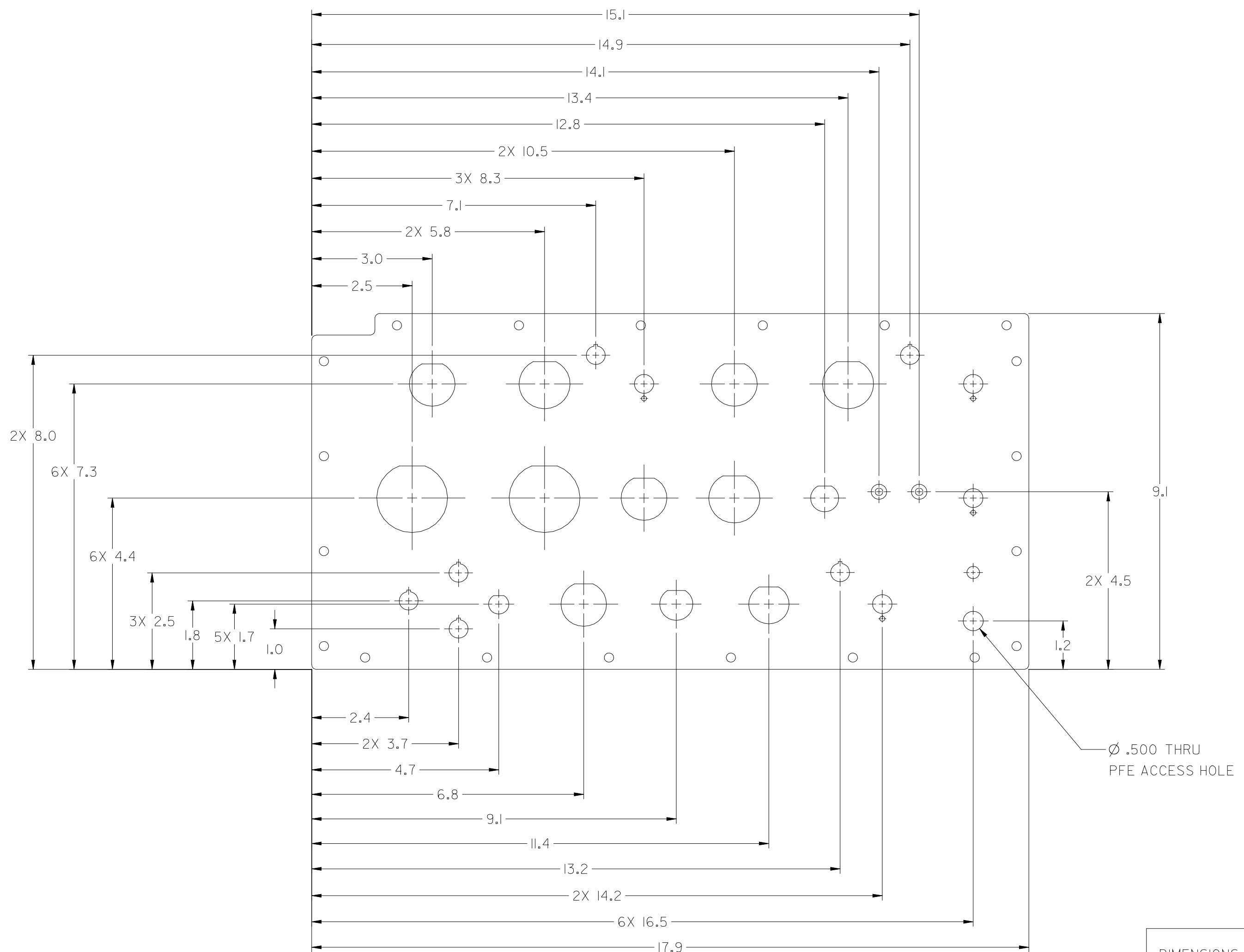


FIGURE M.3.1.6-1 WORF FRONT CONNECTOR PANEL ASSEMBLY



NOTES:

1. MATERIAL: .250 THICK, 7075 ALUMINUM PLATE
2. FINISH: CHEMICAL CONVERSION COAT
3. CONTROL LABELS OMITTED FOR CLARITY

DIMENSIONS	INCHES
DECIMAL	X.X = REFERENCE DIMENSIONS X.XXX = +/- 0.010 inches

FIGURE M.3.1.6-2 WORF FRONT CONNECTOR PANEL

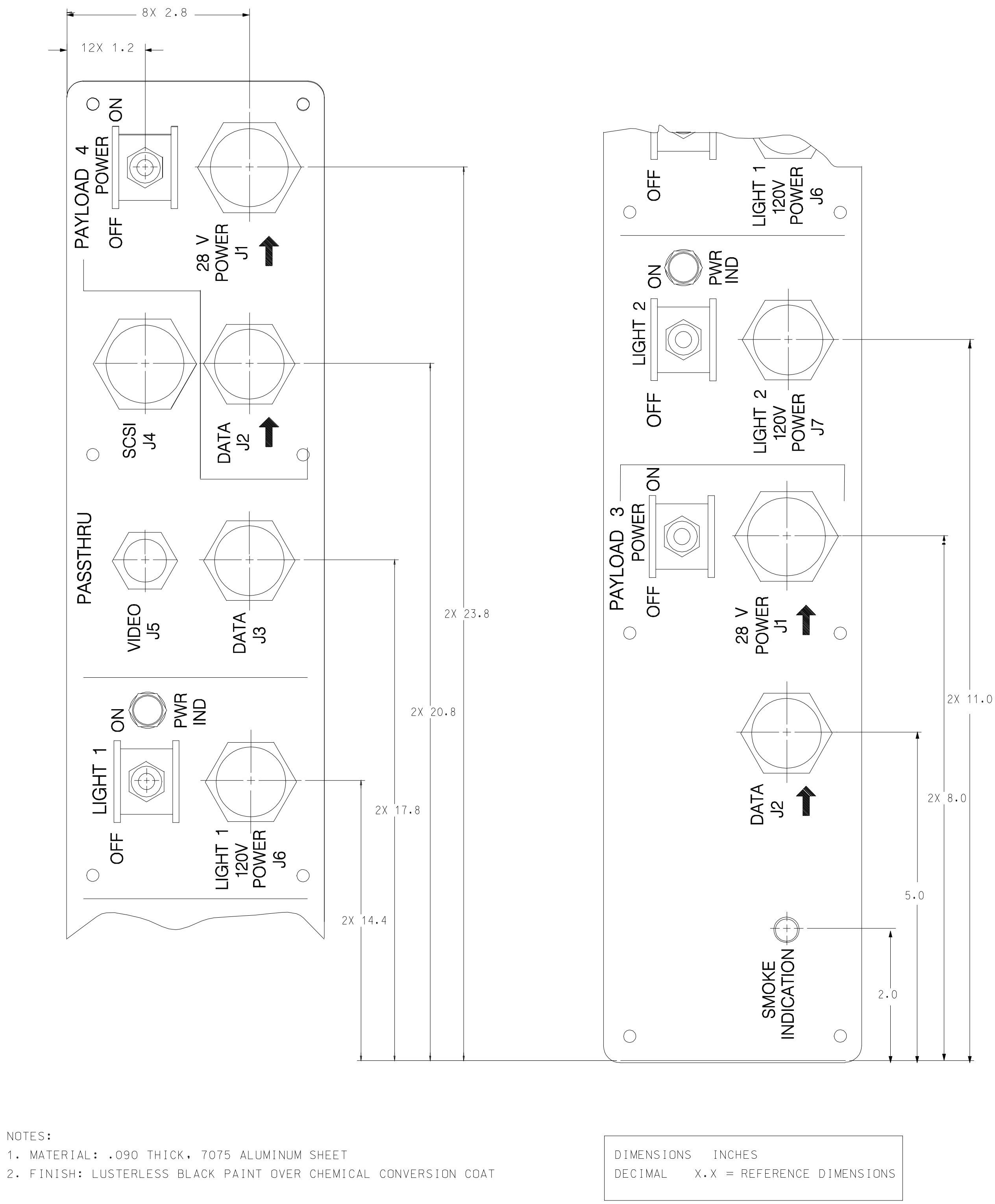
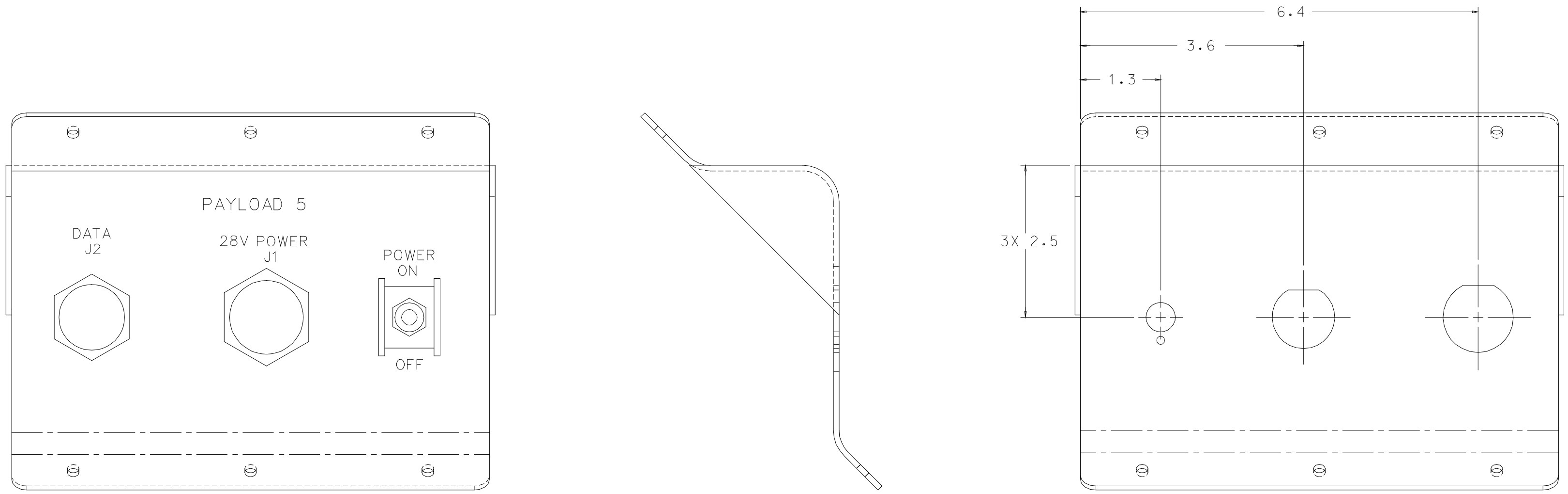


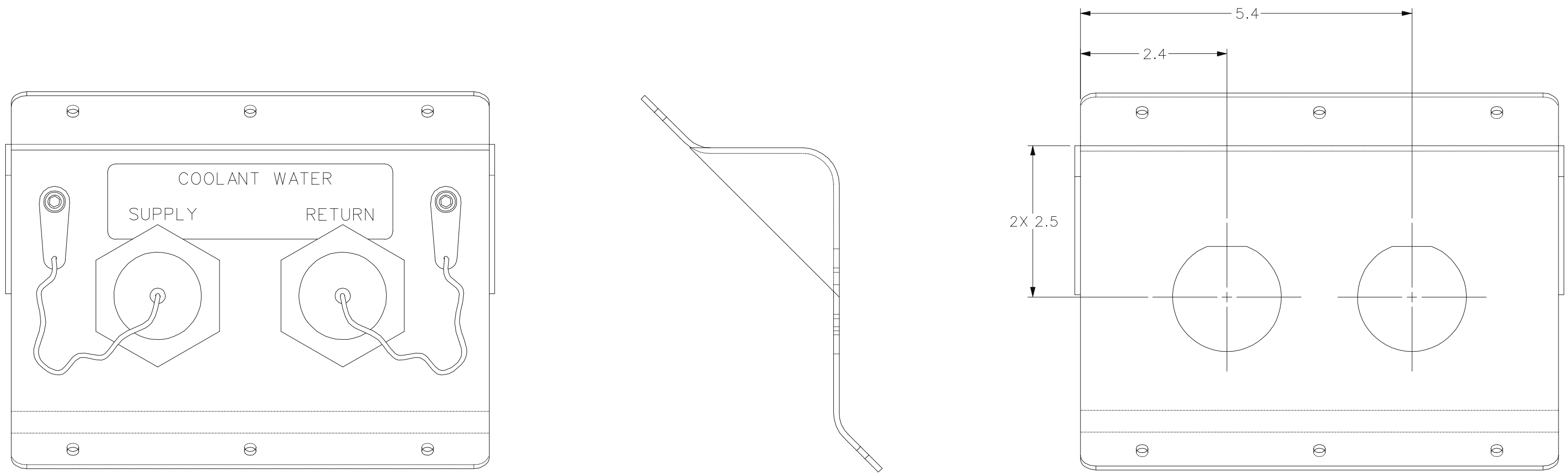
FIGURE M.3.1.6-3 WORF MAIN CAMERA CONNECTOR PANEL DETAILS



NOTES:
1. MATERIAL: .090 THICK, 7075 ALUMINUM SHEET
2. FINISH: CHEMICAL CONVERSION COAT

DIMENSIONS	INCHES
DECIMAL	X.X = REFERENCE DIMENSIONS

FIGURE M.3.1.6-4 WORF CAMERA CONNECTOR AUXILIARY PANEL 1



NOTES:

1. MATERIAL: .090 THICK, 7075 ALUMINUM SHEET

2. FINISH: CHEMICAL CONVERSION COAT

DIMENSIONS	INCHES
DECIMAL	X.X = REFERENCE DIMENSIONS

FIGURE M.3.1.6-5 WORF CAMERA CONNECTOR AUXILIARY PANEL 2

M.3.2 POWER CABLE WIRING DETAILS AND PIN ASSIGNMENTS

Power cable wiring details and pin assignments are shown in Table M.3.2-1, WORF Power Connector Panel Interface Definition. The interfacing payload power cables **shall** be compatible with the details and pin assignments in Table M.3.2-1.

TABLE M.3.2-1 WORF POWER CONNECTOR PANEL INTERFACE DEFINITION

WORF CONNECTOR DESIGNATION	INTERFACE TYPE	WORF PANEL TYPE (LOCATION)	WORF CONNECTOR TYPE (RECOMMENDED PL MATING CONN)	CONTACT POSITION	SIGNAL DEFINITION	CABLE TYPE	REMARKS
PAYLOAD 1 28 V POWER J1	Payload 1 Power (28 Vdc)	Front Connector Panel (Front Panel)	MS27468T17F6S (MS27467T17F6P)	A B C D E F	+28 Vdc Supply +28 Vdc Return Chassis Ground No Connection No Connection No Connection	M27500-12RE2U00	+28Vdc (EMC HO) +28V RTN (EMC HO) Chassis GND N/C N/C N/C
PAYLOAD 2 28 V POWER J1	Payload 2 Power (28 Vdc)						
PAYLOAD 3 28 V POWER J1	Payload 3 Power (28 Vdc)	Main Camera Connector Panel (Payload Volume)	MS27468T17F6S (MS27467T17F6P)	A B C D E F	+28 Vdc Supply +28 Vdc Return Chassis Ground No Connection No Connection No Connection	M27500-12RE2U00	+28Vdc (EMC HO) +28V RTN (EMC HO) Chassis GND N/C N/C N/C
PAYLOAD 4 28 V POWER J1	Payload 4 Power (28 Vdc)						
PAYLOAD 5 28 V POWER J1	Payload 5 Power (28 Vdc)	Auxiliary Panel 1 (Payload Volume)					
LAPTOP 28 V POWER J6	Laptop Power (28 Vdc)	Front Connector Panel (Front Panel)	MS3474L14-12S (MS3476L14-12P)	A - H J K L M	No Connection +28 Vdc Supply +28 Vdc Return Chassis Ground No Connection	M27500-16RE2U00	N/C +28Vdc (EMC HO) +28V RTN (EMC HO) Chassis GND N/C
LIGHT 1 120 V POWER J7	Portable Lighting Power (120 Vdc)	Main Camera Connector Panel (Payload Volume)	NATC07T15N97SN (NATC06G15N97PN)	A B C D E F G H J K L M	No Connection No Connection No Connection No Connection No Connection No Connection Chassis Ground No Connection No Connection No Connection +120 Vdc Return +120 Vdc Supply	M27500-16RC3U06	NC NC NC NC NC NC GND NC NC NC +120 Vdc RTN +120 Vdc NC SUP
LIGHT 2 120 V POWER J6	Portable Lighting Power (120 Vdc)						

M.3.3 DATA CABLE WIRING DETAILS AND PIN ASSIGNMENTS

Data cable wiring details and pin assignments are shown in Table M.3.3-1 for the front connector, main camera connector, and camera connector auxiliary panels. The interfacing payload data cables **shall** be compatible with the details and pin assignments in Table M.3.3-1.

TABLE M.3.3-1 WORF DATA CONNECTOR PANEL INTERFACE DEFINITION (5 PAGES)

WORF CONNECTOR DESIGNATION	INTERFACE TYPE	WORF PANEL TYPE (LOCATION)	WORF CONNECTOR TYPE (RECOMMENDED PL MATING CONN)	CONTACT POSITION	SIGNAL DEFINITION RACK/RIC/SSPCM PERSPECTIVE	CABLE TYPE	REMARKS
LAPTOPVIDEO	Laptop Video (EIA-170)	Front Connector Panel (Front Panel) FCP J5	BJ76 (PL75)	1 2	RS170TX (+) RS170TX (-)	NDBC-TFE-22-2SJ-75	WORF Analog Video Output
LAPTOP ETHERNET	Laptop Ethernet	Front Connector Panel (Front Panel) FCP J4	MS27468T11F35S (MS27467T11F35P)	1 2 3 4 5-13	Ethernet Receive + Ethernet Receive - Ethernet Transmit + Ethernet Transmit - No Connection	NDBC-TFE-22-2SJ-100	E-NET RX (+) E-NET RX (-) E-NET TX (+) E-NET TX (-) N/C
PASSTHRU CONNECTORS SCSI	Payload PASSTHRU Connector (SCSI-2)	Front Connector Panel (Front Panel) FCP J9 Main Camera Connector Panel (Payload Volume) CCP J4 Note 1	MS27468T17F35S (MS27467T17F35P)	1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 – 22 23 – 24 25 – 26 27 – 28 29 – 30 31 32 33 – 34 35	Ground (D0) Data Bus 0 Ground (D1) Ground (D4) Ground (D2) Data Bus 2 Data Bus 1 Data Bus 3 Ground (D3) Data Bus 4 Ground (D5) Data Bus 5| Ground (D6) Data Bus 6 Ground (D7) Data Bus 7 Ground (Parity) Data (Parity) Ground Reserved Termination Power Reserved Ground Ground (Attention) Ground (Reset) Ground Ground (Busy)	NDBC-TFE-22-2SJ-100	GND (D0 -) D0 (+) GND (D1 -) GND (D4-) GND (D2 -) D2 (+) D1 (+) D3 (+) GND (D3 -) D4 (+) GND (D5 -) D5 (+) GND (D6 -) D6 (+) GND (D7 -) D7 (+) Parity (-) DB (Parity +) GND (-) Reserved TERMPWR Reserved GND (-) ATN (-) RST (-) GND (-) BSY (-)

TABLE M.3.3-1 WORF DATA CONNECTOR PANEL INTERFACE DEFINITION (5 PAGES)

WORF CONNECTOR DESIGNATION	INTERFACE TYPE	WORF PANEL TYPE (LOCATION)	WORF CONNECTOR TYPE (RECOMMENDED PL MATING CONN)	CONTACT POSITION	SIGNAL DEFINITION RACK/RIC/SSPCM PERSPECTIVE	CABLE TYPE	REMARKS
PASSTHRU SCSI (Continued)				36	Busy		BSY (+)
				37	Ground Acknowledge		ACK (-)
				38	Acknowledge		ACK (+)
				39	Attention		ATN (+)
				40	Reset		RST (+)
				41	Ground (Message)		MSG (-)
				42	Message		MSG (+)
				43	Ground (Select)		SEL (-)
				44	Select		SEL (+)
				45	Ground Control/Data		C/D (-)
				46	Control/Data		C/D (+)
				47	Ground (Request)		REQ (-)
				48	Request		REQ (+)
				49	Ground Input/Output		I/O (-)
				50	Input/Output		I/O (+)
				51	Option		OPT
				52	Option		OPT
				53	Differential Sense		DS
				54	Ground		GND (-)
PASSTHRU CONNECTORS DATA	Payload Passthru Connector (Ethernet/ RS-232/RS-422)	Front Connector Panel (Front Panel) FCP J8 Main Camera Connector Panel (Payload Volume) CCP J3	MS27468T15F35S (MS27467T15F35P)	1	Carrier Detect	M27500-22TN9N06	CD
				2	RS-232		RS232
				3	RS-232		RS232
				4	Data Terminal Ready		DTR
				5	Signal Return		SIGNAL RTN
				6	Data Set Ready		DSR
				7	Request to Send		RTS
				8	Clear to Send		CTS
				9	Ring Indicator		RI
		Note 2		10	No Connection		NC
				11	Ethernet	NDBC-TFE-22-2SJ-100	E-NET E-NET
				12	Ethernet		E-NET

TABLE M.3.3-1 WORF DATA CONNECTOR PANEL INTERFACE DEFINITION (5 PAGES)

WORF CONNECTOR DESIGNATION	INTERFACE TYPE	WORF PANEL TYPE (LOCATION)	WORF CONNECTOR TYPE (RECOMMENDED PL MATING CONN)	CONTACT POSITION	SIGNAL DEFINITION RACK/RIC/SSPCM PERSPECTIVE	CABLE TYPE	REMARKS
				13	Ethernet		E-NET RS422 RS422 RS422 RS422 N/C
				14	Ethernet		
				15	RS-422	M27500-22TN2N06	
				16	RS-422		
				17	RS-422		
				18	RS-422		
				19 - 37	No Connection		
PASSTHRU CONNECTORS VIDEO	Payload Passthru Connector (S-Video)	Front Connector Panel (Front Panel) FCP J10 Main Camera Connector Panel (Payload Volume) CCP J5 Note 3	MS27468T9F35S (MS27467T9F35P)	1 2 3 4 5 6	Color Ground Color No connection Ground Intensity (Luminance) Intensity (Luminance) No connection	NDBC-TFE-22-2SJ-75	C GND (C) N/C GND (Y) Y N/C
PAYLOAD DATA	Payload Data	Front Connector Panel (Front Panel) FCP J2 Main Camera Connector Panel (Payload Volume) CCP J2	MS27468T15F35S (MS27467T15F35P)	1	RS 170 Receive +	NDBC-TFE-22-2SJ-75	RS170 RX (+) RS170 RX (-)
				2	RS 170 Receive -		
				3	No Connection		N/C
				4	Analog 1 +	M27500-22TN2N06	Analog 1 (+) Analog 1 (-) Analog 2 (+) Analog 2 (-)
				5	Analog 1 -		
				6	Analog 2 +		
				7	Analog 2 -		
		Auxiliary Panel 1 (Payload Volume) ICP J2 Note 4		8	Discrete 1 +		Discrete 1 (+) Discrete 1 (-) Discrete 2 (+) Discrete 2 (-)
				9	Discrete 1 -		
				10	Discrete 2 +		
				11	Discrete 2 -		

TABLE M.3.3-1 WORF DATA CONNECTOR PANEL INTERFACE DEFINITION (5 PAGES)

WORF CONNECTOR DESIGNATION	INTERFACE TYPE	WORF PANEL TYPE (LOCATION)	WORF CONNECTOR TYPE (RECOMMENDED PL MATING CONN)	CONTACT POSITION	SIGNAL DEFINITION RACK/RIC/SSPCM PERSPECTIVE	CABLE TYPE	REMARKS
				12	Discrete 3 +		Discrete 3 (+) Discrete 3 (-)
				13	Discrete 3 -		
				14	Ethernet Receive +	NDBC-TFE-22-2SJ-100	E-Net RX (+) E-Net RX (-) E-Net TX (+) E-Net TX (-)
				15	Ethernet Receive -		
				16	Ethernet Transmit +		
				17	Ethernet Transmit -		
				18 - 23	No Connection		N/C
				24	PPC Bus 01 +	NDBC-TFE-22-2SJ-100	PPCB1 (+) PPCB1 (-) PPCB2 (+) PPCB2 (-) (Communicate with higher # PL)
				25	PPC Bus 01 -		
				26	PPC Bus 02 +		
				27	PPC Bus 02 –		
				28	No Connection		N/C
				29	PPC Bus 03 +		PPCB3 (+) PPCB3 (-) PPCB4 (+) PPCB4 (-) (Communicate with lower # PL)
				30	PPC Bus 03 -		
				31	PPC Bus 04 +		
				32	PPC Bus 04 -		
				33	No Connection		N/C
				34	RS-422 Receive +	MS27500-22TN2N06	RS422 RX (+) RS422 RX (-) RS422 TX (+) RS422 TX (-)
				35	RS-422 Receive -		
				36	RS-422 Transmit +		
				37	RS-422 Transmit -		

Note 1: WORF Rack provides the connector and cable between FCP J9 and CCP J4 for Pass –Through SCSI uses.

Note 2: WORF Rack provides the connector and cable between FCP J8 and CCP J3 for Pass –Through Data uses.

TABLE M.3.3-1 WORF DATA CONNECTOR PANEL INTERFACE DEFINITION (5 PAGES)

WORF CONNECTOR DESIGNATION	INTERFACE TYPE	WORF PANEL TYPE (LOCATION)	WORF CONNECTOR TYPE (RECOMMENDED PL MATING CONN)	CONTACT POSITION	SIGNAL DEFINITION RACK/RIC/SSPCM PERSPECTIVE	CABLE TYPE	REMARKS

Note 3: WORF Rack provides the connector and cable between FCP J10 and CCP J5 for Pass –Through Video uses.

Note 4: Payload 1 and 2 are connected at Front Connector Panel (FCP), Payload 3 and 4 are connected at Main Camera Connector Panel (CCP), and payload 5 is connected at Auxiliary Panel (ICP).

M.3.4 HUMAN FACTORS INTERFACE REQUIREMENTS

M.3.4.1 OPTICAL AND LIGHTING

A. The WORF Rack payload that requires its own workspace lighting *should* provide a provision for shutting that lighting off during WORF payload operations. The WORF Rack volume will have a portable workspace light that can be turned off during payload operations in all WORF nominal operational configurations.

B. To preserve the optical environment when two payloads are located within the WORF payload volume, all surfaces of the WORF payload which will be exposed to incoming light from the nadir window port *should* have a diffuse surface reflectance of no more than 12 percent for a wave length range between 400 and 700 nm.

C. To preserve the optical environment when two payloads are located within the WORF payload volume, the specular surface reflectance of each individual WORF payload *should* not exceed 10 percent for a wavelength between 400 and 700 nm. The payload may meet this requirement by design or utilization of temporary equipment covers for the payload when not in use.

D. WORF payload hardware located within the WORF payload volume *should* have a lusterless black finish such that the black color is visually comparable to any of the following colors: #37030, #37031, #37038, or #37056 in accordance with FED-STD-595.

M.3.4.2 CONTINUOUS NOISE LIMITS

The WORF payload **shall** meet the continuous noise limits requirement in G.3.12.1.

M.4.0 VERIFICATION

M.4.1 RESPONSIBILITIES

The payload developer is responsible for providing verification for all applicable requirements in this appendix, as allocated to the payload through the payload unique ICD. The ISS Program is responsible for review and approval of the submitted verification.

M.4.2 VERIFICATION METHODS

Compliance with the requirements stated in Section M.3.0 are proven using one or more of the methods described in paragraph 4.2.

M.4.3 WORF RACK TO SUBRACK PAYLOAD INTERFACE VERIFICATION REQUIREMENTS

M.4.3.1 STRUCTURAL/MECHANICAL INTERFACES

M.4.3.1.1 PAYLOAD VOLUME

Verification that the WORF payload does not exceed the payload envelope shown in Figure M.3.1.1-1 *should* be verified by analysis of the payload provided drawing and list of the payload equipment, including the volume of each item. The verification *should* be considered successful when the analysis of the WORF payload does not exceed the payload envelope.

Verification Submittal: CoC

M.4.3.1.2 SEAT TRACKS

Verification that the moment of payload hardware attached to the seat tracks is no greater than 750 in-lb **shall** be by analysis. The verification **shall** be considered successful when the analysis report confirms the moment of the payload hardware.

Verification Submittal: Analysis Report

M.4.3.1.3 SMALL CAMERA BRACKET

Verification that the payload attaches securely to the WORF provided small camera bracket *should* be by analysis or inspection. The verification *should* be considered successful with the analysis report or inspection shows the payload interface with the WORF provided small camera bracket is per Figure M.3.1.3-1.

Verification Submittal: CoC

M.4.3.1.4 PAYLOAD SUPPORT SHELF

A. Verification that the payload support shelf attachment point provisions are in accordance with Figure M.3.1.4-3 *should* be by inspection. The verification *should* be considered successful when the inspection of the payload support shelf attachment point provisions are in compliance.

Verification Submittal: CoC

B. Verification that the mating holes and tolerances are per Paragraph M.3.1.4.B *should* be by inspection. The verification *should* be considered successful when the inspection shows the mating holes and tolerances are in compliance.

Verification Submittal: CoC

C. Verification that the payload fastener used to attach to the payload support shelf is thread size 0.19-32 (#10-32) **shall** be by inspection. The verification **shall** be considered successful when the inspection of the drawings and/or as-built flight hardware shows the payload fastener is in compliance.

Verification Submittal: CoC

D. Verification that the payload uses dry film lubrication, silver plating, or application of approved anti-seize compound to prevent fastener seizing *should* be by inspection. The verification *should* be considered successful when the inspection of the drawings and/or flight hardware shows the payload used dry film lubrication, silver plating, or application of approved anti-seize compound to prevent fastener seizing.

Verification Submittal: CoC

E. Verification that all payload provided fasteners are self-retracting (i.e. spring loaded) and do not protrude below the payload mounting flange *should* be by inspection. The verification *should* be considered successful when the inspection of the drawings/and or flight hardware shows the payload provided fasteners are self-retracting and do not protrude below the payload mounting flange.

Verification Submittal: CoC

F. Verification that the payload alignment guides are non-metallic, self-retracting, and do not pose a damage hazard to the surface of the payload support shelf *should* be by inspection. The verification *should* be considered successful when the inspection of the drawings and/or as-built flight hardware shows that the payload alignment guides are non-metallic, self-retracting, and do not post a damage hazard to the surface of the payload support shelf.

Verification Submittal: CoC

M.4.3.1.5 LAB WINDOW

Verification that the subrack payload at the lab window location provides a keep-out zone as specified in Figure M.3.1.5-1 **shall** be by inspection. The verification **shall** be considered successful when the inspection of the configuration drawings shows the payload keep-out zone is in compliance.

Verification Submittal: CoC

M.4.3.1.6 ELECTRICAL POWER AND DATA CONNECTOR LOCATIONS

NVR

M.4.3.2 POWER CABLE WIRING DETAILS AND PIN ASSIGNMENTS

Verification that the interfacing payload power cables are compatible **shall** be by inspection. The verification **shall** be considered successful when the inspection of drawings and flight hardware shows that the interfacing payload power cables are compatible with the details and pin assignments in Table M.3.2-1.

Verification Submittal: CoC

M.4.3.3 DATA CABLE WIRING DETAILS AND PIN ASSIGNMENTS

Verification that the interfacing payload data cables are compatible **shall** be by inspection. The verification **shall** be considered successful when the inspection of drawings and flight hardware shows that the interfacing payload data cables are compatible with the details and pin assignments in Table M.3.3-1.

Verification Submittal: CoC

M.4.3.4 HUMAN FACTORS INTERFACE REQUIREMENTS

M.4.3.4.1 OPTICAL AND LIGHTING

A. Verification that the payload which has its own work space light has the capability to extinguish that light during WORF payload operations *should* be by inspection. The verification *should* be considered successful when the inspection shows the payload has the capability to extinguish its own work space light.

Verification Submittal: CoC

B. Verification that all surfaces of the WORF payload which will be exposed to incoming light from nadir window port meet the diffuse surface reflectance requirement *should* be by inspection. The verification *should* be considered successful when the inspection shows that the diffuse surface reflectance is no more than 12 percent for a wavelength range between 400 and 700 nm.

Verification Submittal: CoC

C. Verification that the WORF payload meets the specular surface reflectance *should* be by inspection. The verification *should* be considered successful when the inspection shows the specular surface reflectance does not exceed 10 percent for a wavelength between 400 and 700 nm.

Verification Submittal: CoC

D. Verification that the WORF payload hardware located within the WORF payload volume has a lusterless black finish *should* be by inspection. The verification *should* be considered successful when the inspection of the as-built hardware shows the hardware has a lusterless black finish such that the black color is visually comparable to any of the following colors: #37030, #37031, #37038, or #37056 in accordance with FED-STD-595.

Verification Submittal: CoC

M.4.3.4.2 CONTINUOUS NOISE LIMITS

Continuous noise limits requirements for the WORF payload **shall** be verified per the requirement in G.4.3.12.1.

APPENDIX N

ISS TO INTEGRATED RACK INTERFACE REQUIREMENTS

APPENDIX N – ISS TO INTEGRATED RACK INTERFACE REQUIREMENTS

N.1.0 INTRODUCTION

N.1.1 PURPOSE

This appendix provides requirements, guidelines and data deliverables for integrated payload racks on ISS.

N.1.2 SCOPE

This appendix addresses integrated payload racks in the USL, JEM or Columbus modules of ISS.

N.1.3 USE

These requirements, guidelines and data deliverables are applied to integrated payload racks in addition to the general requirements, guidelines and data deliverables in Section 3.0 and are allocated to a payload through the payload unique ICD. The PD and the ISS Program must jointly agree on the interfaces and identify requirements as applicable if the interface exists, and not applicable if the interface does not exist for the payload configuration documented in the ICD.

N.2.0 DOCUMENTATION

See Section 5.0.

N.3.0 ISS TO INTEGRATED RACK INTERFACE REQUIREMENTS

N.3.1 STRUCTURAL/MECHANICAL AND MICROGRAVITY INTERFACE REQUIREMENTS

N.3.1.1 STRUCTURAL/MECHANICAL INTERFACES

N.3.1.1.1 RACK WEIGHT

Integrated racks **shall** be limited to 804.2 kg (1773 lbs).

N.3.1.1.2 ON-ORBIT KEEP-OUT ZONE FOR KBAR

Integrated racks *should* comply with the on-orbit keep-out zone for Kneebrace Bolt Action Replacement (KBAR) as defined in SSP 41017 Part 1, Figures 3.2.1.1.2-1 Rack Static Envelope (Side View) and 3.2.1.1.2-2 Rack Static Envelope (Front View).

N.3.1.1.3 RACK ROTATION

Integrated racks *should* be capable of rotating a minimum of 80 degrees about the pivot point for on-orbit installation, removal, and maintenance functions.

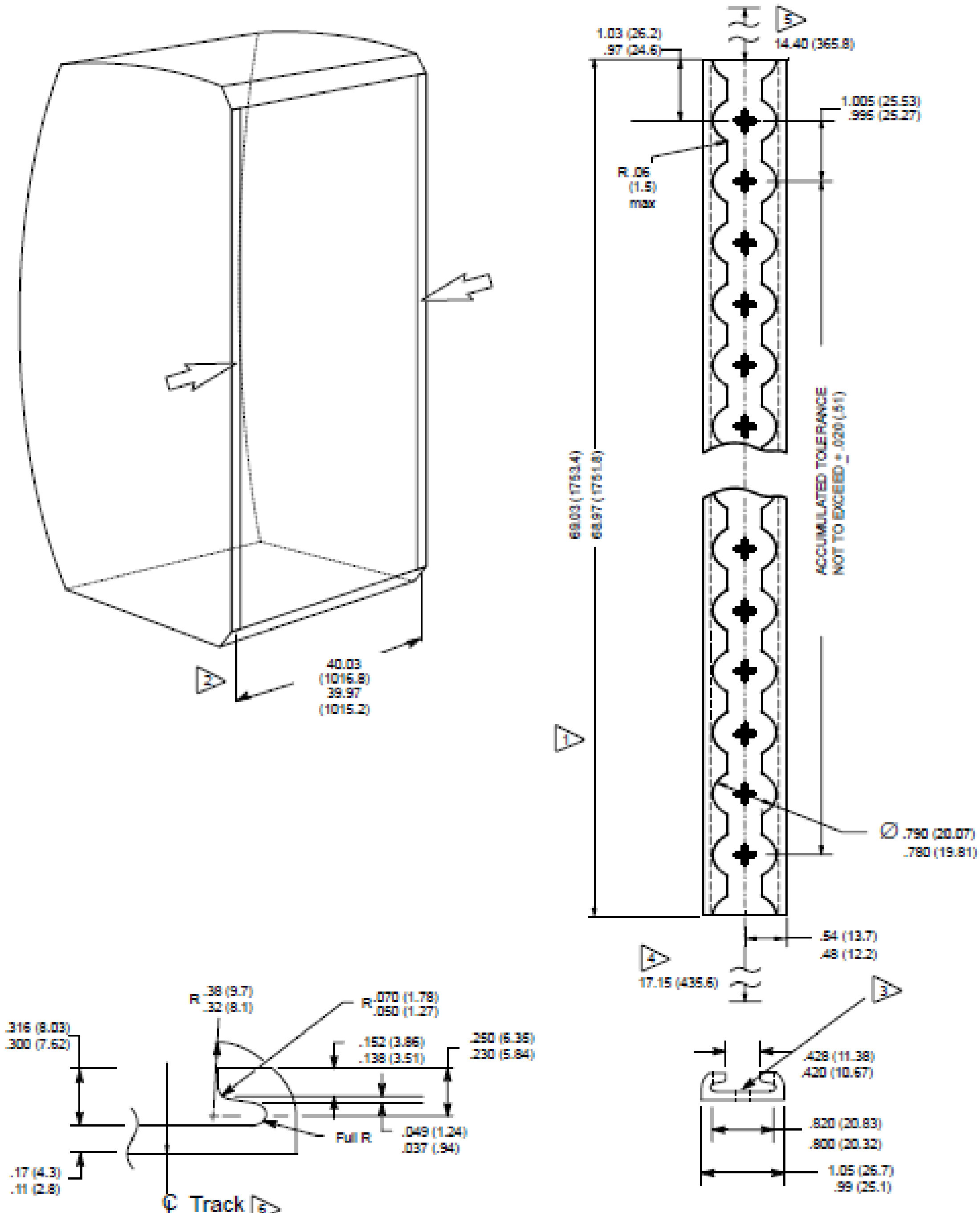
N.3.1.1.4 RACK ROTATION WITH UTILITIES

Integrated racks that are designed to rotate *should* be free to rotate fully as specified in Paragraph N.3.1.1.3 while connected to rack utilities (e.g. power, data, video, and fluid lines) from the pressurized element.

Note: This guideline does not apply to the following racks: Racks utilizing ARIS or PaRIS, MELFI, Window Observational Research Facility (WORF), EXPRESS, Human Research Facility (HRF) Rack 1, and HRF Rack 2.

N.3.1.1.5 SEAT TRACKS

Integrated racks **shall** have seat tracks installed in the locations defined in Figure N.3.1.1.5-1.



1. Typical for 80" rack. Length is dependent on rack size and available space. Minimum length of 40.54 (1029.7).
2. Centerline to centerline of tracks.
3. Fastener will not protrude above the bottom of the seat track.
4. Maximum distance from GSE points E and F.
5. Maximum distance from GSE points G and H.
6. Front Face of Seat Track Is within static envelope.

FIGURE N.3.1.1.5-1 RESTRAINTS AND MOBILITY AIDS HARDWARE INTERFACE

N.3.1.1.6 UMBILICAL PHYSICAL MATE

Integrated racks *should* provide a Rack UIP and umbilicals that allow connection of rack utilities from the rack to the UIP defined in Figure N.3.1.1.6-1 and the appropriate UIP connector layout defined in Figures N.3.1.1.6-2 through N.3.1.1.6-5.

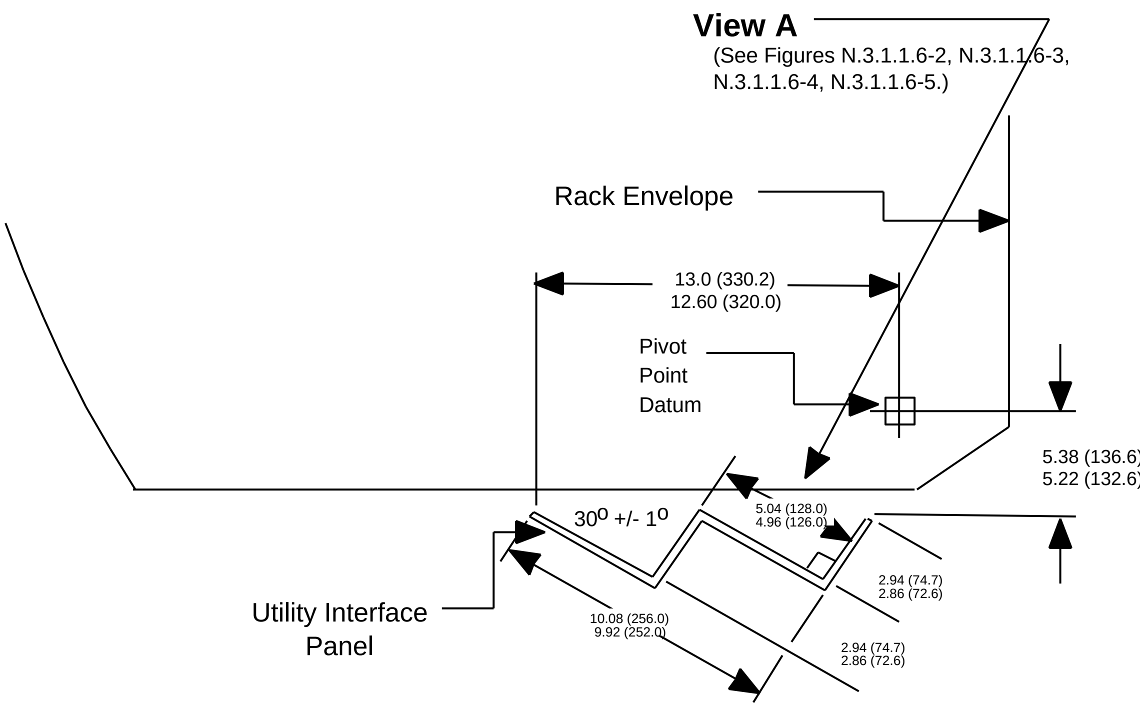
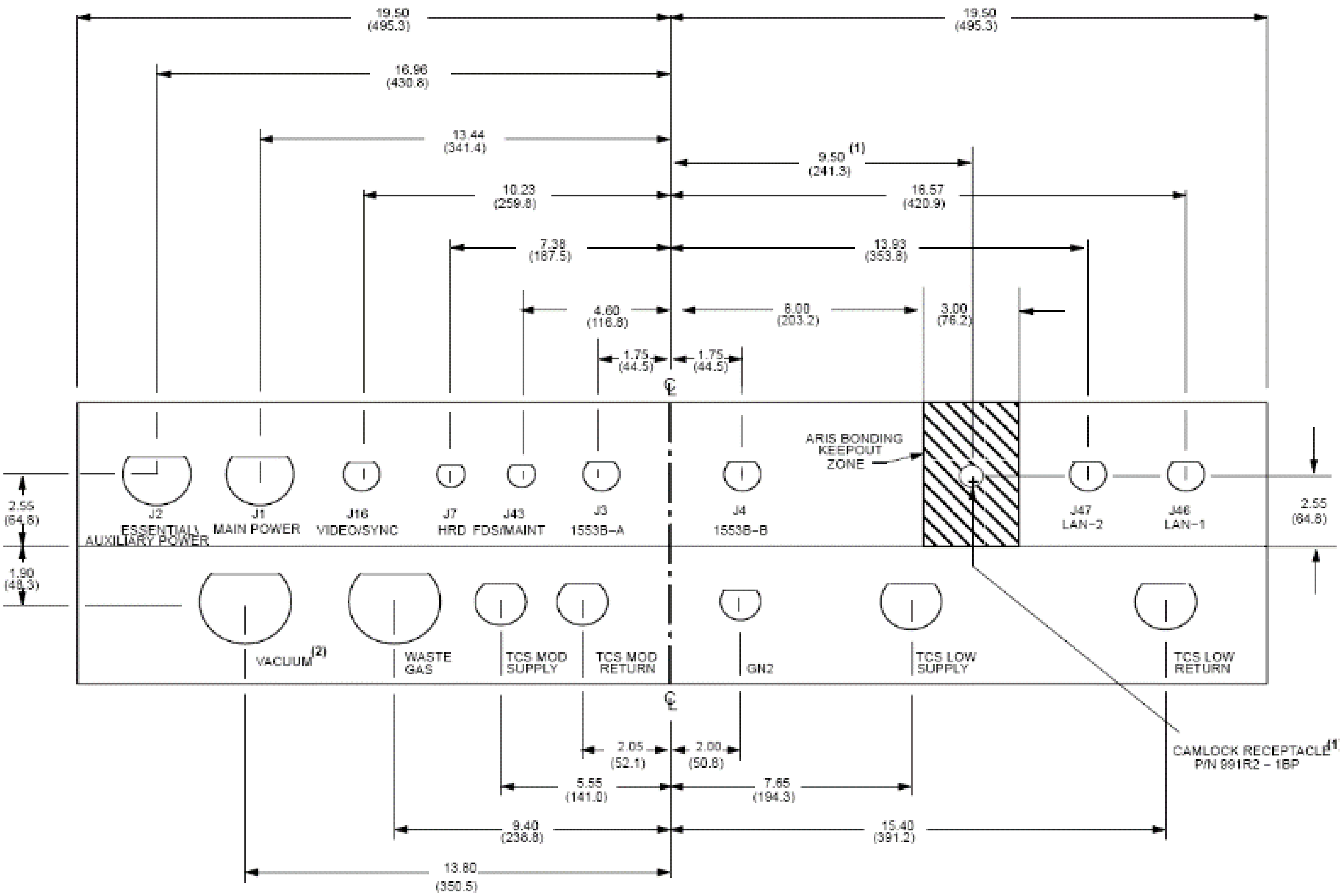


FIGURE N.3.1.1.6-1 UIP LOCATIONS AND DIMENSIONS



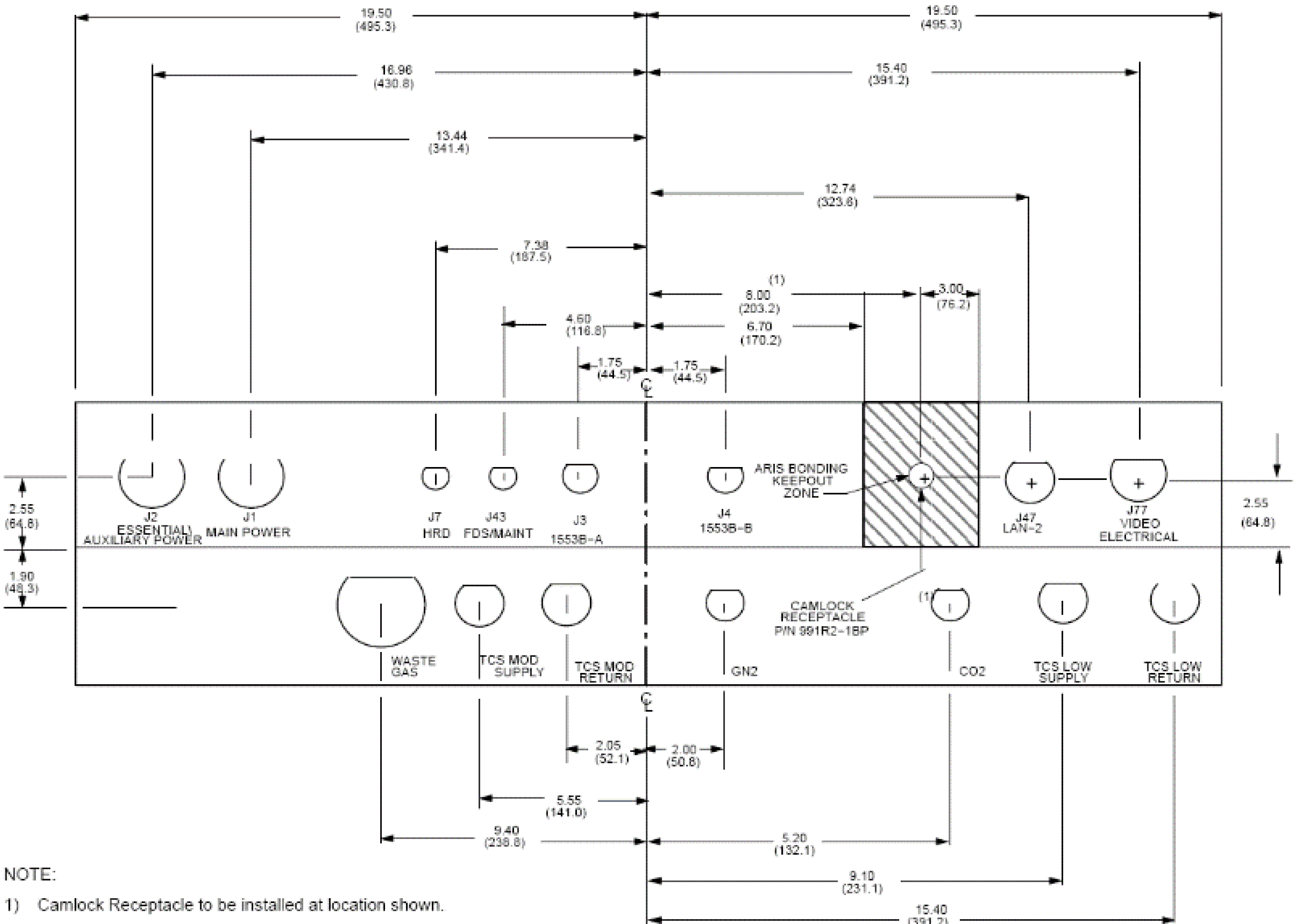
NOTE:

1) Camlock Receptacle to be installed at location shown.

2) Not available on USL Racks LAB1P1, LAB1P2, LAB1P4, LAB1D3.

3) All dimensions are nominal dimensions.

FIGURE N.3.1.1.6-2 USL SPECIFIC CONNECTOR LOCATIONS

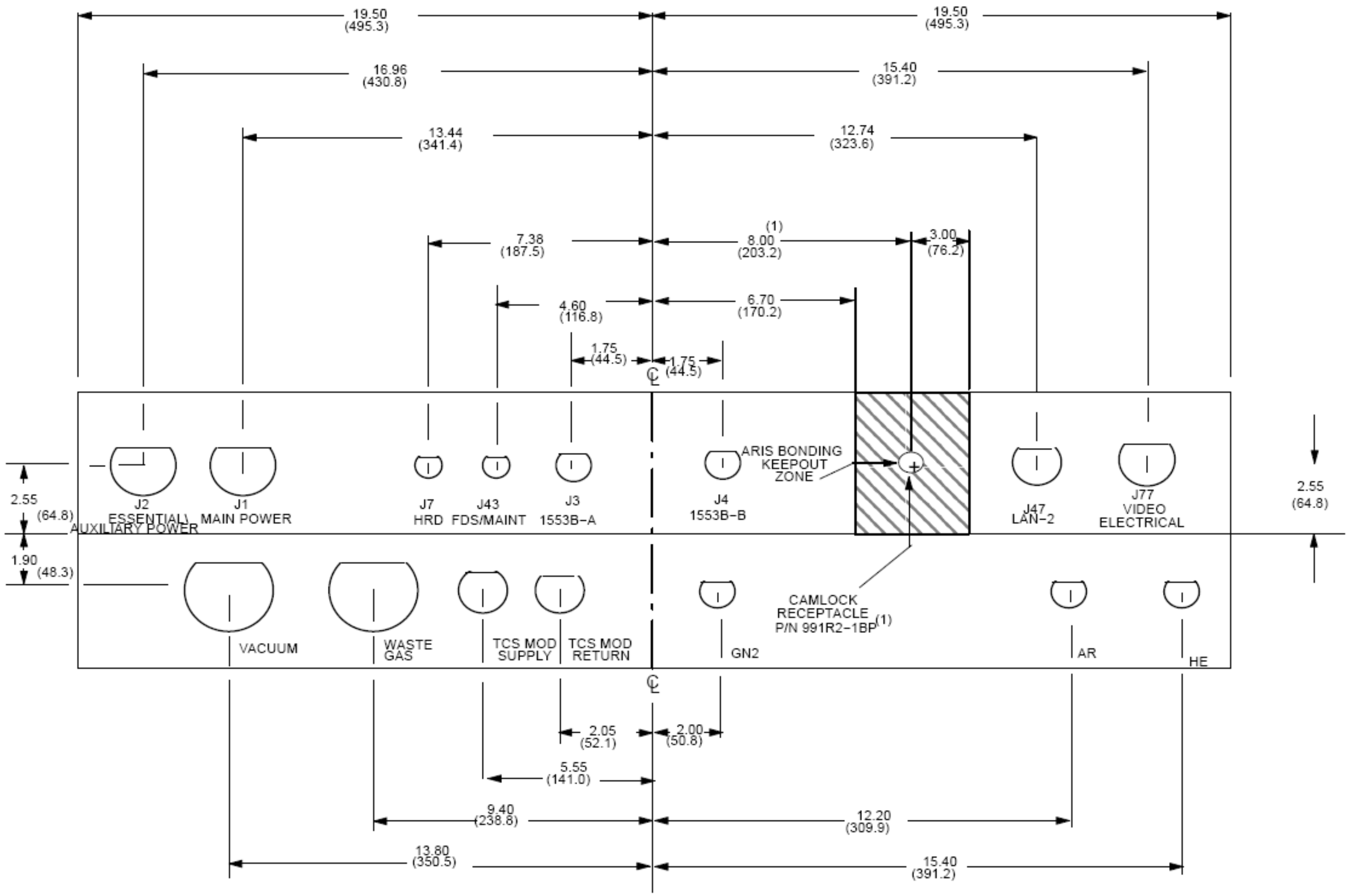


NOTE:

1) Camlock Receptacle to be installed at location shown.

2) All dimensions are nominal dimensions.

FIGURE N.3.1.1.6-3 JAXA LIFE SCIENCE RACK CONNECTOR LOCATIONS



NOTE:

1) Camlock Receptacle to be installed at location shown.

2) All dimensions are nominal dimensions.

FIGURE N.3.1.1.6-4 JAXA MATERIAL PROCESSING RACK CONNECTOR LOCATIONS

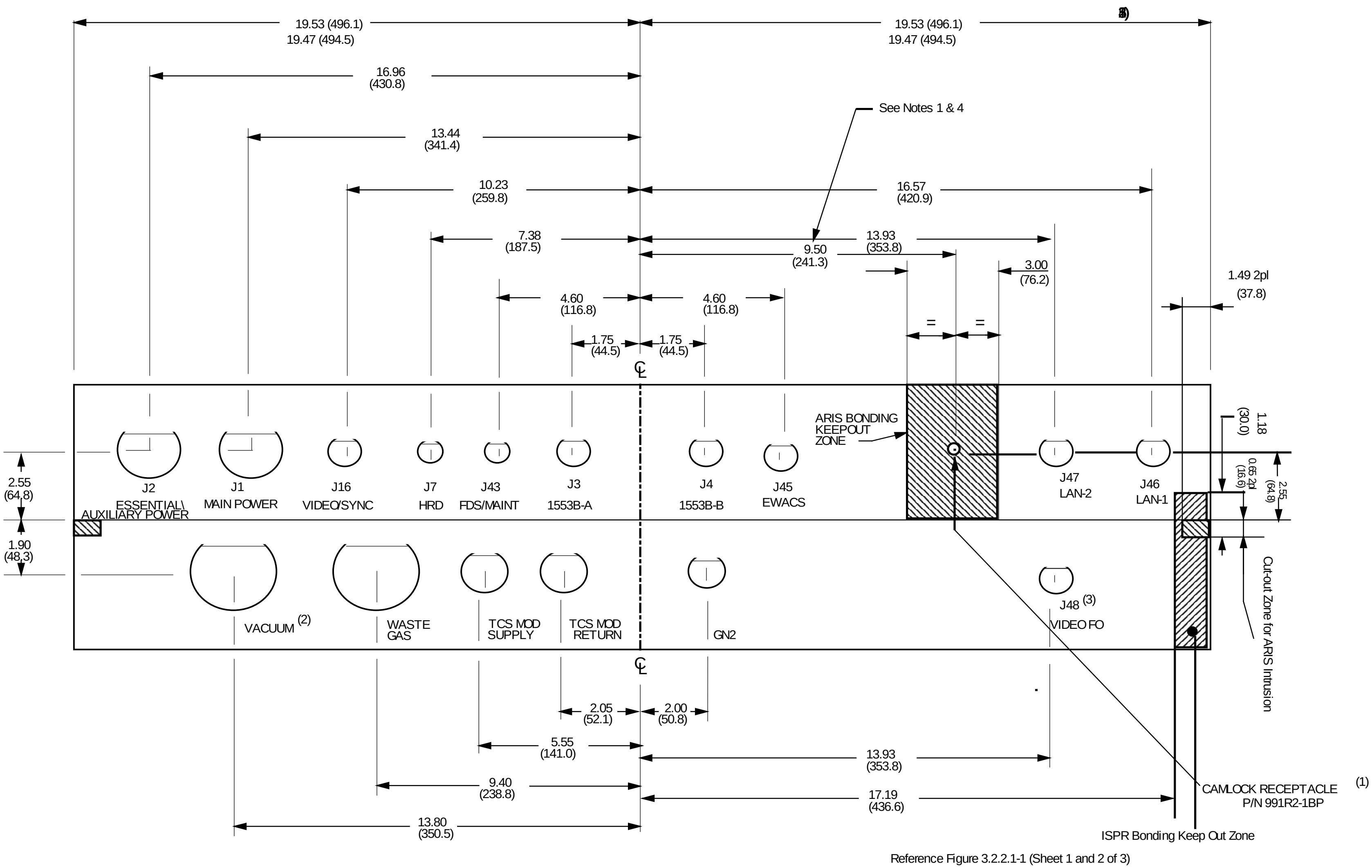


FIGURE N.3.1.1.6-5 COLUMBUS SPECIFIC CONNECTOR LOCATIONS

N.3.1.1.7 CONNECTOR PHYSICAL MATE

A. Payloads **shall** physically mate with the UIP connectors intended to be used by the payload as listed in Table N.3.1.1.7-1.

B. Payload connectors **shall** meet the requirements of SSQ 21635 or equivalent.

C. Payloads **shall** provide protection for all de-mated UIP connectors to prevent physical damage and contamination.

TABLE N.3.1.1.7-1 MODULE CONNECTORS

	Module Connector	Module Part Number	Resource
		UIP	
A	J1	NATC07T25LN3SN	Main Power
B	J2	NATC07T25LN3SA	Essential/Auxiliary Power
C	J3	NATC07T15N35SN	1553 Bus A
D	J4	NATC07T15N35SA	1553 Bus B
E	J7	NATC07T13N4SN	HRDL
F	J16	NATC07T15N97SB	Optical Video
G	J43	NATC07T13N35SA	FDS/Power Maintenance
H	J45	NATC07T11N35SC	EWACS
I	J46	NATC07T11N35SA	LAN-1
J	J47	NATC07T11N35SB	LAN-2
K	J77	NATC07T13N35SB	Electrical Video
L	TCS Mod Supply	683-16348, male, Category 6, Keying B	TCS Mod Supply
M	TCS Mod Return	683-16348, male, Category 6, Keying C	TCS Mod Return
N	TCS Low Supply	683-16348, male, Category 6, Keying B	TCS Low Supply
O	TCS Low Return	683-16348, male, Category 6, Keying C	TCS Low Return
P	GN_2	683-16348, male, Category 8, Keying B	GN_2
Q	Vacuum Exhaust	683-16348, male, Category 3, Keying B	Vacuum Exhaust
R	Vacuum Resource	683-16348, male, Category 3, Keying A	Vacuum Resource
S	Ar	683-16348, male, Category 8, Keying C	AR
T	He	683-16348, male, Category 8, Keying E	HE
U	CO_2	683-16348, male, Category 8, Keying D	CO_2

N.3.1.1.8 UTILITY INTERFACE PANEL CONNECTOR PIN ASSIGNMENTS

A. The main and auxiliary power connectors, J1 and J2, **shall** meet the pin assignments as specified in Figure N.3.1.1.8-1.

Note: ISS provides the capability to support simultaneous use of Main (J1) and Auxiliary (J2) power at each ISPR location. Constrained element level payload operations may occur from individual payload racks which automatically switch to or require simultaneous use of auxiliary power. ISS is required to reserve the maximum auxiliary power needed on that channelized Bus (even when not in use) to prevent Bus overload. For this reason, auxiliary power feeds will nominally be powered off by the module Remote Power Controller (RPC). Specific constraints on the use of auxiliary power will be defined in the payload unique ICD.

B. The low rate data bus connectors, J3 and J4, **shall** meet the pin assignments as specified in Figure N.3.1.1.8-2 and Figure N.3.1.1.8-3.

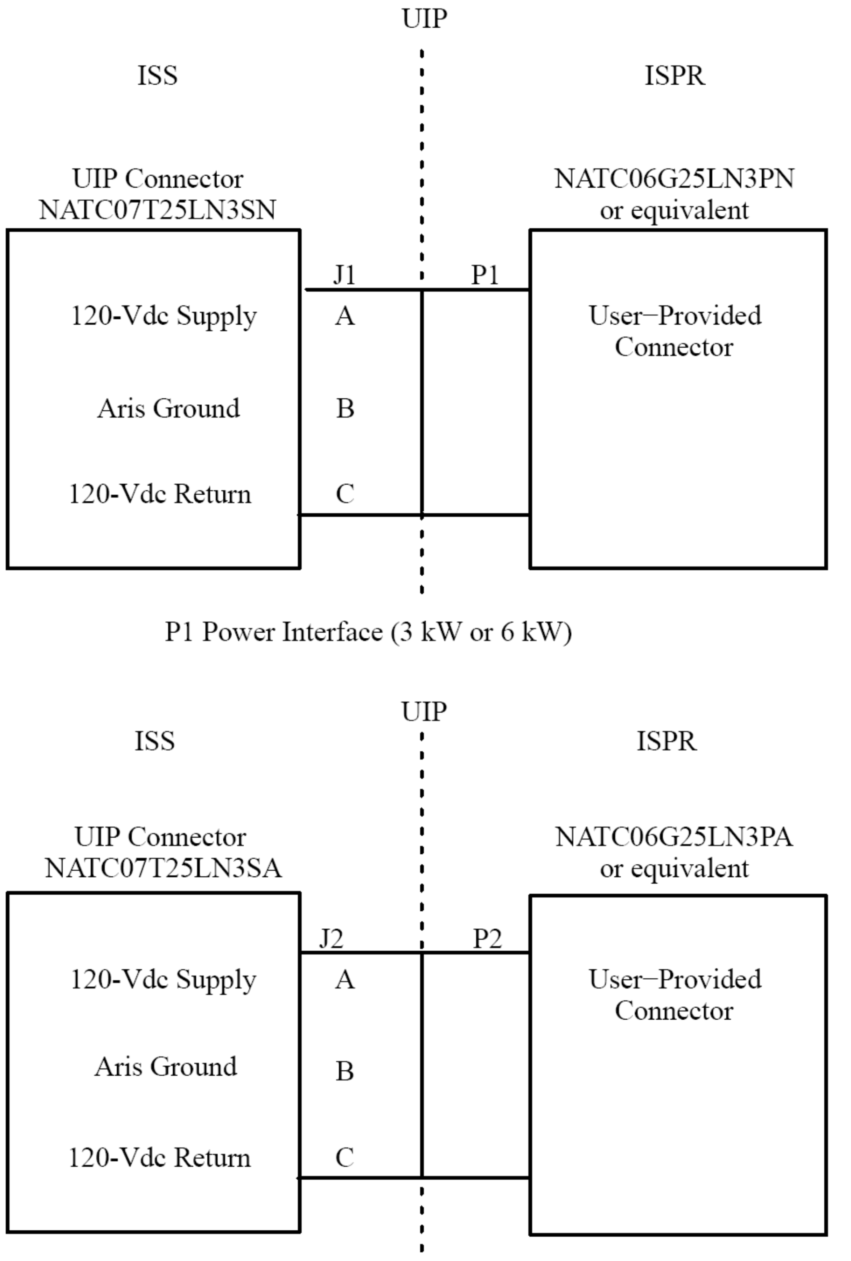
C. The medium rate data connectors, J46 and J47, **shall** meet the pin assignments as specified in Figure N.3.1.1.8-4 and Figure N.3.1.1.8-5.

D. The high rate data connector, J7, *should* meet the pin assignments as specified in Figure N.3.1.1.8-6.

E. The Rack Maintenance Switch/Smoke Detector P43 connector **shall** meet the pin out interfaces of the UIP J43 connector as specified in Figure N.3.1.1.8-7.

F. The PFM NTSC video optical connector, J16, *should* meet the pin assignments as specified in Figure N.3.1.1.8-8.

G. The electrical video connector, J77, **shall** meet the pin assignments as specified in Figure N.3.1.1.8-9.



P2 Power Interface (1.2 kW to 1.44 kW) or (6kW in 12 kW Location)

Note: Pin B only used for ARIS racks.
The ARIS Ground in the JEM is only available at ISPR locations A1, A5, and F1.

FIGURE N.3.1.1.8-1 UIP ELECTRICAL POWER CONNECTORS AND PIN ASSIGNMENTS

UTILITY I/F PANEL NATC07T15N35SN or 340105601B07-15-35SN 1553 BUS A	J3	P3	ISPR NATC06G15N35PN (NASA SSQ 21635)*
STANDARD P/L BUS BIT0 ADDRESS (USL)	1		
STANDARD P/L BUS BIT1 ADDRESS (USL)	2		
STANDARD P/L BUS BIT2 ADDRESS (USL)	3		
STANDARD P/L BUS BIT3 ADDRESS (USL)	4		
STANDARD P/L BUS BIT4 ADDRESS (USL)	5		
STANDARD P/L BUS PARITY (USL)	6		
STANDARD P/L BUS LOGIC GND (USL)	7		
SPARE	8		
JEM MOD. SPEC. P/L1 BUS BIT0 ADDRESS	9		
JEM MOD. SPEC. P/L1 BUS BIT1 ADDRESS	10		
JEM MOD. SPEC. P/L1 BUS BIT2 ADDRESS	11		
JEM MOD. SPEC. P/L1 BUS BIT3 ADDRESS	12		
JEM MOD. SPEC. P/L1 BUS BIT4 ADDRESS	13		
JEM MOD. SPEC. P/L1 BUS PARITY	14		
JEM MOD. SPEC. P/L1 BUS LOGIC GND	15		
SPARE	16		
JEM MOD. SPEC. P/L3 BUS BIT0 ADDRESS	17		
JEM MOD. SPEC. P/L3 BUS BIT1 ADDRESS	18		
JEM MOD. SPEC. P/L3 BUS BIT2 ADDRESS	19		
JEM MOD. SPEC. P/L3 BUS BIT3 ADDRESS	20		
JEM MOD. SPEC. P/L3 BUS BIT4 ADDRESS	21		
JEM MOD. SPEC. P/L3 BUS PARITY	22		
JEM MOD. SPEC. P/L3 BUS LOGIC GND	23		
SPARE	24		
APM MODULE SPECIFIC P/L BUS A-	25		
APM MODULE SPECIFIC P/L BUS A+	26		
JEM MODULE SPECIFIC P/L4 1553B BUS A-	27		
JEM MODULE SPECIFIC P/L4 1553B BUS A+	28		
JEM MODULE SPECIFIC P/L3 1553B BUS A-	29		
JEM MODULE SPECIFIC P/L3 1553B BUS A+	30		
SPARE	31		
JEM MODULE SPECIFIC P/L2 1553B BUS A-	32		
JEM MODULE SPECIFIC P/L2 1553B BUS A+	33		
JEM MODULE SPECIFIC P/L1 1553B BUS A-	34		
JEM MODULE SPECIFIC P/L1 1553B BUS A+	35		
STANDARD P/L 1553B BUS A- (USL)	36		
STANDARD P/L 1553B BUS A+ (USL)	37		

Note: Data buses are controlled impedance twisted shielded pairs with the shield terminated on the connector backshell.

Note: JEM module specific P/L bus interfaces are not applicable to the APM.
JEM module specific P/L2, P/L3, and P/L4 bus interfaces are not applicable to the USL.
JEM module specific P/L3 and P/L4 bus interfaces are applicable only to limited locations in the JEM.
APM module specific P/L bus interfaces are not applicable to the JEM and USL.

Note: Both the NASA SSQ21635 and ESA SCC3401/056 connectors are intermatable.

Note: The bus address logic ground will be connected to the ISPR Remote Terminal logic ground.

Note: Although APM is globally changed to COL throughout this document, for specific C&DH references APM is not being changed.

*International Payload Buses IP Negotiation Dependent.

FIGURE N.3.1.1.8-2 UIP LOW RATE DATA 1553B BUS A CONNECTORS AND PIN ASSIGNMENTS

UTILITY I/F PANEL NATC07T15N35SA or 340105601B07-15-35SA 1553 BUS B	J4	P4	ISPR NATC06G15N35PA (NASA SSQ 21635) or 340105601B06-15-35PA (ESA SCC 3401/056)
APM MOD. SPEC. P/L BUS BIT 0 ADDRESS	1		
APM MOD. SPEC. P/L BUS BIT 1 ADDRESS	2		
APM MOD. SPEC. P/L BUS BIT 2 ADDRESS	3		
APM MOD. SPEC. P/L BUS BIT 3 ADDRESS	4		
APM MOD. SPEC. P/L BUS BIT 4 ADDRESS	5		
APM MOD. SPEC. P/L BUS PARITY	6		
APM MOD. SPEC. P/L BUS LOGIC GND	7		
SPARE	8		
JEM MOD. SPEC. P/L2 BUS BIT 0 ADDRESS	9		
JEM MOD. SPEC. P/L2 BUS BIT 1 ADDRESS	10		
JEM MOD. SPEC. P/L2 BUS BIT 2 ADDRESS	11		
JEM MOD. SPEC. P/L2 BUS BIT 3 ADDRESS	12		
JEM MOD. SPEC. P/L2 BUS BIT 4 ADDRESS	13		
JEM MOD. SPEC. P/L2 BUS PARITY	14		
JEM MOD. SPEC. P/L2 BUS LOGIC GND	15		
SPARE	16		
JEM MOD. SPEC. P/L4 BUS BIT 0 ADDRESS	17		
JEM MOD. SPEC. P/L4 BUS BIT 1 ADDRESS	18		
JEM MOD. SPEC. P/L4 BUS BIT 2 ADDRESS	19		
JEM MOD. SPEC. P/L4 BUS BIT 3 ADDRESS	20		
JEM MOD. SPEC. P/L4 BUS BIT 4 ADDRESS	21		
JEM MOD. SPEC. P/L4 BUS PARITY	22		
JEM MOD. SPEC. P/L4 BUS LOGIC GND	23		
SPARE	24		
APM MODULE SPECIFIC 1553B P/L BUS B-	25		
APM MODULE SPECIFIC 1553B P/L BUS B+	26		
JEM MODULE SPECIFIC P/L4 1553B BUS B-	27		
JEM MODULE SPECIFIC P/L4 1553B BUS B+	28		
JEM MODULE SPECIFIC P/L3 1553B BUS B-	29		
JEM MODULE SPECIFIC P/L3 1553B BUS B+	30		
SPARE	31		
JEM MODULE SPECIFIC P/L2 1553B BUS B-	32		
JEM MODULE SPECIFIC P/L2 1553B BUS B+	33		
JEM MODULE SPECIFIC P/L1 1553B BUS B-	34		
JEM MODULE SPECIFIC P/L1 1553B BUS B+	35		
STANDARD P/L 1553B BUS B- (USL)	36		
STANDARD P/L 1553B BUS B+ (USL)	37		

Note: Data buses are controlled impedance twisted shielded pairs with the shield terminated on the connector backshell.

Note: JEM module specific P/L bus interfaces are not applicable to the APM.
JEM module specific P/L2, P/L3, and P/L4 bus interfaces are not applicable to the USL.
JEM module specific P/L3 and P/L4 bus interfaces are applicable only to limited locations in the JEM.
APM module specific P/L bus interfaces are not applicable to the JEM and USL.

Note: Both the NASA SSQ21635 and ESA SCC3401/056 connectors are intermatable.

Note: The bus address logic ground will be connected to the ISPR Remote Terminal logic ground.

Note: Although APM is globally changed to COL throughout this document, for specific C&DH references APM is not being changed.

FIGURE N.3.1.1.8-3 UIP LOW RATE DATA 1553B BUS B CONNECTOR AND PIN ASSIGNMENTS

ISS NATC07T11N35SA or 340105601B07-11-35SA	J46	P46	ISPR NATC06G11N35PA or 340105601B06G-11-35PA
SPARE	1	1	
Receive Data + from APM LAN-1 (CLSW1)	2	2	
Receive Data - from APM LAN-1 (CLSW1)	3	3	
Receive Data – from USL LAN-1	4	4	
SPARE	5	5	
SPARE	6	6	
SPARE	7	7	
Transmit Data – to USL LAN-1	8	8	
SPARE	9	9	
Transmit Data + to APM LAN-1 (CLSW1)	10	10	
Transmit Data - to APM LAN-1 (CLSW1)	11	11	
Receive Data + from USL LAN-1	12	12	
Transmit Data + to USL LAN-1	13	13	

Note: Interface to the APM LAN-1 for ESA use only. Interface only applicable to the APM. Interface to USL LAN-1 not applicable to the APM.

FIGURE N.3.1.1.8-4 UIP MEDIUM RATE DATA USL LAN-1 CONNECTOR AND PIN ASSIGNMENTS

ISS NATC07T11N35SB or 340105601B07-11-35SB	J47	P47	ISPR NATC06G11N35PB (NASA SSQ 21635) or 340105601B06G-11-35PB
SPARE	1	1	
Receive Data + from APM LAN-2 (CLSW2)	2	2	
Receive Data – from APM LAN-2 (CLSW2)	3	3	
Receive Data – from USL/JEM/APM LAN-2	4	4	
SPARE	5	5	
SPARE	6	6	
SPARE	7	7	
Transmit Data – to USL/JEM/APM LAN-2	8	8	
SPARE	9	9	
Transmit Data + to APM LAN-2 (CLSW2)	10	10	
Transmit Data - to APM LAN-2 (CLSW2)	11	11	
Receive Data + from USL/JEM/APM LAN-2	12	12	
Transmit Data + to USL/JEM/APM LAN-2	13	13	

Note: Interface to the APM LAN-2 for ESA use only. Interface only applicable to the APM.

FIGURE N.3.1.1.8-5 UIP MEDIUM RATE DATA USL/JEM/APM LAN-2 CONNECTOR AND PIN ASSIGNMENTS

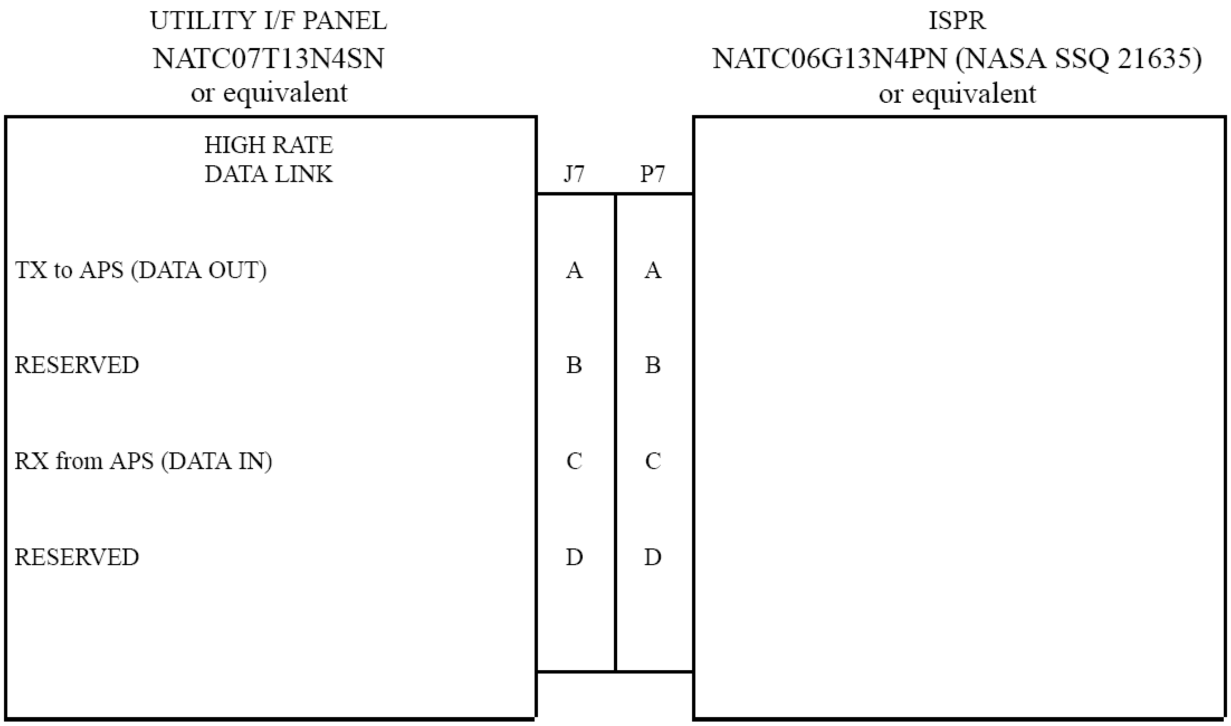


FIGURE N.3.1.1.8-6 UIP HIGH RATE DATA CONNECTOR AND PIN ASSIGNMENTS

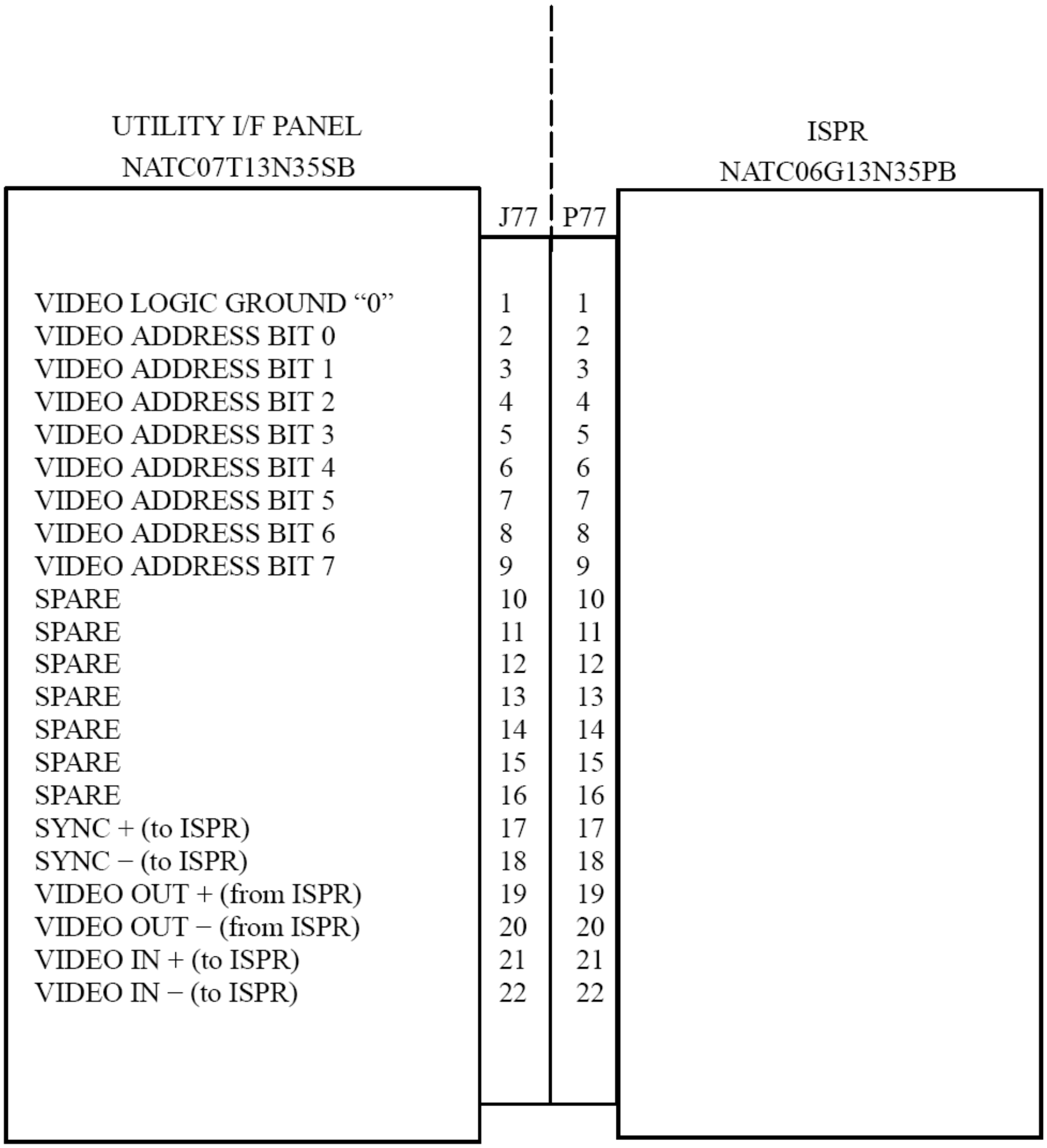
UTILITY I/F PANEL NATC07T13N35SA or 340105601B07−13−35SAB01 MAINTENANCE SWITCH/FIRE DETECTION SUPPORT INTERFACE	J43	P43	ISPR NATC06G13N35PA 340105601B06−13−35PAB01
SMOKE DET SCATTER −	1	1	
SPARE	2	2	
SPARE	3	3	
SPARE	4	4	
SPARE	5	5	
SPARE	6	6	
SPARE	7	7	
SPARE	8	8	
SPARE	9	9	
SPARE	10	10	
SPARE	11	11	
FAN VENTILATION IND +	12	12	
FAN VENTILATION IND −	13	13	
SMOKE DET SCATTER +	14	14	
SMOKE IND CMD −	15	15	
SMOKE DET OBSCURATION +	16	16	
SMOKE DET OBSCURATION −	17	17	
SMOKE DET BIT ENABLE −	18	18	
PWR REMOVAL SWITCH POSITION −	19	19	
PWR REMOVAL SWITCH POSITION +	20	20	
SMOKE IND CMD +	21	21	
SMOKE DET BIT ENABLE +	22	22	

FIGURE N.3.1.1.8-7 UIP FIRE DETECTION SUPPORT AND RACK MAINTENANCE SWITCH SIGNAL CONNECTOR AND PIN ASSIGNMENTS

UTILITY I/F PANEL NATC07T15N97SB or 340105601B07-15-97SB			ISPR NATC06G15N97PB or 340105601B07-15-97PB
VIDEO/SYNC	J16	P16	
VIDEO ADDRESS BIT 0	A		
VIDEO ADDRESS BIT 1	B		
SYNC	C		
VIDEO ADDRESS BIT 2	D		
VIDEO ADDRESS BIT 3	E		
VIDEO ADDRESS BIT 4	F		
VIDEO LOGIC GROUND "0"	G		
VIDEO ADDRESS BIT 5	H		
VIDEO ADDRESS BIT 6	J		
VIDEO ADDRESS BIT 7	K		
VIDEO LINE 01 [1)]	L		
VIDEO LINE 02 [1)]	M		

Note 1: Video address is ISPR module location unique.
Note 2: Video Line 01 for USL: Video into VSU
for COL: Video from/to VDPU
Video Line 02 for USL: Video from VSU
for COL: Video from/to VDPU

FIGURE N.3.1.1.8-8 UIP OPTICAL VIDEO CONNECTOR AND PIN ASSIGNMENTS



Note: J77 is available in the JEM only.

FIGURE N.3.1.1.8-9 UIP ELECTRICAL VIDEO CONNECTOR AND PIN ASSIGNMENTS

N.3.1.2 MICROGRAVITY

Microgravity requirements limit the disturbing effects of integrated racks and non-rack payloads on the microgravity environment. The requirements are separated into the quasi-steady category (frequencies below 0.01 Hz), the vibratory category (frequencies between 0.01 Hz and 300 Hz), and the transient category. For integrated racks, the interface points are the locations on the ISS structure where rack attachment brackets or isolation systems connect to the ISS.

N.3.1.2.1 QUASI-STEADY REQUIREMENTS

For frequencies below 0.01 Hz, integrated racks and non-rack payloads *should* limit unbalanced translational average impulse to generate less than 10 lb·s (44.5 N·s) within any 10 to 500 second period, along any ISS coordinate system vector.

N.3.1.2.2 VIBRATORY REQUIREMENTS

Racks without ARIS and ARIS racks not actively isolating **shall** limit produced forces to the values shown in Table N.3.1.2.2–1 (Figure N.3.1.2.2–1) or the acceleration limits in Table N.3.1.2.2-2 (Figure N.3.1.2.2-2).

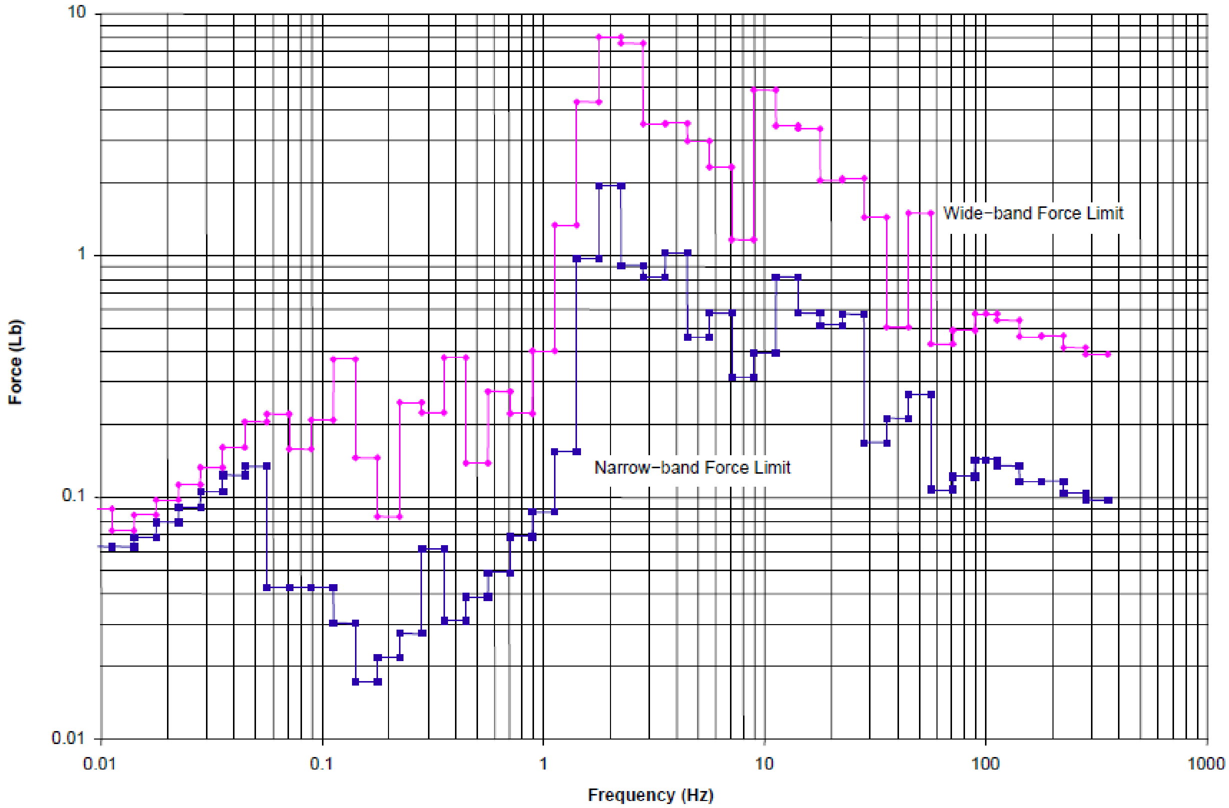


FIGURE N.3.1.2.2-1 ALLOWABLE ONE−THIRD OCTAVE INTERFACE FORCES FOR INTEGRATED RACKS AND NON−RACK PAYLOADS, 0.5% DAMPING FACTOR

TABLE N.3.1.2.2-1 ALLOWABLE INTEGRATED RACK NARROW-BAND ENVELOPE AND WIDEBAND INTERFACE FORCE VALUES FOR ISPRS, 0.5% DAMPING FACTOR

Freq (Hz)	NB lb f	WB Lb f	Freq (Hz)	NB lb f	WB Lb f	Freq (Hz)	NB lb f	WB Lb f
0.008913	0.06261	0.089635	0.3548	0.061482	0.224779	11.22	0.817148	3.451307
0.01122	0.06261	0.089635	0.3548	0.030924	0.378806	14.13	0.817148	3.451307
0.01122	0.06261	0.073218	0.4467	0.030924	0.378806	14.13	0.579786	3.358266
0.01413	0.06261	0.073218	0.4467	0.038934	0.138909	17.78	0.579786	3.358266
0.01413	0.068172	0.084667	0.5623	0.038934	0.138909	17.78	0.516921	2.048448
0.01778	0.068172	0.084667	0.5623	0.04901	0.274588	22.39	0.516921	2.048448
0.01778	0.079202	0.097495	0.7079	0.04901	0.274588	22.39	0.57451	2.091627
0.02239	0.079202	0.097495	0.7079	0.06922	0.222568	28.18	0.57451	2.091627
0.02239	0.091377	0.112968	0.8913	0.06922	0.222568	28.18	0.168996	1.443748
0.02818	0.091377	0.112968	0.8913	0.087153	0.404688	35.48	0.168996	1.443748
0.02818	0.105641	0.133067	1.122	0.087153	0.404688	35.48	0.212776	0.50643
0.03548	0.105641	0.133067	1.122	0.154561	1.337042	44.67	0.212776	0.50643
0.03548	0.123739	0.161094	1.413	0.154561	1.337042	44.67	0.267886	1.498072
0.04467	0.123739	0.161094	1.413	0.976353	4.322593	56.23	0.267886	1.498072
0.04467	0.134457	0.205508	1.778	0.976353	4.322593	56.231	0.10793	0.431721
0.05623	0.134457	0.205508	1.778	1.953413	8.01995	70.79	0.10793	0.431721
0.05623	0.042699	0.22137	2.239	1.953413	8.01995	70.791	0.122491	0.489965
0.07079	0.042699	0.22137	2.239	0.915835	7.567684	89.13	0.122491	0.489965
0.07079	0.042699	0.158917	2.818	0.915835	7.567684	89.131	0.143827	0.575309
0.08913	0.042699	0.158917	2.818	0.818034	3.504552	100	0.143827	0.575309
0.08913	0.042699	0.2093	3.548	0.818034	3.504552	112.2	0.143827	0.575309
0.1122	0.042699	0.2093	3.548	1.029953	3.531682	112.2	0.135367	0.541469
0.1122	0.030213	0.373089	4.467	1.029953	3.531682	141.3	0.135367	0.541469
0.1413	0.030213	0.373089	4.467	0.460611	2.979207	141.3	0.115819	0.463274
0.1413	0.017289	0.146008	5.623	0.460611	2.979207	177.8	0.115819	0.463274
0.1778	0.017289	0.146008	5.623	0.579824	2.330438	177.8	0.116941	0.467763
0.1778	0.021755	0.083429	7.079	0.579824	2.330438	223.9	0.116941	0.467763
0.2239	0.021755	0.083429	7.079	0.315606	1.16448	223.9	0.104363	0.417452
0.2239	0.027396	0.24715	8.913	0.315606	1.16448	281.8	0.104363	0.417452
0.2818	0.027396	0.24715	8.913	0.39737	4.848007	281.8	0.097688	0.390751
0.2818	0.061482	0.224779	11.22	0.39737	4.848007	354.8	0.097688	0.390751

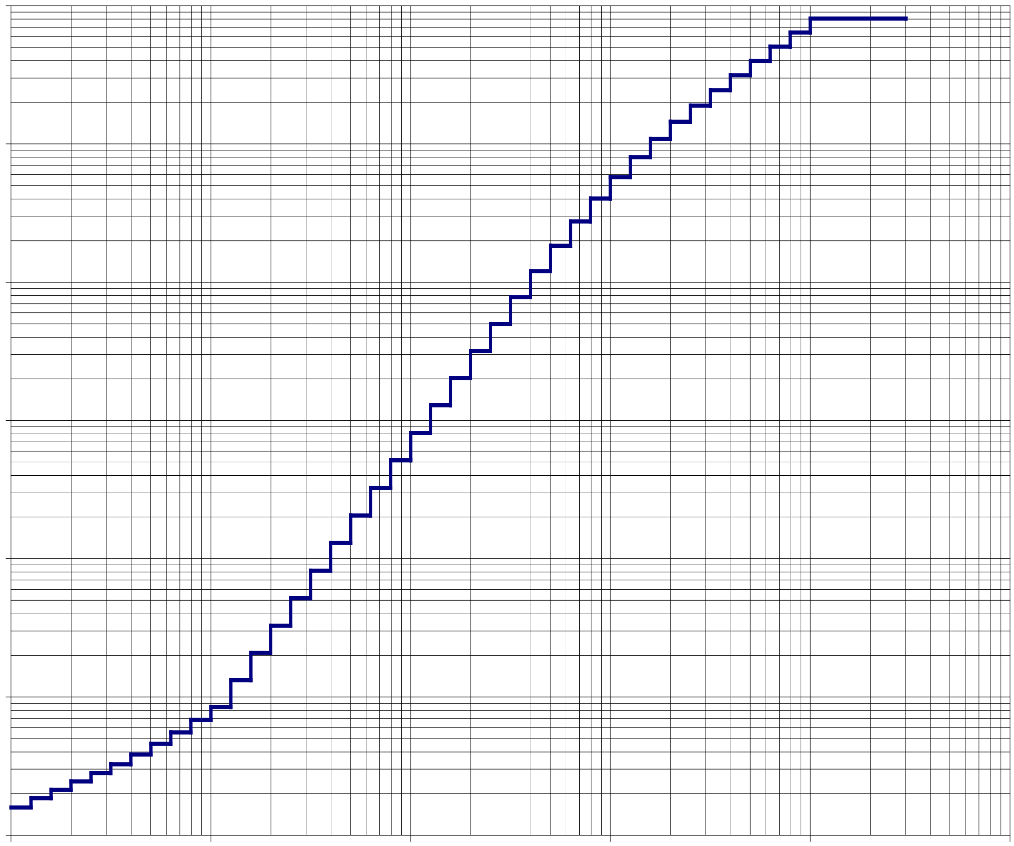


FIGURE N.3.1.2.2-2 NON−ARIS TO ARIS ACCELERATION LIMIT ALTERNATIVE TO FORCE LIMITS

TABLE N.3.1.2.2-2 NON-ARIS INTEGRATED RACK TO ARIS ACCELERATION LIMIT ALTERNATIVE TO FORCE LIMITS

Freq	Accel Limit (ug)	Freq	Accel Limit (ug)	Freq	Accel Limit (ug)
0.0089	0.159	0.226	5.18	5.74	2746
0.0112	0.159	0.285	5.18	7.23	2746
0.0112	0.185	0.285	8.19	7.23	4026
0.0141	0.185	0.359	8.19	9.11	4026
0.0141	0.213	0.359	12.97	9.11	5758
0.0178	0.213	0.452	12.97	11.48	5758
0.0178	0.244	0.452	20.53	11.48	8021
0.0224	0.244	0.570	20.53	14.47	8021
0.0224	0.281	0.570	32.49	14.47	10898
0.0283	0.281	0.718	32.49	18.23	10898
0.0283	0.325	0.718	51.42	18.23	14495
0.0356	0.325	0.904	51.42	22.96	14495
0.0356	0.383	0.904	81.33	22.96	18956
0.0449	0.383	1.139	81.33	28.93	18956
0.0449	0.458	1.139	128.51	28.93	24483
0.0565	0.458	1.435	128.51	36.45	24483
0.0565	0.556	1.435	202.73	36.45	31346
0.0712	0.556	1.808	202.73	45.93	31346
0.0712	0.682	1.808	318.99	45.93	39894
0.0897	0.682	2.278	318.99	57.87	39894
0.0897	0.843	2.278	499.90	57.87	50578
0.1130	0.843	2.871	499.90	72.91	50578
0.1130	1.322	2.871	778.69	72.91	63958
0.1424	1.322	3.617	778.69	91.86	63958
0.1424	2.079	3.617	1202.18	91.86	80751
0.1794	2.079	4.557	1202.18	100.00	80751
0.1794	3.280	4.557	1832.55	300.00	80751
0.2260	3.280	5.741	1832.55		

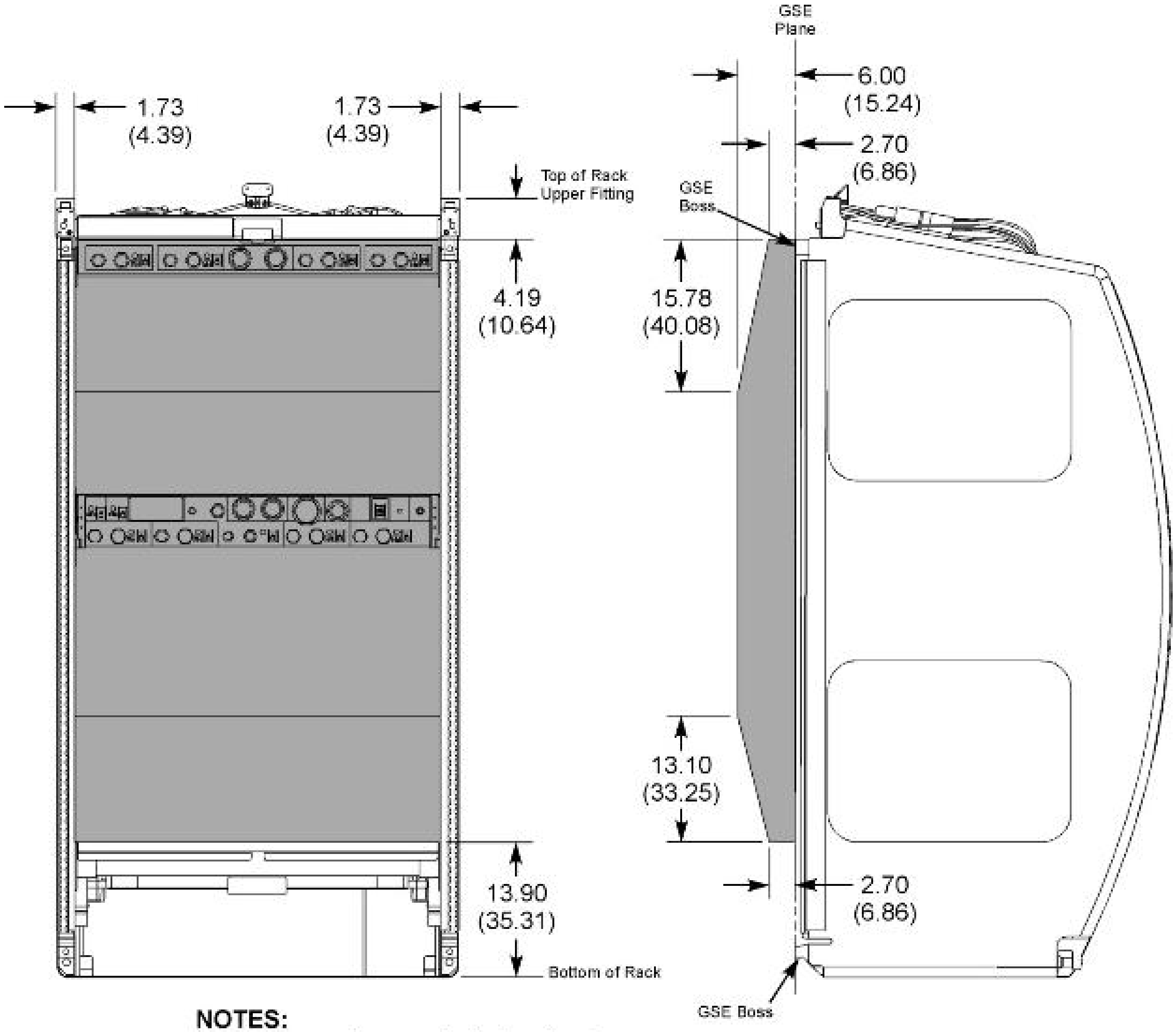
N.3.1.2.3 TRANSIENT REQUIREMENTS

Payloads that generate a microgravity disturbance **shall** limit force applied to the ISS over any ten-second period to an impulse of no greater than 10 lb·s (44.5 N·s).

N.3.1.3 PROTRUSION REQUIREMENTS

Payload permanent hardware **shall** not extend beyond the integrated rack GSE plane. The GSE plane is a reference plane that is defined by the front surface of the four rack GSE bosses as shown in Figure N.3.1.3-1. A permanent protrusion is a payload hardware item which is never intended to be removed.

Note: ISIS drawer handles are exempt from this requirement.



NOTES:
1. All dimensions are in inches (cm).
2. If Payload protrusions are designed to this envelope they will generally be unaffected by rack rotation and remain clear of translation paths.
3. JPM1A1 and JPM1F1 cannot accommodate temporary protrusions due to the interference with the Intermodule Ventilation (IMV) function.

FIGURE N.3.1.3-1 GSE PLANE AND RECOMMENDED NON-PERMANENT PROTRUSIONS ENVELOPE

N.3.2 ELECTRICAL INTERFACE REQUIREMENTS

N.3.2.1 ELECTRICAL POWER CHARACTERISTICS

Electrical power characteristics are specified in this section for Interface B electrical power. Integrated racks connected to UIPs in the USL, JEM, and COL are required to be compatible with the prescribed characteristics of the EPS. For purposes of this document, compatibility is defined as operating without producing an unsafe condition or one that could result in damage to ISS equipment or payload hardware.

N.3.2.1.1 INTERFACE B STEADY-STATE VOLTAGE CHARACTERISTICS

The ISS will provide the Interface B steady-state voltage limits of 116 to 126 Vdc.

N.3.2.1.2 RIPPLE VOLTAGE CHARACTERISTICS

N.3.2.1.2.1 RIPPLE VOLTAGE AND NOISE

The integrated rack connected to Interface B **shall** operate and be compatible with the EPS time domain ripple voltage and noise level of 2.5 Vrms maximum within the frequency range of 30 Hz to 1 MHz.

N.3.2.1.2.2 RIPPLE VOLTAGE SPECTRUM

The Integrated rack connected to Interface B **shall** operate and be compatible with the EPS ripple voltage spectrum as shown in Figure N.3.2.1.2.2-1.

Note: This limit is 6 dB below the EMC CS-01, CS-02 requirement in SSP 30237, Space Station Electromagnetic Emission and Susceptibility Requirements, up to 30 MHz.

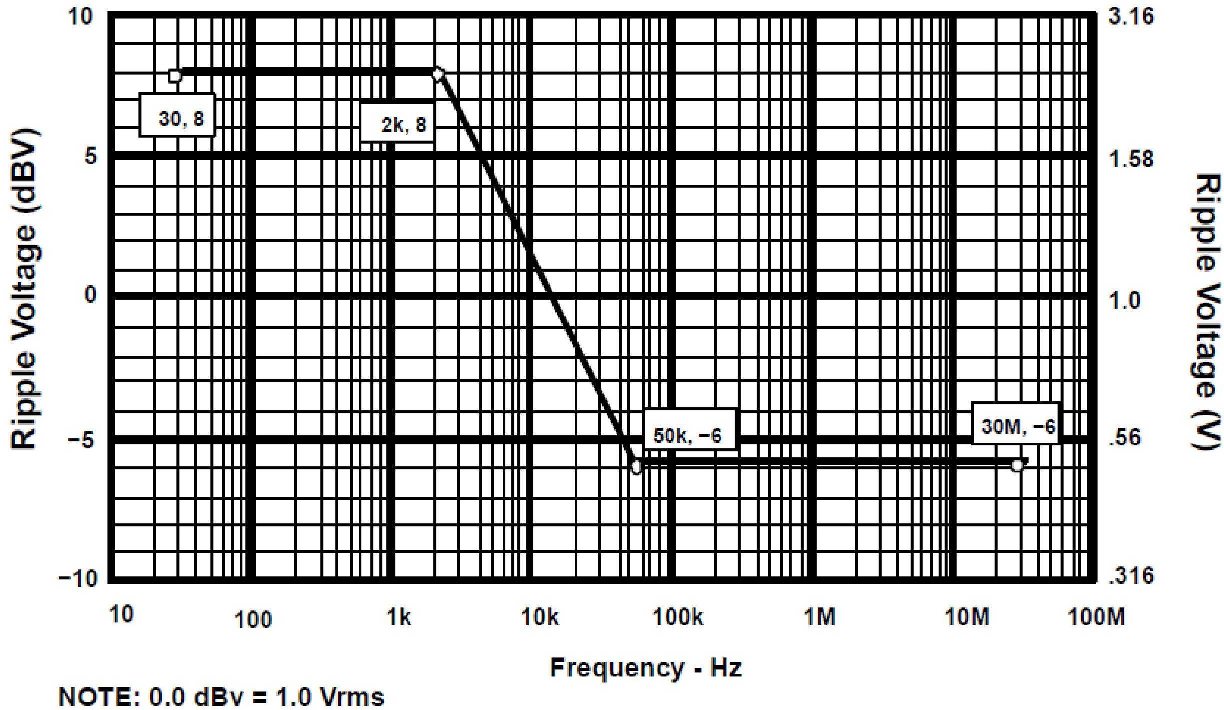


FIGURE N.3.2.1.2.2-1 MAXIMUM INTERFACES B AND C RIPPLE VOLTAGE SPECTRUM

N.3.2.1.3 TRANSIENT VOLTAGES

N.3.2.1.3.1 INTERFACE B

The integrated rack at Interface B **shall** operate and be compatible with the limits of magnitude and duration for the voltage transients at Interface B as shown in Figure N.3.2.1.3.1-1. The envelope shown in this figure applies to the transient responses exclusive of any periodic ripple and/or random noise components that may be present.

Note: Columbus EPS transients less than 100 microseconds are defined in COL-ESA-RQ-014, Columbus EMC & Power Quality Requirements, Paragraphs 4.1.5.3 and 4.1.7.2 (in compliance with CS06 requiring a 10 microsecond pulse injection). Payloads meeting CS06 requirements in SSP 30237 are in compliance with the Columbus requirements.

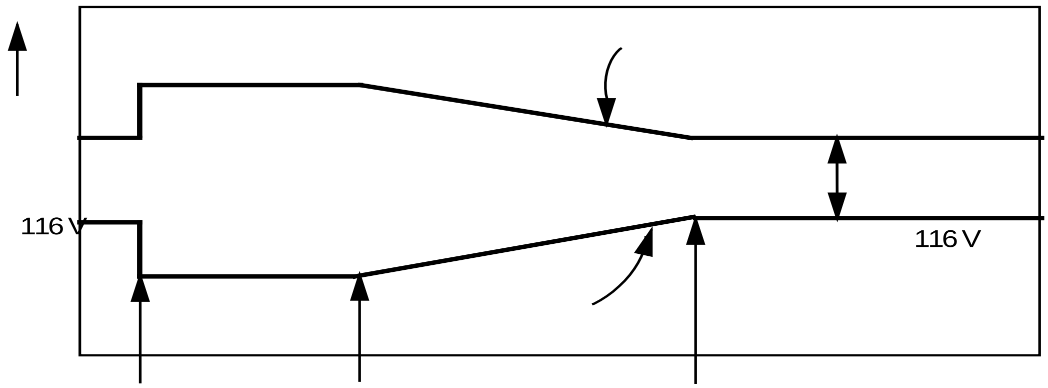


FIGURE N.3.2.1.3.1-1 INTERFACE B VOLTAGE TRANSIENTS

N.3.2.1.3.2 FAULT CLEARING AND PROTECTION

The integrated rack connected to either Interface B *should* not be damaged by transient voltage conditions that are within the limits shown in Figure N.3.2.1.3.2-1. Loads may be exposed to transient overvoltage conditions during operation of the power system's fault protection components.

Note: This requirement ensures payloads are not damaged by the transient over-voltage (300 microseconds) and under voltage (50 msec) in duration.

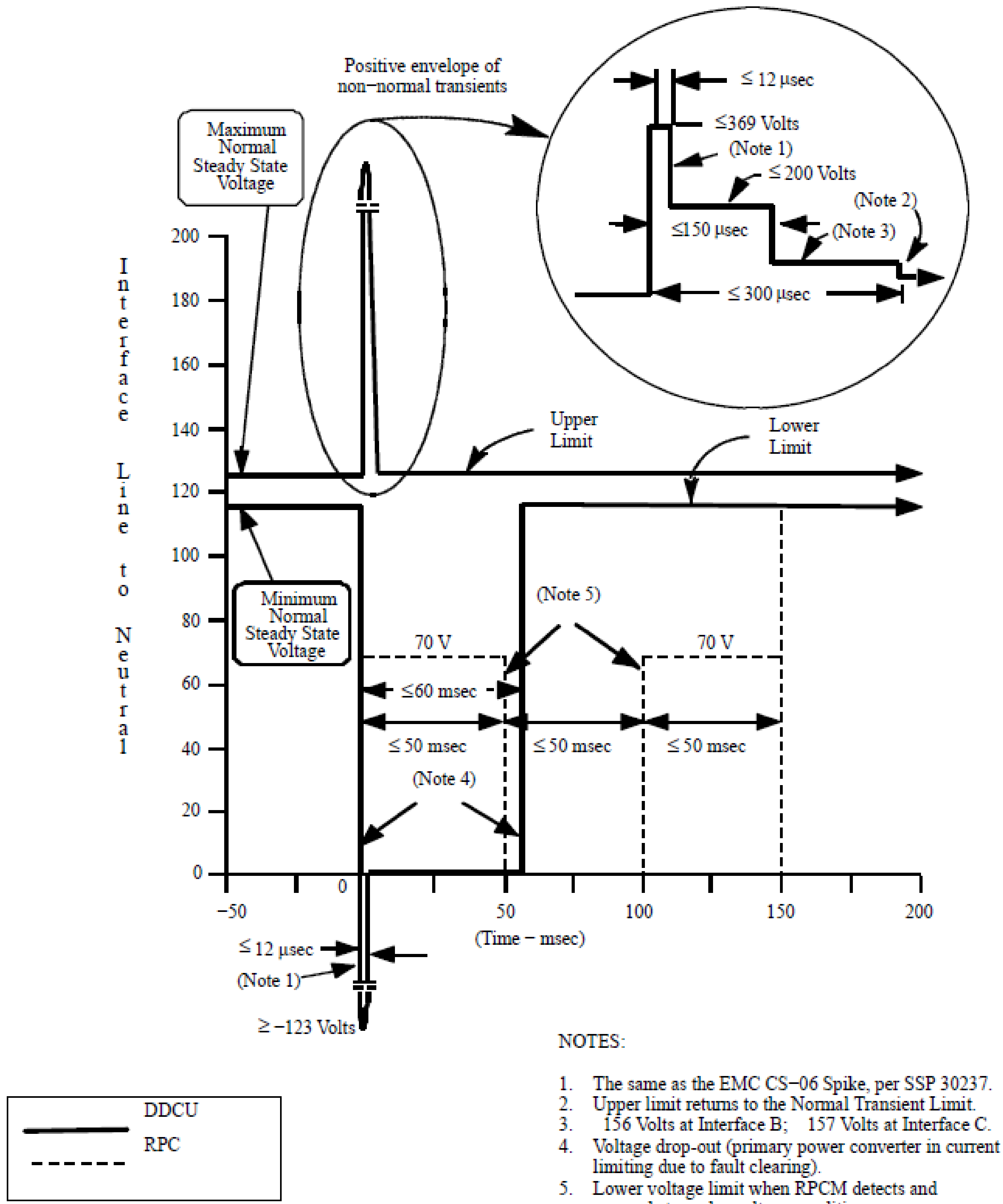


FIGURE N.3.2.1.3.2-1 FAULT CLEARING AND PROTECTION TRANSIENT LIMITS

N.3.2.1.3.3 NON-NORMAL VOLTAGE RANGE

The integrated rack connected to Interface B *should* not be damaged by a maximum overvoltage of +165 Vdc for 10 seconds and undervoltage conditions of +102 Vdc for an indefinite period of time.

Note: In this case, damage to the payload refers to the damage of the EMI filter and Power Converters as a result of overvoltage and undervoltage condition. For example, damage to the EMI filter may impact limiting emission and the immunity of equipment to electrical disturbances, and cannot shunt unwanted interference.

N.3.2.2 ELECTRICAL POWER INTERFACE

N.3.2.2.1 COMPATIBILITY WITH SOFT START/STOP RPC

An integrated rack connected to Interface B **shall** initialize with the soft start/stop performance characteristics when power is applied, sustained, and removed by control of remote power control switches. The soft start/stop function, active only when the RPC is commanded on or off, is limited to 100 A/ms, or less, by the RPC output. The response of the soft start/stop function is linear for resistive loads for 1 ms to 10 ms for USL feeds, 1.5 ms to 5 ms for JEM 50 A main feeds, 1.5 ms to 5 ms for JEM 25 A main feeds, and 0.1 ms to 5 ms for JEM 10 A auxiliary feeds between 10% and 90% of rated current level.

Notes:

1. Soft start/stop characteristics of U.S. standard RPCMs are shown in Figure N.3.2.2.1-1.
2. The Columbus SSPC has no soft start capability.

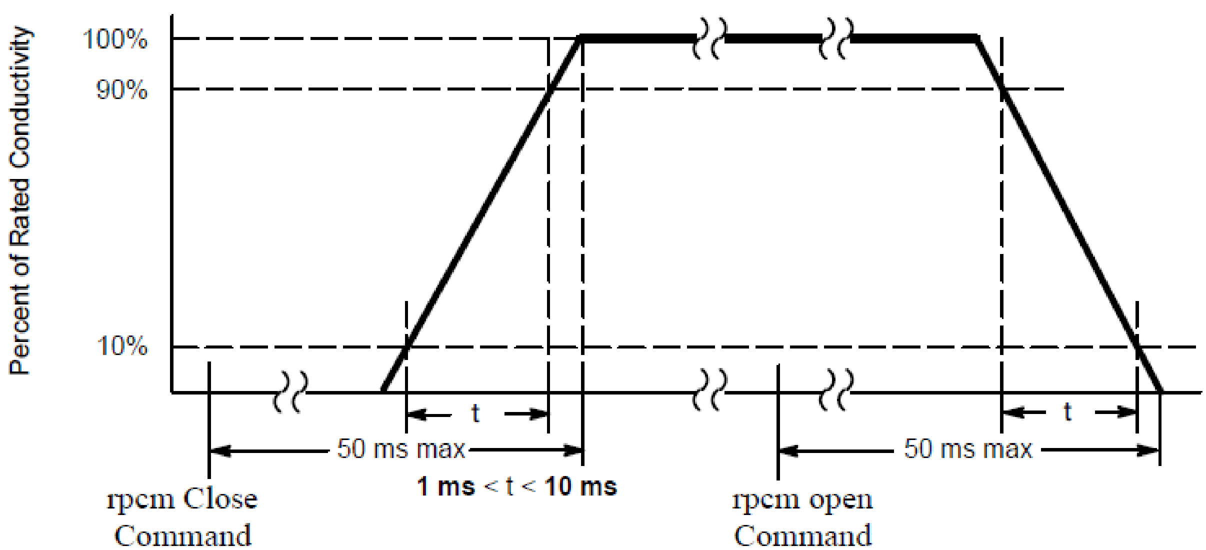


FIGURE N.3.2.2.1-1 U.S. RPCM SOFT START/STOP CHARACTERISTICS

N.3.2.2.2 SURGE CURRENT

The surge current at the power input to the integrated rack connected to Interface B **shall** not exceed a duration of 10 ms when powered from a voltage source with characteristics specified in section N.3.2.1 and Paragraph N.3.2.2.1, with the exception that the source impedance is considered to be 0.1 ohm. The duration of surge current is measured as the duration in which the current exceeds the maximum steady state input current derived from the payload maximum continuous power. These requirements apply to all operating modes and changes including power-up and power-down.

N.3.2.2.3 REVERSE CURRENT

Integrated rack payloads **shall** meet the reverse current requirements per paragraph G.3.2.2.2.

N.3.2.2.4 CIRCUIT PROTECTION DEVICES

N.3.2.2.4.1 REMOTE POWER CONTROLLER (RPC) CHARACTERISTICS

The ISS power source will provide protection to the rack interface for integrated rack overload conditions by means of a RPC. The overload limitation characteristics of the power feeders are defined in Figure N.3.2.2.4.1-1, Figure N.3.2.2.4.1-2, and Figure N.3.2.2.4.1-3. The curves define the region for RPCs connected to rack locations in the JEM, COL and USL Modules.

For current limiting switches, the shaded regions in the figures show the current limit regions from the time the protection devices start to control the current within the specified range, to the maximum time where the protection device trips and interrupts the current flow.

For non-current limiting switches, the shaded regions in the figure show the range of the over-current threshold from minimum trip decision time, to the maximum trip decision time.

Table N.3.2.2.4.1-1, Detailed Upstream Protection Characteristics, defines the characteristics of the RPCs.

USL: Rack locations are connected to non-current limiting RPCs for 3 kW and 6 kW feeds, and to current limiting RPCs for 1.44 kW (Auxiliary) feeds. Nominal current ratings are 25, 50, and 12 amperes respectively.

For the non-current limiting RPCs:

- A feeder current above the threshold at 500% to 600% of nominal rating for 0 μs to 10 μs will cause the RPC to trip
- A feeder current above the threshold at 190% to 210% of nominal rating for 1 ms to 2 ms will cause the RPC to trip.
- A feeder current above the threshold at 110% to 120% of nominal rating for 40 ms to 48 ms will cause the RPC to trip.

For the current limiting RPCs on the 1.44 kW feeds:

The current will be controlled to within the limiting level of 13.2 to 14.4 amperes within 1 millisecond. The RPC will trip if the current remains in the limiting region up to the decision time of 34.5 ±3.5 ms.

JEM: ISPR locations are connected to current limiting RPCs. A current level above its percent of the RPC nominal rating may cause the RPC to begin limiting the current. The limiting level will not exceed Ilu percent of the nominal RPC current rating. Current limiting will be within this region within 50 μs after the onset of an overcurrent condition. The RPC will trip, if the current limiting continues to the decision time from 6 ms to 20 ms. In addition, the RPC provides a trip threshold which will be within the decaying region shown from 20 ms to 500 ms after the overcurrent condition occurs. The RPC will trip if the overcurrent condition crosses the trip threshold. During this interval, Itu is the guaranteed trip level, and Itd is the guaranteed no-trip level. Nominal current ratings are shown in Figure N.3.2.2.4.1-2.

COL: All ISPR locations are connected to current limiting SSPCs. The SSPCs have no soft start capabilities. Current limit levels and trip times are defined in Table N.3.2.2.4.1-1. Trip coordination (selective protection) is achieved by utilization of payload-provided downstream protection devices with a current limit below the current limit region of the SSPCs or with a trip time of 1.5 ms to 3.5 ms. The SSPC will trip if overload is not removed before decision time.

TABLE N.3.2.2.4.1-1 DETAILED UPSTREAM PROTECTION CHARACTERISTICS

PWR Interface	Main PWR Feeder				
	Current Limitation Level		Minimum Trip Threshold	Trip Decision Time (1)	
	Min.	Max		Min.	Max.
3 kW ISPR					
COL	36.0 A	39.6 A	N/A	1.5 ms	3.5 ms
JEM	(2)	(2)	N/A	(2)	(2)
USL	N/A	N/A	27.5 A	40 ms	48 ms
6 kW ISPR					
COL	72.0 A	79.2 A	N/A	1.5 ms	3.5 ms
JEM	(3)	(3)	N/A	(3)	(3)
USL	N/A	N/A	55.0 A	40 ms	48 ms
12 kW ISPR					
USL FEED A/BUS 1	N/A	N/A	55.0 A	40 ms	48 ms
FEED B/BUS 2	N/A	N/A	55.0 A	40 ms	48 ms

PWR Interface	AUX PWR Feeder				
	Nom. Power	Current Limitation Level		Trip Decision Time (1)	
		Min.	Max	Min.	Max.
ISPR					
COL Lateral	1.2 kW	26.1 A	29.7 A	1.5 ms	3.5 ms
COL Overhead	1.2 kW	18.0 A	19. 8 A	1.5 ms	3.5 ms
JEM	1.2 kW	(4)	(4)	(4)	(4)
USL	1.44 kW	13.2 A	14.4 A	31 ms	38 ms

Notes:
(1) Trip decision time within range of min. and max. limiting/trip threshold
(2) See Figure N.3.2.2.4.1-2. Apply 25A RPC characteristics
(3) See Figure N.3.2.2.4.1-2. Apply 50A RPC characteristics
(4) See Figure N.3.2.2.4.1-2. Apply 25A RPC characteristics for JPM1F2, JPM1A5 and JPM1D4 locations and apply 10A RPC characteristics for the other locations.

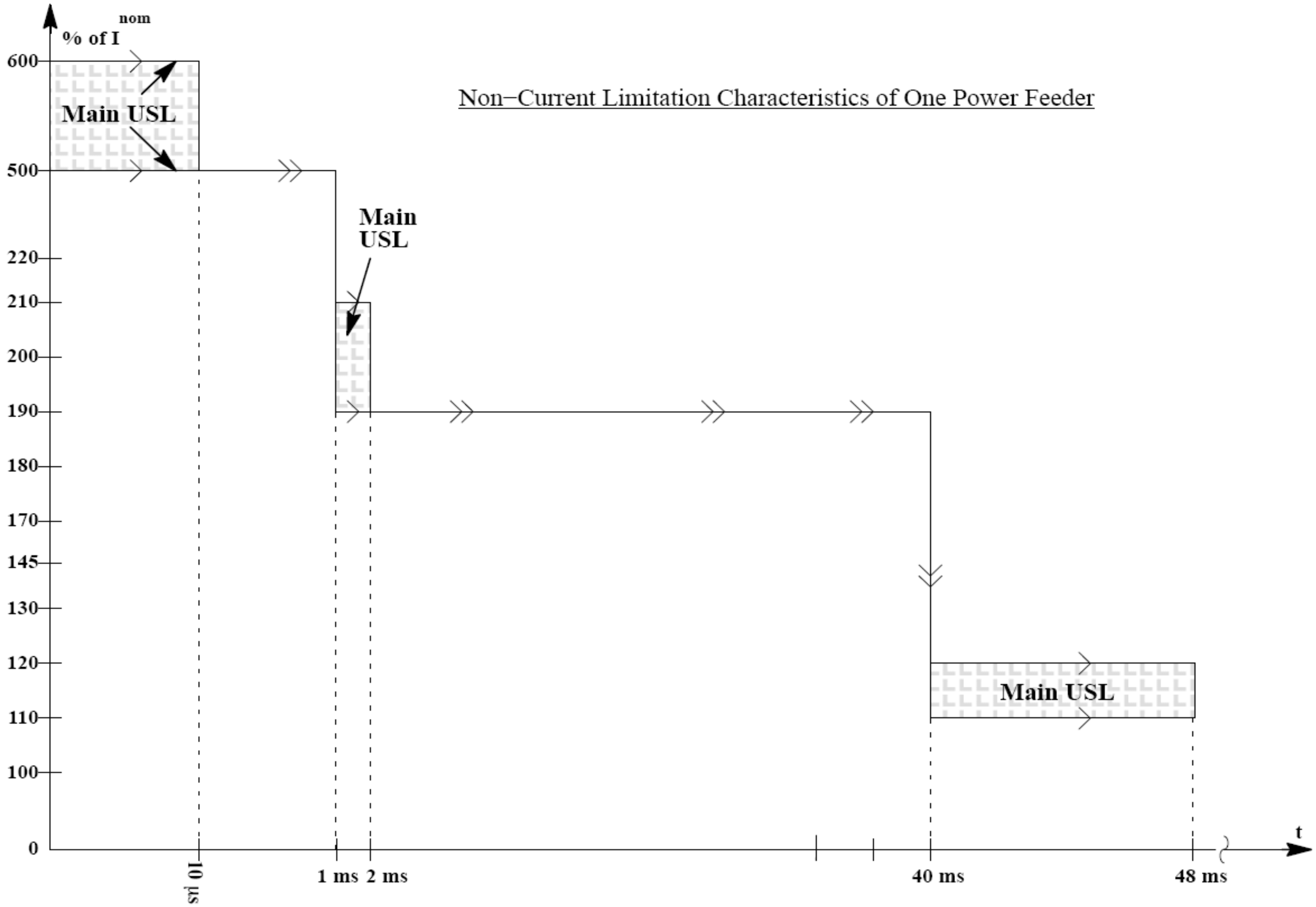
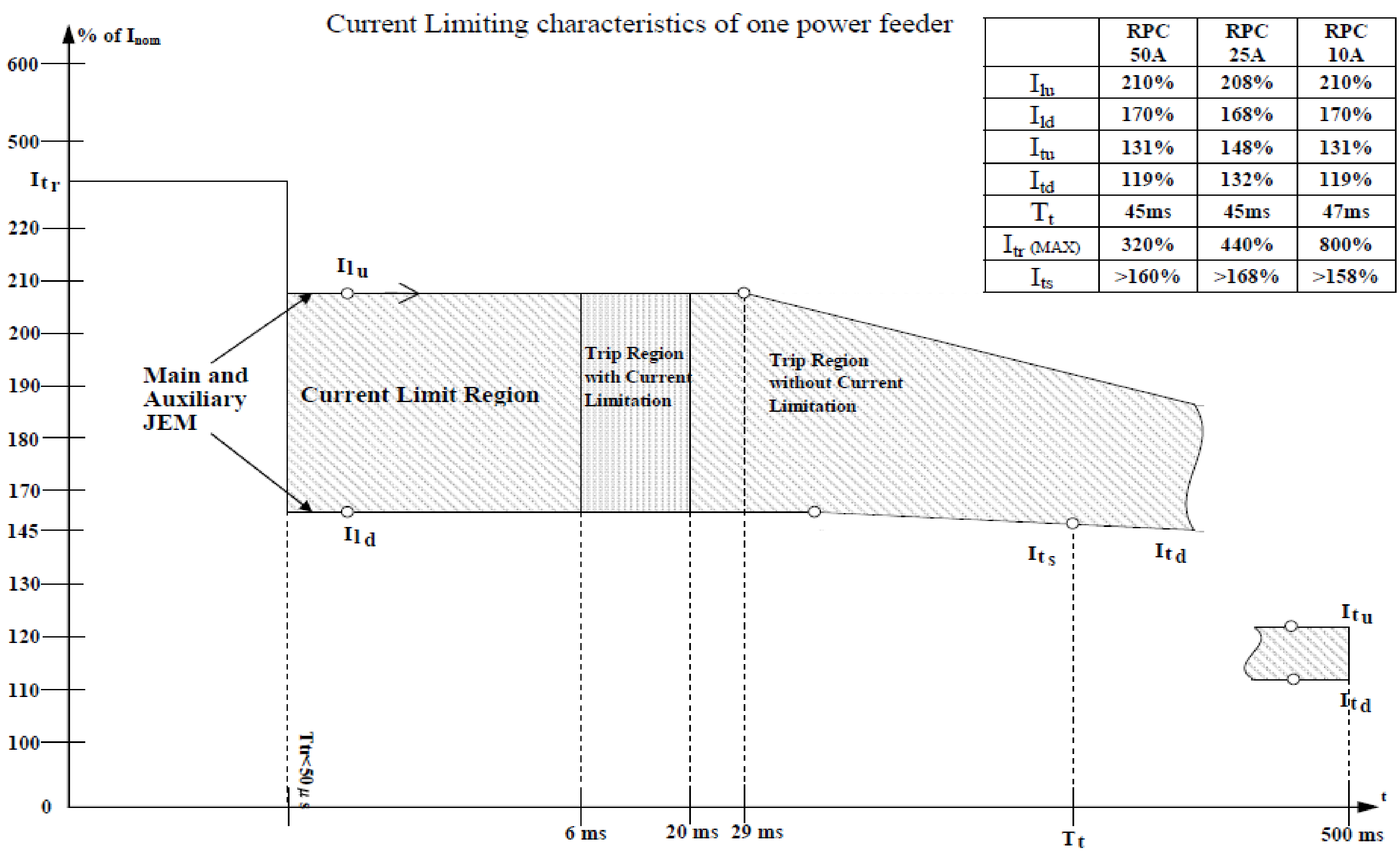
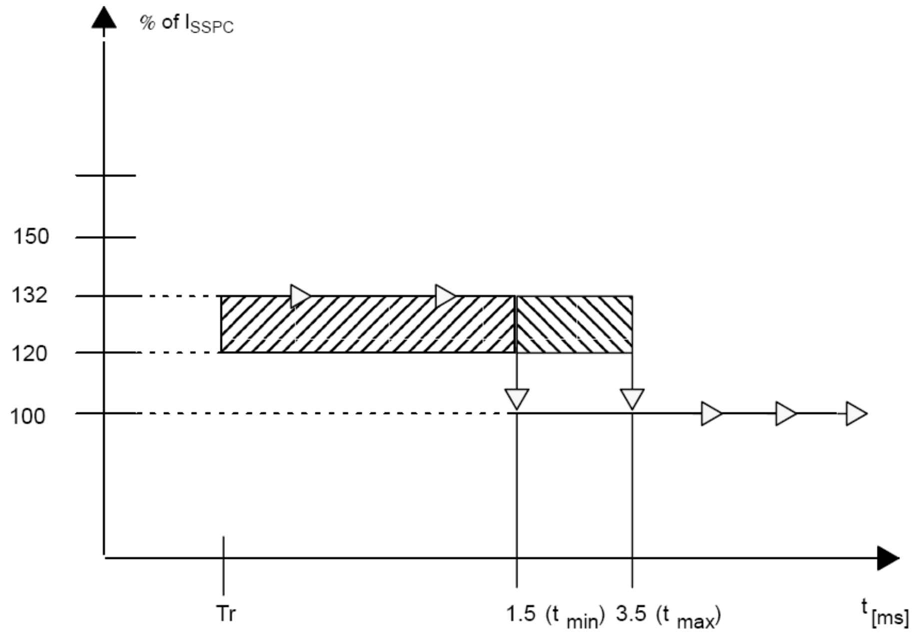


FIGURE N.3.2.2.4.1-1 USL OVERLOAD PROTECTION CHARACTERISTICS



	RPC 50A	RPC 25A	RPC 10A
I_{lu}	210%	208%	210%
I_{ld}	170%	168%	170%
I_{tu}	131%	148%	131%
I_{td}	119%	132%	119%
T_t	45ms	45ms	47ms
I_{tr} (MAX)	320%	440%	800%
I_{ts}	>160%	>168%	>158%

FIGURE N.3.2.2.4.1-2 JEM OVERLOAD PROTECTION CHARACTERISTICS



I_{SSPC} = 60 A for 6 kW main power feeder
= 30 A for 3 kW main power feeder
= 15 A for aux power feeder in overhead rack positions (O1 and O2)

Tr = Reaction time (duration not specified)

t_{min}, t_{max} = min/max triptime

FIGURE N.3.2.2.4.1-3 COL OVERLOAD PROTECTION CHARACTERISTICS

N.3.2.2.4.2 RPC INTERFACE REQUIREMENTS

A. The Integrated rack connected to an Interface B ISPR location **shall** operate with the characteristics shown in Figure N.3.2.2.4.1-1, Figure N.3.2.2.4.1-2, and Figure N.3.2.2.4.1-3 as described in Paragraph N.3.2.2.4.1.

B. The Integrated rack connected to Interface B **shall** provide current limiting overcurrent protection for all internal loads (exclusive of overcurrent protection circuits and devices) drawing power from an Interface B power feed. For the purpose of this requirement, internal overcurrent protection circuits and devices are not considered to be loads.

N.3.2.2.4.3 PAYLOAD TRIP COORDINATION WITH RPC

The payload power circuit protection device in the integrated rack connected to Interface B **shall** be designed to provide trip coordination, i.e., the downstream circuit protection device disconnects a shorted circuit or an overloaded circuit from the upstream power interface without tripping the upstream circuit protection device. The trip coordination is achieved either by shorter trip time or lower current limitation than the upstream protection devices defined in paragraph N.3.2.2.4.2.A.

N.3.2.2.5 INTERFACE B COMPLEX LOAD IMPEDANCES

The load impedance presented by the integrated rack connected to the Main Interface B **shall** be above the load impedance magnitude limit or within the phase limits defined by Figures N.3.2.2.5-1, N.3.2.2.5-2 and N.3.2.2.5-3 over the frequency range of 50 Hz to 100 kHz.

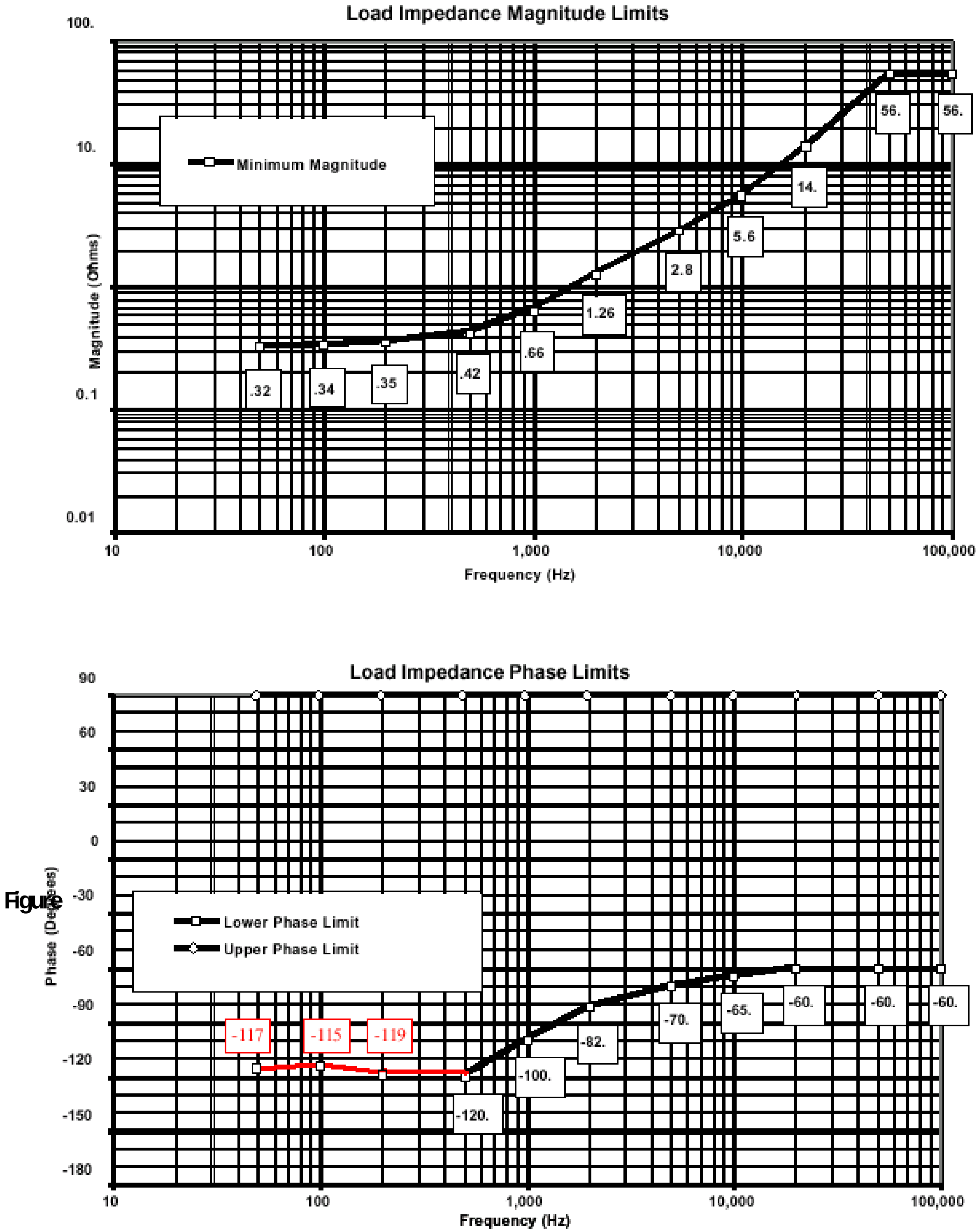
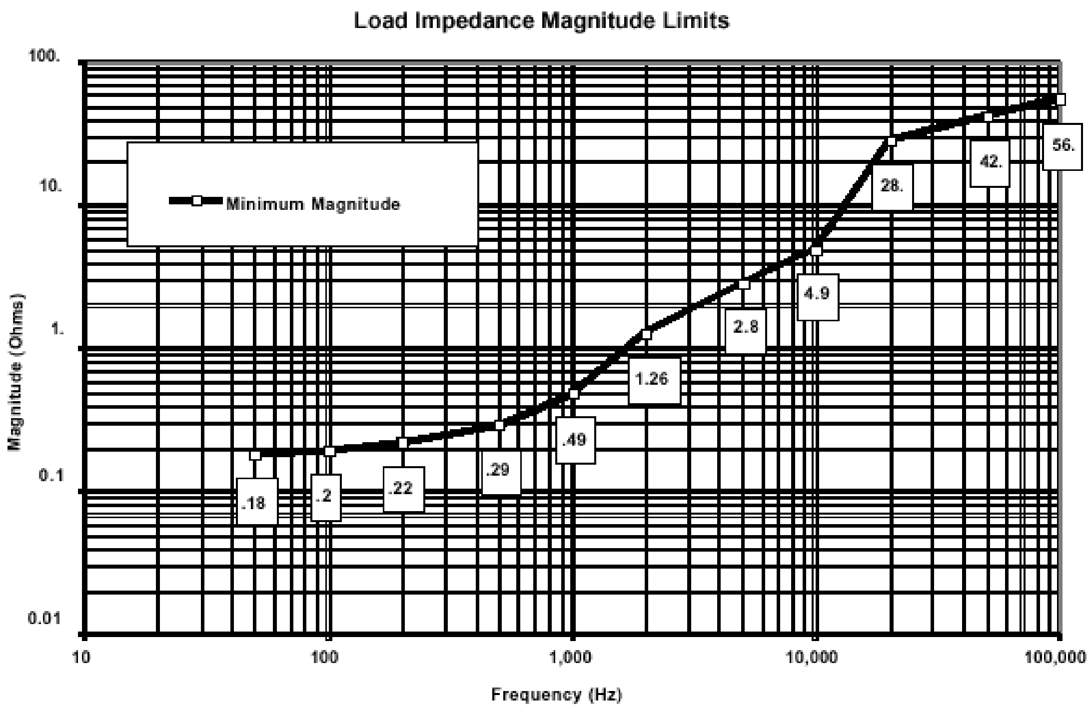


FIGURE N.3.2.2.5-1 3KW INTERFACE B LOAD IMPEDANCE LIMITS



Figure

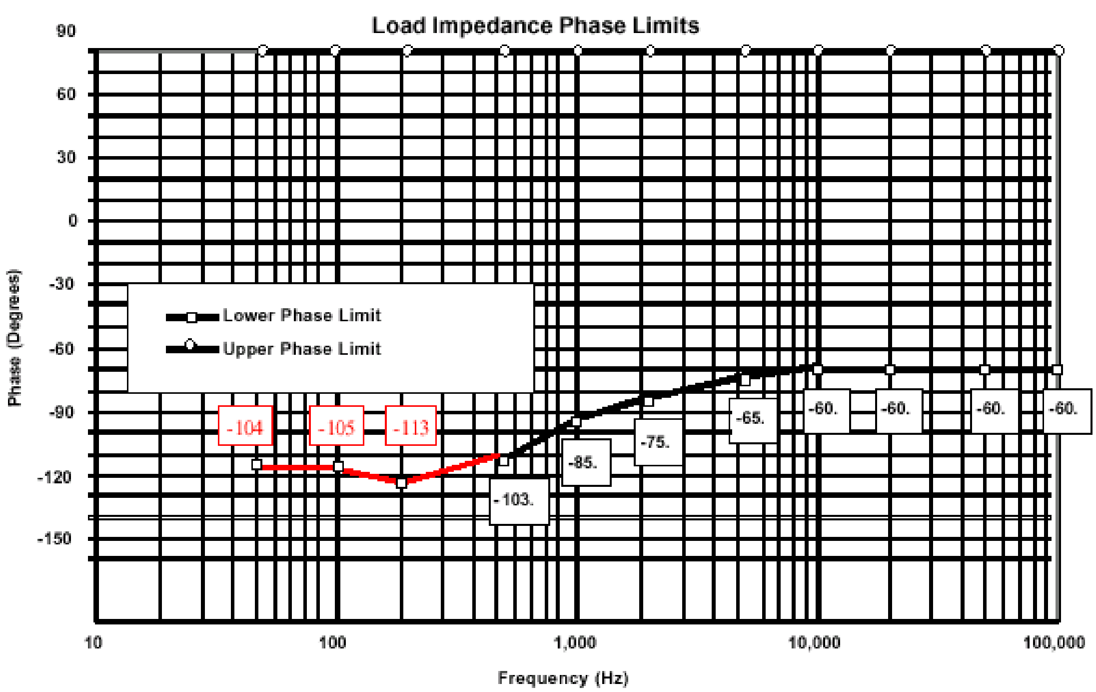
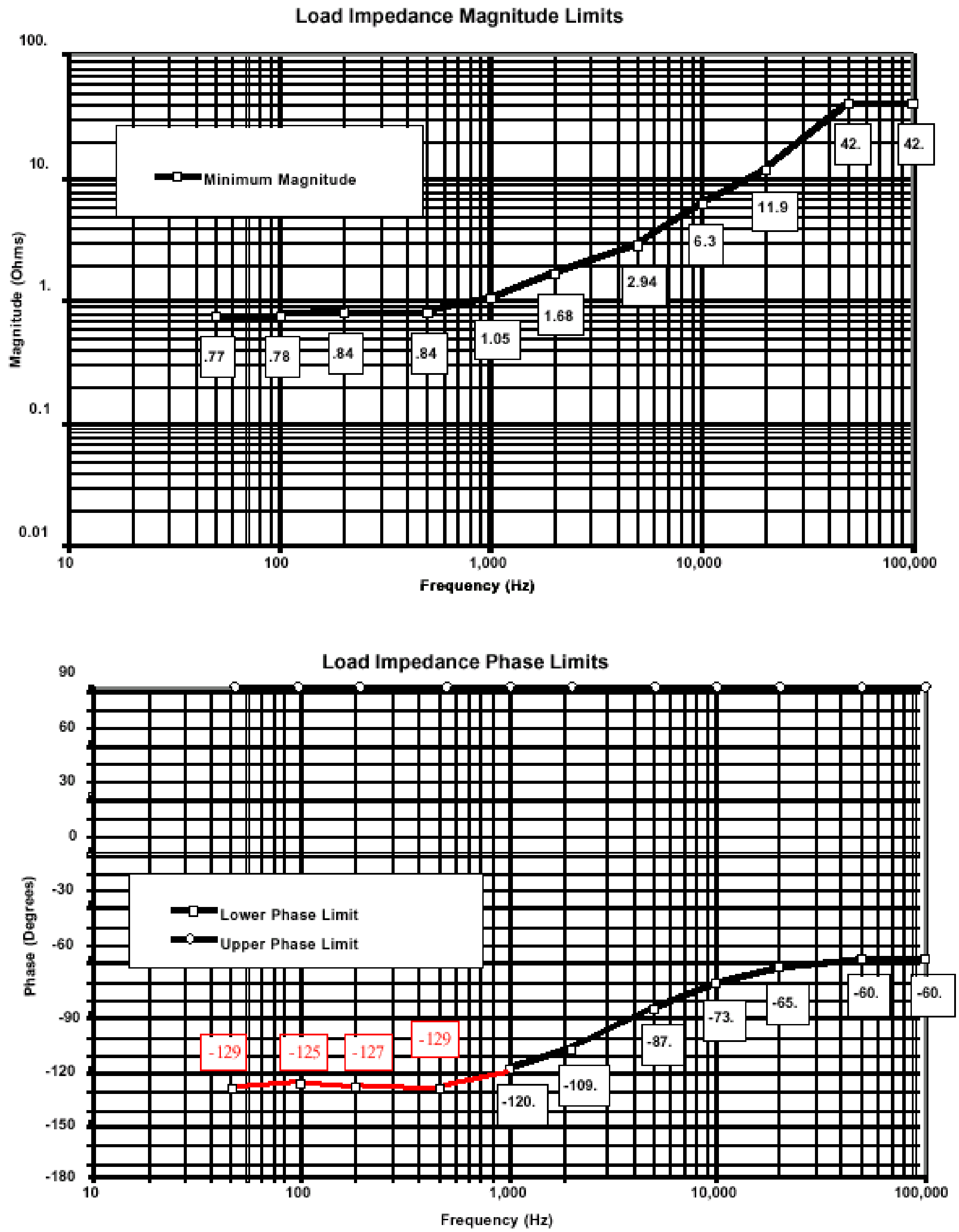


FIGURE N.3.2.2.5-2 6KW INTERFACE B LOAD IMPEDANCE LIMITS



Figure

FIGURE N.3.2.2.5-3 1.2 TO 1.44 KW AUXILIARY INTERFACE B LOAD IMPEDANCE LIMITS

N.3.2.2.6 LARGE SIGNAL STABILITY

The integrated rack connected to Interface B **shall** maintain stability with the ISS EPS interface by damping a transient response to 10 percent of the maximum response amplitude within 1.0 ms, and remaining below 10 percent thereafter under the following conditions:

1. The rise time/fall time (between 10% and 90% of the amplitude) of the input voltage pulse is less than 10 μs.
2. The voltage pulse is to be varied from 100 μs to 150 μs in duration.

Note: Figure N.3.2.2.6-1 is provided to clarify the above requirement.

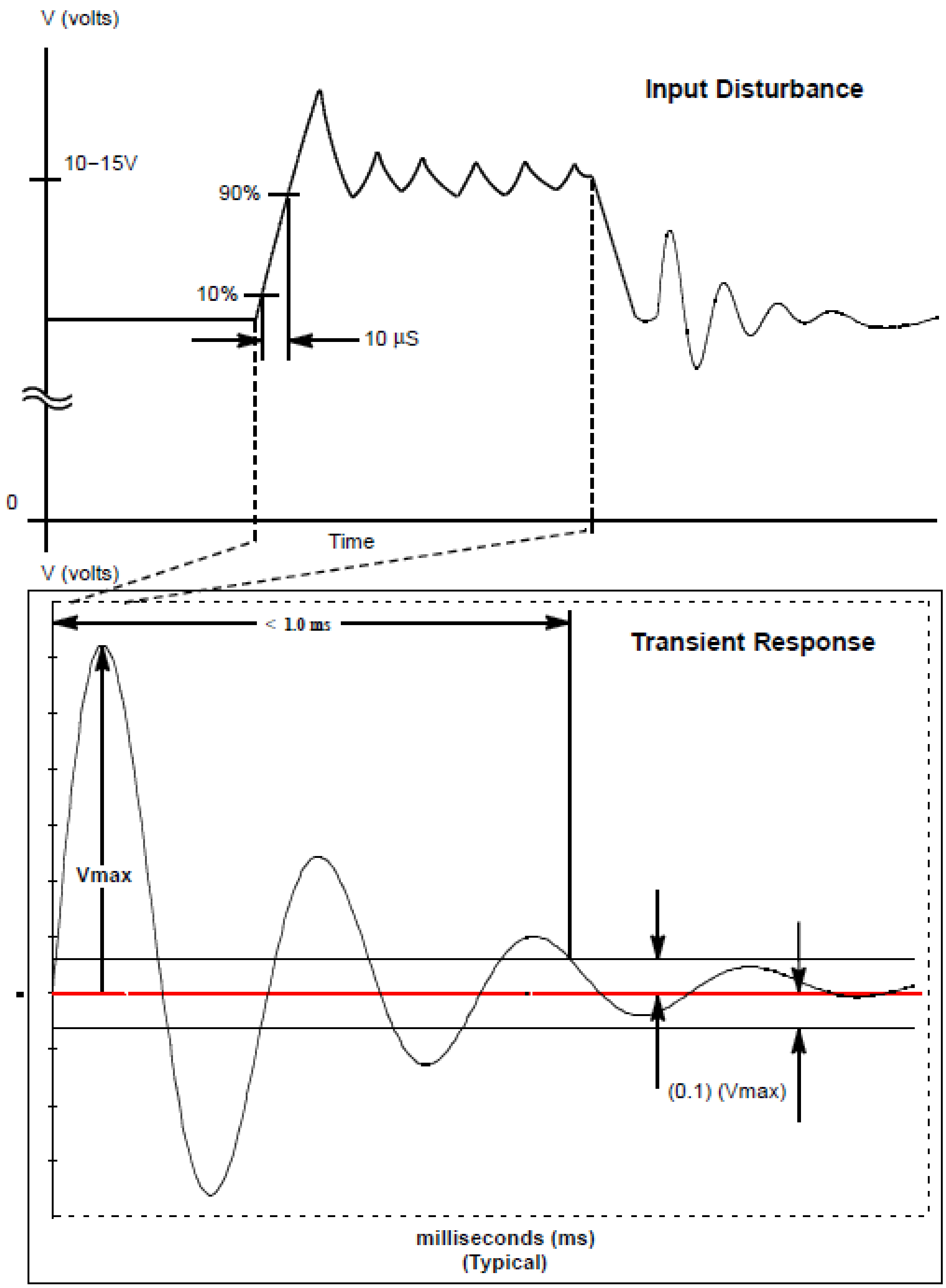


FIGURE N.3.2.2.6-1 PULSE APPLIED TO THE POWER INPUT OF THE INTEGRATED RACK OR EPCE

N.3.2.2.7 MAXIMUM LOAD STEP SIZE

For 6 kW and 12 kW racks, step changes in power demand by the integrated rack connected to Interface B **shall** not exceed 3 kW on a single power feed.

N.3.2.2.8 POWER OFF RESIDUAL VOLTAGE

After switching the module RPC into the "OFF" state, the module still provides a residual voltage at the integrated rack interface. Integrated racks that connect to Interface B *should* be compatible with the characteristics in Table N.3.2.2.8-1. Payloads utilizing a SSPCM are compatible with this requirement.

TABLE N.3.2.2.8-1 RESIDUAL VOLTAGE AND LEAKAGE CURRENT AT THE ISPR INTERFACE

	USL	COL	JEM
Residual Voltage in "OFF" State	≤ 10 V	≤ 11.8 V	≤ 6 V
Leakage Current	< 5 mA	< 5 mA	≤ 4 mA

N.3.2.2.8.1 INTEGRATED RACK WIRE SIZE FOR MAIN AND AUXILIARY POWER FEEDS

Integrated racks **shall** use 4 gauge wire for main and auxiliary connections at the UIP.

Note: General wire derating requirements, 3.2.1.2.2, are applicable for all other wiring applications.

N.3.2.2.9 RACK MAINTENANCE SWITCH (RACK POWER SWITCH)

A. The integrated rack **shall** provide a guarded, two-position, manually operated lever lock switch (Rack Maintenance Switch), compatible with the circuit characteristics in Table N.3.2.2.9-1, Bi-Level Data Characteristics (Switch Contact), that initiates the removal of power to the integrated rack, and is installed in a visible and accessible location on the front of the rack.

TABLE N.3.2.2.9-1 BI-LEVEL DATA CHARACTERISTICS (SWITCH CONTACT)

PARAMETER	ENG. UNIT	ISPR
Type Transfer		**Floating (Isolation resistance >1M□) dc coupled**
I/F Resistance (closed)	Ω	< 2.5
I/F Resistance (open)	MΩ	> 1
Open Circuit Leakage Current	mA	0 to 100
Operating Current (closed)	mA	0.2 to 30
Minimum Open Circuit Voltage	V	20

B. The Rack Maintenance Switch **shall** be wired such that the switch in the UP position provides a CLOSED circuit on the J43 connector pins 19 and 20.

C. The Rack Maintenance Switch, including the Smoke Indicator LED, **shall** be labeled with JSC 27260, Decal Process Document and Catalog, decal SDG32105718-001 or SDG32106318 with dash number as specified in Table N.3.2.2.9-2.

Note: The IPLAT assists the PD in selecting the correct dash number.

TABLE N.3.2.2.9-2 RACK MAINTENANCE SWITCH (RACK POWER SWITCH) LABEL

LAB/CAM	JEM/COL	JEM	NODE 2	NODE 3	LAB
-002	-003	-004	-005	-006	-007

N.3.2.2.10 ELECTRICAL STANDALONE STABILITY

The payload connected to Interface B, and EPCE connected to Interface C, **shall** provide local stability by meeting the following conducted susceptibility requirements:

- Paragraph 3.2.2.1 of SSP 30237 (CS01)
- Paragraph 3.2.2.2 of SSP 30237 (CS02)
- Paragraph 3.2.2.3 of SSP 30237 (CS06)

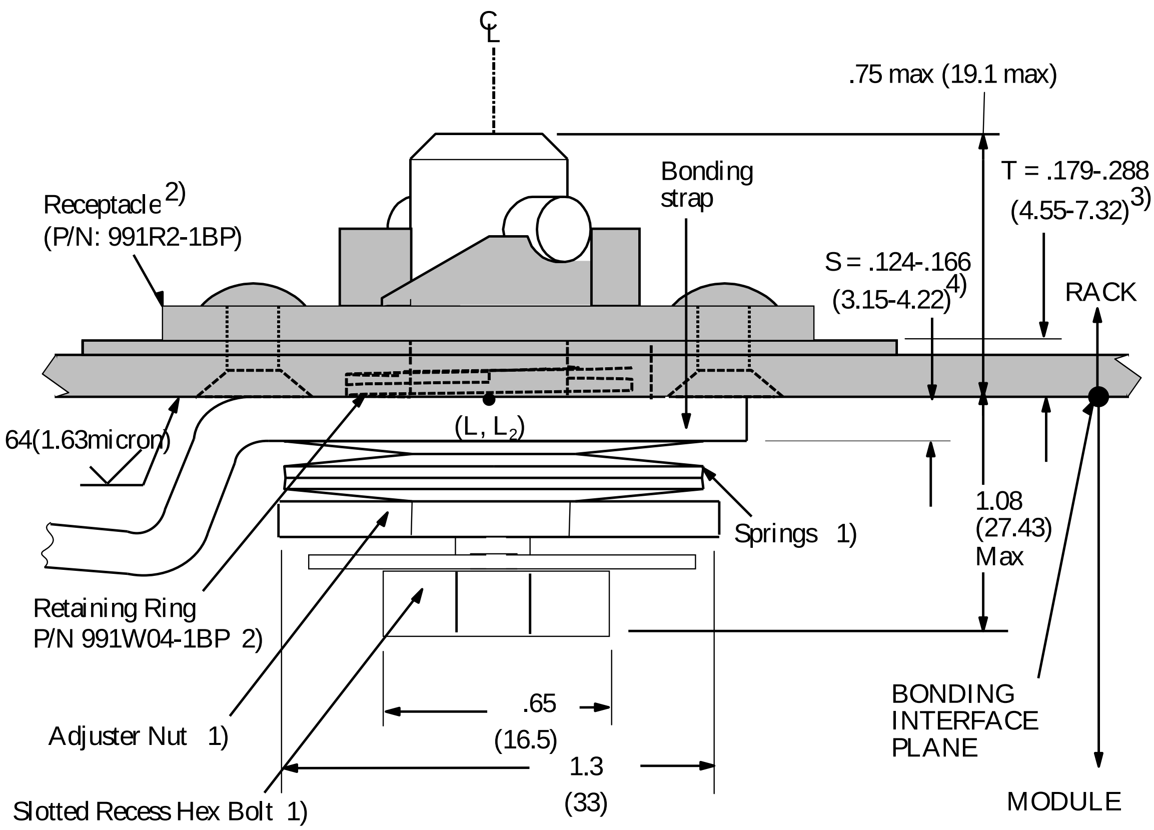
N.3.2.3 RACK ELECTROMAGNETIC COMPATIBILITY

General requirements contain Electrical Grounding (3.2.1.4), Electrical Bonding (3.2.2.8), and Electromagnetic Compatibility (3.2.2) requirements applicable to all payloads.

N.3.2.3.1 RACK BONDING STRAP

The integrated rack **shall** interface with the Class R and Class H requirements at the interface with the module bond strap per Figures N.3.2.3.1-1 through N.3.2.3.1-3 below.

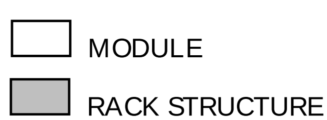
The bonding interface is as shown in Figure N.3.2.3.1-1, Rack Bonding Interface Profile, and Figure N.3.2.3.1-2, Rack Bonding Surface (Bottom View). For the profile view, use Figure N.3.2.3.1-1 (Part 1 of 3) for all modules except the JEM. For Mitsubishi Heavy Industries (MHI) or Ishikawajima Harima Industries (IHI) rack structures in the JEM, use Figure N.3.2.3.1-1 (Part 2 of 3) for profile. For U.S. racks in the JEM, use Figure N.3.2.3.1-1 (Part 3 of 3) for profile. The surfaces at the bonding interface are electroless nickel plated to a minimum thickness of 0.0015 in. (0.038 mm). Each rack will contain two bonding interfaces as shown in Figure N.3.2.3.1-3, Rack Bonding Interface Locations. The modules will accommodate bonding interfaces as per Table N.3.2.3.1-1.



Notes:

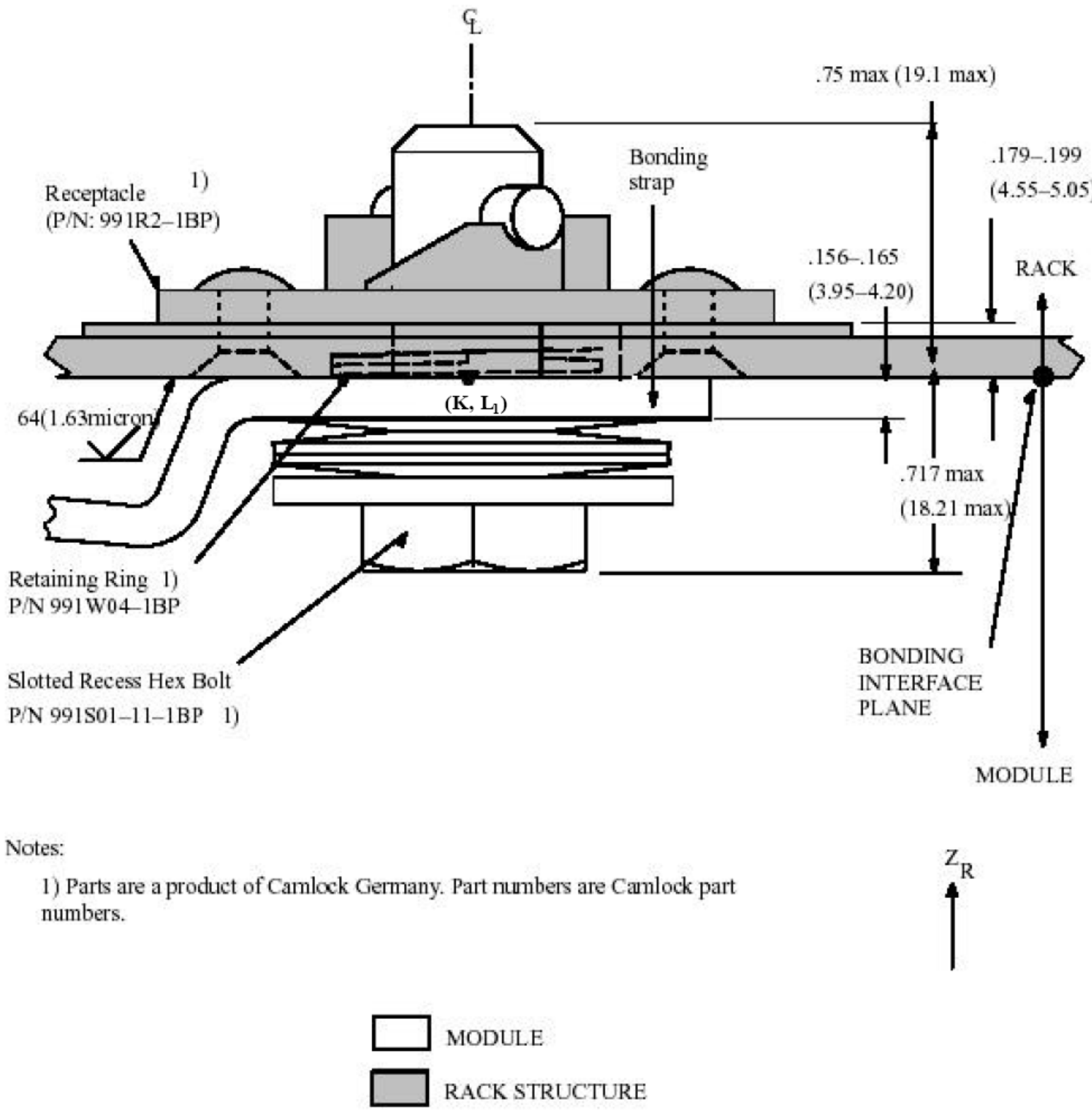
1) Bonding Strap Fasteners Part Number 683-60738-001 is a product of the Boeing Co; bolt dimensions compatible with Receptacle Camlock P/N 991R2-1BP; Material Stainless Steel, passivated.
2) Parts are a product of Camlock Germany. Part numbers are Camlock part numbers.

   The retaining ring is on the module side of the interface and is supplied by The Boeing Co.
3) T = .179 - .199 (4.55 - 5.05) for MHI & IHI Racks Structures
   T = .218 - .288 (5.54 - 7.32) for Boeing Racks Structure
4) S = .156 - .165 (3.95 - 4.20) for COL
   S = .124 - .166 (3.15 - 4.22) for USL, MPLM



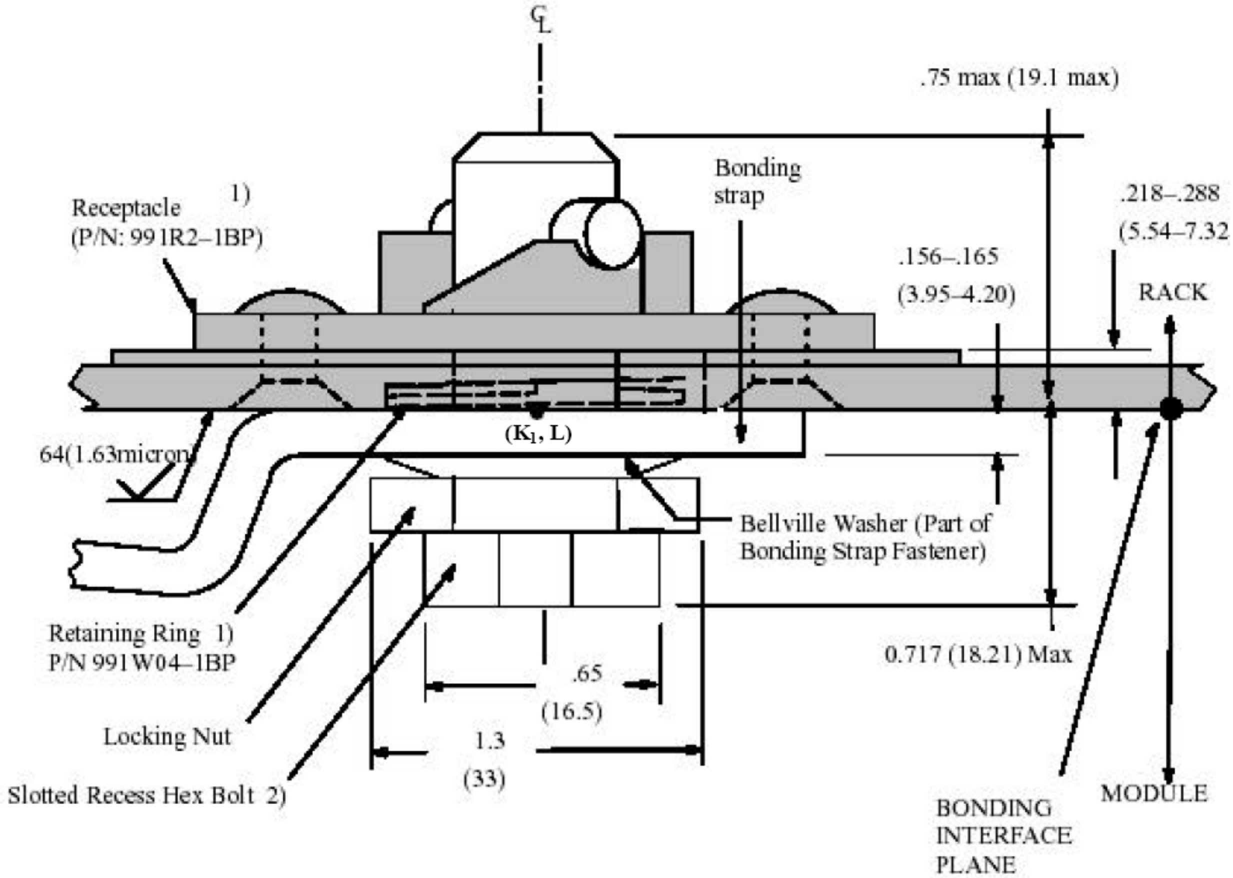
USL, COL, MPLM

FIGURE N.3.2.3.1-1 RACK BONDING INTERFACE PROFILE (PART 1 OF 3)



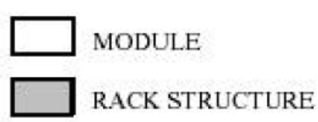
MHI & IHI RACK STRUCTURES IN THE JEM

FIGURE N.3.2.3.1-1 RACK BONDING INTERFACE PROFILE (PART 2 OF 3)



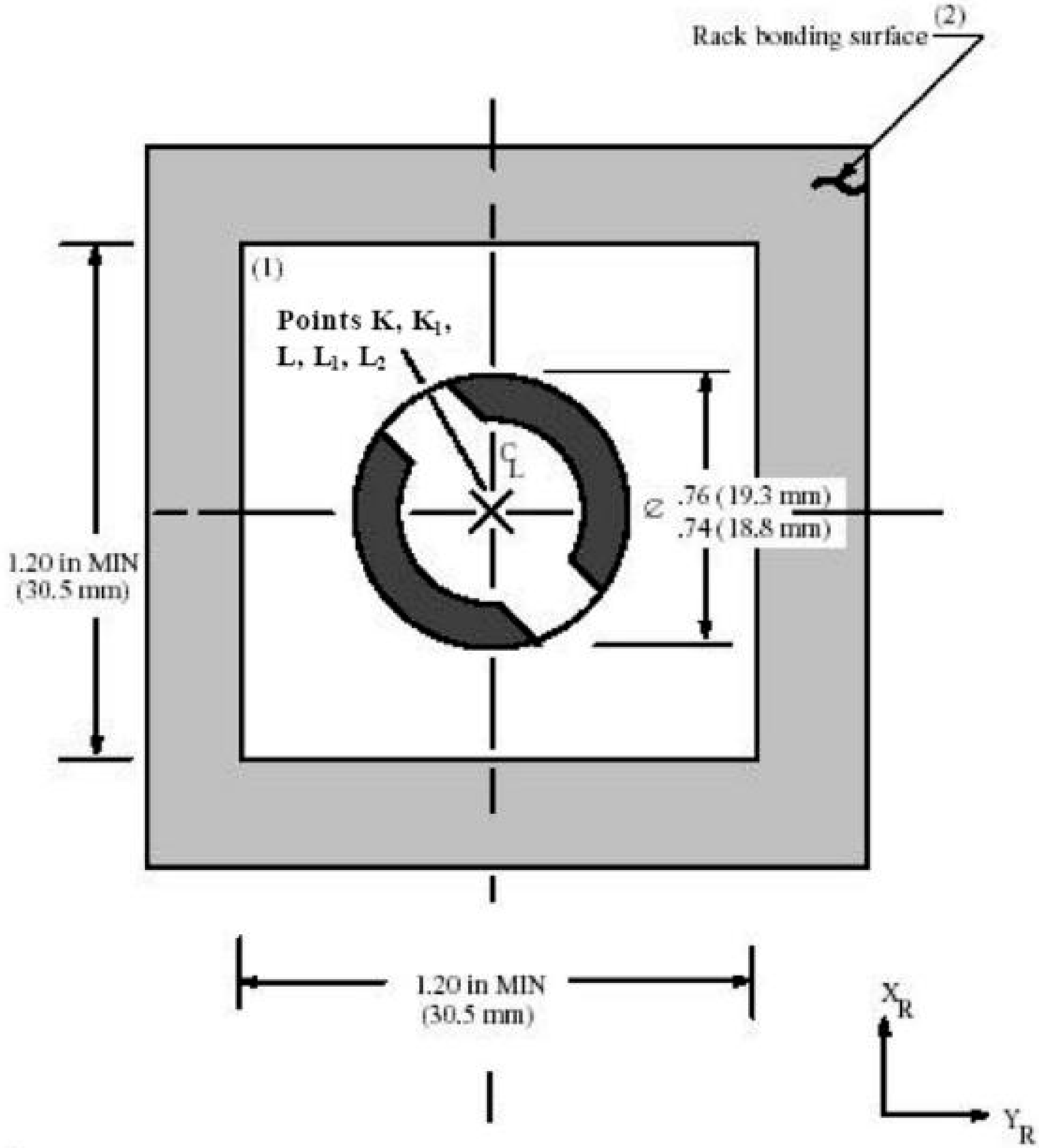
1) Parts are a product of Camlock Germany. Part numbers are Camlock part numbers. The retaining ring is on the module side of the interface and is supplied by The Boeing Co.

2) Part Number 683–60751–001 is a product of the Boeing Co; bolt dimensions compatible with Receptacle Camlock P/N 991R2–1BP; Material Stainless Steel, passivated.



BOEING RACK STRUCTURES IN THE JEM

FIGURE N.3.2.3.1-1 RACK BONDING INTERFACE PROFILE (PART 3 OF 3)

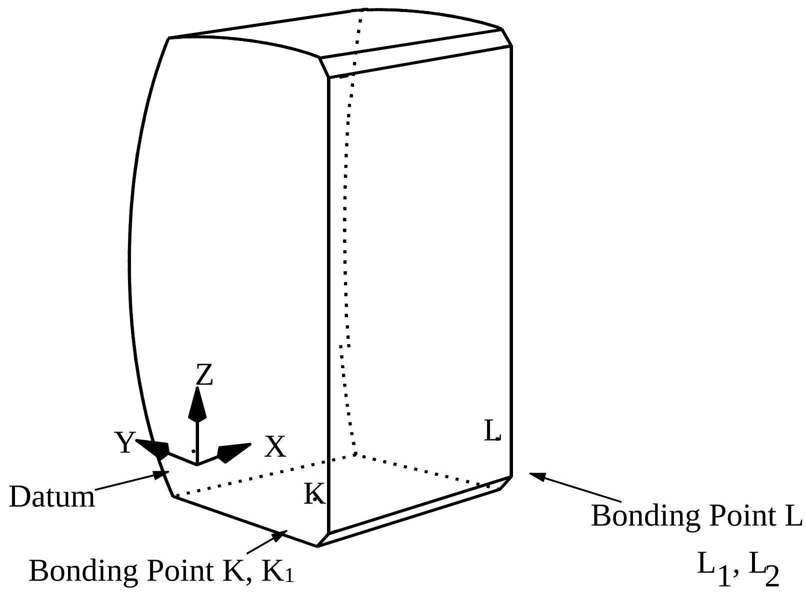


1/4 Turn Fastener receptacle viewed through access hole in the rack bonding surface
(Orientation is for reference only)

(1) – Minimum Bonding Surface Contact area
(2) – Reference only

Note: Dimensions are in inches (mm)

FIGURE N.3.2.3.1-2 RACK BONDING SURFACE (BOTTOM VIEW)



From Datum	X	Y	Z
Rack Bonding Interface Coordinates K	0.06 (1.5) -0.06 (-1.5)	-16.76 (-425.6) -16.84 (-427.7)	-1.35 (-34.3) -1.59 (-40.4)
Rack Bonding Interface Coordinates K_1 [3]	1.21 (30.7) 1.09 (27.7)	-20.458(-519.6) -20.538(-521.7)	-1.53 (-38.9) -1.59 (-40.4)
Rack Bonding Interface Coordinates L	38.21 (970.5) 38.09 (967.5)	-20.458(-519.6) -20.538(-521.7)	-1.53 (-38.9) -1.59 (-40.4)
Rack Bonding Interface L_1 [1]	39.36 (999.7) 39.24 (996.7)	-16.76 (-425.6) -16.84 (-427.7)	-1.35 (-34.3) -1.59 (-40.4)
Rack Bonding Interface L_2 [2]	38.21 (970.5) 37.74 (958.6)	-20.458 (-519.6) -20.538 (-521.7)	-1.35 (-34.3) -1.59 (-40.4)

NOTE: Coordinates are defined at the centerline of the access hole shown in Figure N.3.2.3.1-2.
[1] - JAXA UNIQUE, JAXA RACKS IN JEM
[2] - JAXA RACK IN USL
[3]- Boeing RACK IN JEM, two bonding points K_1 and L are necessary

FIGURE N.3.2.3.1-3 RACK BONDING INTERFACE LOCATIONS

TABLE N.3.2.3.1-1 MODULE BONDING INTERFACES

Module	Bonding Interface
COL	Point L, L_2
JEM	Points K, K_1,L,L_1
USL	Point L, L_2

N.3.2.3.2 ARIS ISPR BONDING

Class R bonding for Active Rack Isolation System (ARIS) ISPR is accomplished through the use of a mesh strap that is provided as part of the ARIS standard umbilical assembly which is part of the ARIS Kit. ARIS ISPRs are bonded to the ISS through an interface on the UIP on the module standoff. Class H bonding is accomplished through a third wire in the power connector.

The location of the bonding interface and receptacle on module structure is defined in Figures N.3.1.1.6-2 through N.3.1.1.6-5. The receptacle part number is 991R2-1BP (built by Camlock AG) and will be supplied and installed by the module provider.

The ARIS provided bonding strap will include captive fasteners used for mating the bonding strap to the module provided receptacle as shown in Figure N.3.2.3.2-1, ARIS/ISPR Bonding Interface Profile.

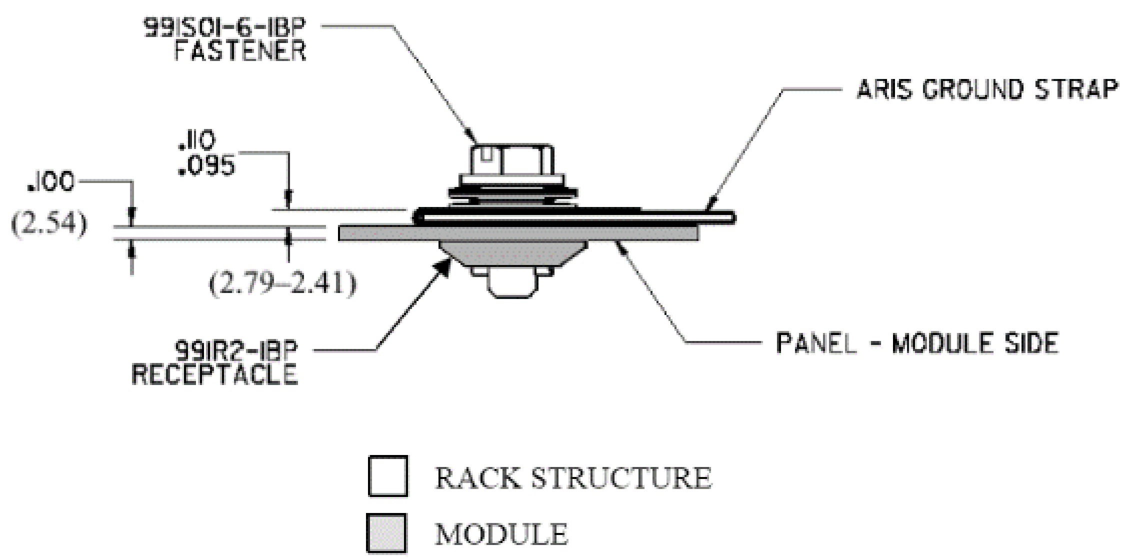


FIGURE N.3.2.3.2-1 ARIS/ISPR BONDING INTERFACE PROFILE

N.3.3 COMMAND AND DATA HANDLING INTERFACE REQUIREMENTS

Command and Data Handling requirements for payloads are addressed in Appendix I.

N.3.3.1 MIL-STD-1553B (LRDL)

The integrated rack payload **shall** meet MIL-STD-1553B requirements per section I.3.4, including all applicable sub-paragraphs.

N.3.4 PAYLOAD NTSC VIDEO INTERFACE REQUIREMENTS

This section is limited to internal video interfaces. The USL and Columbus provide a fiber optic video interface in accordance with Paragraph N.3.4.1, Payload NTSC Video Characteristics for Fiber Optic Video and Paragraph N.3.4.2, NTSC Fiber Optic Video. The JEM provides an NTSC electrical video interface in accordance with Paragraph N.3.4.3, NTSC Electrical Video Interfaces and Paragraph N.3.4.4, NTSC Electrical Connector / Pin Assignments.

Note: Failure to meet the NTSC video requirements can result in unusable video when the source is routed to the Integrated Communications Unit (ICU) for downlink. Payloads sources that fail to meet the EIA-RS-170A for color and EIA-RS-170 for monochrome video requirements can cause synchronization issues within the end-to-end video system.

Recommendation: Perform an engineering evaluation using the payload source and related electronics with the ISS Video Distribution System (VDS) and ICU.

N.3.4.1 PAYLOAD NTSC VIDEO CHARACTERISTICS FOR FIBER OPTIC VIDEO

A. Payload NTSC video characteristics *should* be in accordance with Table N.3.4.1-1, NTSC Video Performance Characteristics for Fiber Optic Video.

B. Video signal to crosstalk noise *should* be greater than or equal to 60 dB while using a low pass filter (f_c = 4.2 MHz), when any one of the following conditions apply:

   (1) The integrated rack has two or more video signals following the same physical path as an electrical signal.

   (2) The integrated rack contains two or more channels of electrical modulated or baseband video.

   (3) The integrated rack is transmitting and receiving video signals to include the sync and control signal. This requirement is not applicable for integrated racks transmitting only one signal and receiving no signal.

This requirement is not applicable for integrated racks transmitting only one signal and receiving no signal.

TABLE N.3.4.1-1 NTSC VIDEO PERFORMANCE CHARACTERISTICS FOR FIBER OPTIC VIDEO

Characteristic	Point-to Point Path Characteristics			Test Method (per TIA/EIA-250-C)
	Value	Recommended	Required	
Amplitude vs. Frequency Response	10 kHz to 300 kHz: 3.58 MHz ± 300 kHz : 4.2 MHz: Monotonic Roll Off above 4.2 MHz 10 MHz:	±0.20 dB ±0.40 dB ±0.70 dB +1.0/–3.0 dB	±0.40 dB ±0.60 dB ±0.90 dB +1.30/–3.30 dB	Para 6.1.1
Chrominance to Luminance Gain Inequality	Nominal	± 3.3 IRE	± 7.0 IRE	Para 6.1.2.1
Chrominance to Luminance Delay Inequality	Nominal	± 21 ns	± 21 ns	Para 6.1.2.2
Luminance Non–Linearity	Nominal	6% Max	6% Max	Para 6.2.1
Differential Gain	Nominal	4% Max	4% Max	Para 6.2.2.1
Differential Phase	Nominal	1.9 °	1.9 °	Para 6.2.2.2
Signal to Noise Ratio (10 KHz to 5 MHz) (Triangular)	Non–weighted	43.8 dB min	43.8 dB min	Para 6.3.1

N.3.4.2 NTSC FIBER OPTIC VIDEO

N.3.4.2.1 PULSE FREQUENCY MODULATION NTSC FIBER OPTIC VIDEO CHARACTERISTICS

The PFM fiber optical video interface consists of one video channel into the rack*, one video channel out of the rack, and one synchronization and control channel. The video hardwired addresses are allocated in Table N.3.4.2.1-1. The PFM fiber optic characteristics *should* be in accordance with Table N.3.4.2.1-2, NTSC Fiber Optic Video Signal Characteristics.

TABLE N.3.4.2.1-1 VIDEO HARDWIRED ADDRESSES

COL ISPR		JEM ISPR		USL ISPR	
Location	**Video Hardwired Address**	**Location**	**Video Hardwired Address**	**Location**	**Video Hardwired Address**
COL1F1	210	JPM1F1	91	LAB1O1	179
COL1F2	211	JPM1F2	92	LAB1O2	180
COL1F3	212	JPM1F3	93	LAB1O3	181
COL1F4	213	JPM1F5	94	LAB1O4	182
COL1A1	214	JPM1F6	95	LAB1O5	183
COL1A2	215	JPM1A1	96	LAB1S1	184
COL1A3	216	JPM1A2	97	LAB1S2	185
COL1A4	217	JPM1A3	98	LAB1S3	186
COL1O1	218	JPM1A4	99	LAB1S4	187
COL1O2	219	JPM1A5	100	LAB1D3	188
Notes: 1. Decimal values to be mapped in 8 bit presentation, bit 0 = LSB. See Figures 3.4.1.2-1 and 3.4.2.1-1. 2. Jumpering address line to ground = logic 0.				LAB1P1	189
				LAB1P2	190
				LAB1P4	191

*Note: The following ISPR locations do not include a video channel into the rack: LAB1P2, LAB1P4, LAB1S3, LAB1O1, LAB1O2, LAB1O3, LAB1O4, and LAB1O5.

TABLE N.3.4.2.1-2 NTSC FIBER OPTIC VIDEO SIGNAL CHARACTERISTICS

PFM Signal Bandwidth	40-72 Megahertz (MHz)
PFM Signal Characteristics	Square wave, FM signal characterized by nominal 50 percent duty cycle
PFM Center Frequency (Blanking Level)	48.57 MHz (0 IRE/0mV)
White Level Frequency	70.25 Mhz (100 IRE/714 mV)
Sync Tip Frequency	40.07 Mhz (-40 IRE/-286 mV)
Blanking Level Variation	+/- 2 Mhz
Video Signal Format	NTSC composite NTSC/EIA-RSA-170A (1)
Pre-emphasis/De-emphasis	per CCIR Recommendation 405 of TIA/EIA-250-C. (1) (2)
Bus Media	Fiber Optics on both SSMB and COL sides
Video Sync	EIA-RS-170A Compliant Black Burst Sync

Notes:
(1) Or any video/data format compatible with PFM characteristics as indicated in this table.
(2) With the emphasis enabled the above set-up results in PFM frequencies of 53.27 MHz for the white level (100 IRE/714 mV), 48.57 MHz for the blanking level (0 IRE/0mv), and 46.67 MHz for sync tip (-40 IRE/-286 mV).

N.3.4.2.2 INTEGRATED RACK NTSC PFM VIDEO TRANSMITTED OPTICAL POWER

The integrated rack that transmits PFM video on the optical video system *should* transmit a video PFM signal at an average optical power greater than -15.5 dBm.

N.3.4.2.3 INTEGRATED RACK NTSC PFM VIDEO AND SYNC SIGNAL RECEIVED OPTICAL POWER

The integrated rack that receives PFM video and sync signal on the optical video system *should* receive a PFM video and sync signal at an average optical power greater than -22.2 dBm.

1. The minimum average transmit power level for optical PFM NTSC video signals to a rack, measured at ambient temperature, at each signal interface provided for ISPR is shown in Table N.3.4.2.3-1.

TABLE N.3.4.2.3-1 OPTICAL PFM NTSC VIDEO SIGNAL TRANSMIT POWER

Signal	USL Output
	Optical Power (dB)
LAB1P1	-22.2
ISPR (Non LAB1P1 Location)	-19.1

2. The minimum average transmit power level for optical PFM NTSC sync and control signals to a rack (USL), measured at ambient temperature, at each interface provided for ISPR is shown in Table N.3.4.2.3-2.

TABLE N.3.4.2.3-2 OPTICAL PFM NTSC SYNC AND CONTROL SIGNAL TRANSMIT POWER (USL)

Signal	USL Output
	Optical Power (dB)
LAB1P1	-22.2
ISPR (Non LAB1P1 Location)	-19.1

Note: Use of the Sync is only required if a payload wants to display its video on board split screen.

3. The COL transmits optical PFM NTSC video and sync and control signals to the ISPR at the minimum optical power levels shown in Table N.3.4.2.3-3 (COL Side-Output).

TABLE N.3.4.2.3-3 VIDEO INTERFACE COL OPTICAL POWER LEVELS

Signal Name	COL Output
	Optical Power Levels (dBm)
COL VIDEO	-20.0
COL SYNC	-20.0

Note: Optical Power Levels are dBm average 50% duty cycle, measured at ambient temperature.

N.3.4.2.4 FIBER OPTIC CABLE CHARACTERISTICS

The integrated rack *should* use fiber optic cable in accordance with Table N.3.4.2.4-1, Fiber Optic Cable Characteristics.

TABLE N.3.4.2.4-1 FIBER OPTIC CABLE CHARACTERISTICS

Parameter	Dimension	Medium Characteristics
Operating Wave length (min/max)	nm	1270/1380
Fibre Type	-	graded index, multimode
Fibre Core Diameter (min/max)	mm	98/102
Fibre Cladding Diameter (min/max)	mm	138/142
Numerical Aperture (min/max)	-	0.28/0.32
Attenuation @ 1290± 10nm	dB/Km	≤ 4
Modal Bandwidth @ 1290± 10nm	MHz x Km	200
-Signal Timing:		
Optical Rise Time (10% to 90%)	ns	≤ 3.5
Optical Fall Time (10% to 90%)	ns	≤ 3.5
Random Jitter (peak to peak) (1)	ns	≤ 0.76
Data Dependent Jitter (peak to peak) (1)	ns	≤ 0.6
Duty Cycle Distortion (peak to peak) (1)	ns	≤ 1

Note:

(1) These parameter refer to fibre optic data test setup.

N.3.4.2.5 PFM NTSC VIDEO FIBER OPTIC CABLE BEND RADIUS

The integrated rack *should* develop the routing, installation and handling procedures to assure the minimum bend radius of 2 inches or greater is maintained at all times for the Fiber Optic Cable.

N.3.4.2.6 PFM NTSC OPTICAL CONNECTOR/PIN ASSIGNMENTS

A. Integrated rack connector P16 mating requirements to the UIP connector J16 are specified in Paragraph N.3.1.1.7.

B. The integrated rack PFM NTSC video fiber optic system P16 connector *should* meet the pin out interfaces of the UIP J16 connector as specified in Figure N.3.1.1.8-8.

N.3.4.3 NTSC ELECTRICAL VIDEO INTERFACES

N.3.4.3.1 CABLES

The cables selected for the transmission of sync and control signals and video and status signals for an ISPR *should* be SSQ 21655 (NDBC-TFE-22-2SJ-75) or equivalent.

N.3.4.3.2 SIGNAL STANDARD

The integrated rack *should* output video and status signals which comply with the signal standard specified in RS-170A at Interface B of Figure N.3.4.3.2-1 to JEM video system. Integrated racks will receive sync signal and video signal at Interface A and C of Figure N.3.4.3.2-1 from the JEM video system which complies with signal characteristic specified in Table N.3.4.3.2-1.

Notes:

(1) Control Line
The control signal from USOS that would be embedded in sync signal cannot be sent to the integrated racks in JEM.

(2) Status Line
The video status of USOS standard, which would be embedded in the video out signal from integrated racks, is sent to USOS. The JEM video system does not decode the camera telemetry of the U.S. payloads.

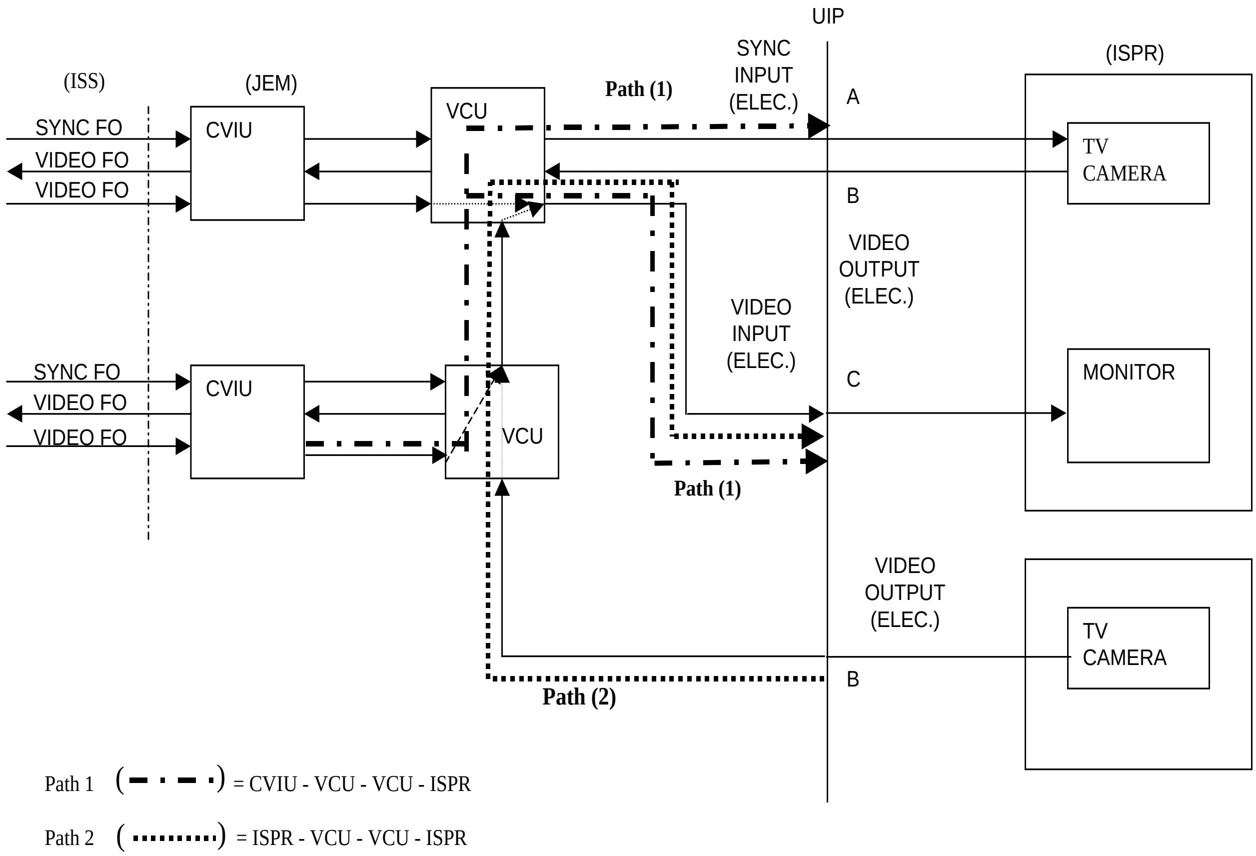


FIGURE N.3.4.3.2-1 INTERFACE POINT FOR JEM ELECTRICAL VIDEO

TABLE N.3.4.3.2-1 JEM VIDEO AND SYNC SIGNAL STANDARD

No.	Parameter	Out-Put Video and Status Signals (RS-170A)	*In-Put sync and input video signals (JEM Video System)	Unit	Note
1	Picture Blanking	10.9 ± 0.2	10.9 ± 0.2	ms	
2	Front Porch	1.5 ± 0.1	1.5 ± 0.1	ms	
3	Sync	4.7 ± 0.1	4.7 ± 0.1	ms	
4	H Sync Level	40 ± 2	40 ± 2	IRE	
5	H Sync Rise Time	0.14 ± 0.02	0.14 +0.06/-0.02	ms	
6	H Sync Fall Time	0.14 ± 0.02	0.14 +0.06/-0.02	ms	
7	Burst Amplitude	40 ± 2	40 +2/-15	IRE	
8	Start of Burst	5.3 ± 0.1	5.3 ± 0.1	ms	
9	Burst Cycle	9	9	cycle	
10	SCH	0 ± 40	0 ± 40	deg.	
11	Equalizing Pulse	2.3 ± 0.1	2.3 ± 0.1	ms	
12	Equalizing Pulse Rise Time	0.14 ± 0.02	0.14 +0.06/-0.02	ms	
13	Equalizing Pulse Fall Time	0.14 ± 0.02	0.14 +0.06/-0.02	ms	
14	Vertical Serration	4.7 ± 0.1	4.7 ± 0.1	ms	
15	Vertical Serration Rise Time	0.14 ± 0.02	0.14 +0.06/-0.02	ms	
16	Vertical Serration Fall Time	0.14 ± 0.02	0.14 +0.06/-0.02	ms	

*Note: These values are based on the following paths:

Path 1 = CVIU to VCU to VCU to ISPR (see Figure N.3.4.3.2-1)

Path 2 = ISPR to VCU to VCU to ISPR (see Figure N.3.4.3.2-1)

N.3.4.3.3 INTERFACE CIRCUIT

The interface circuit of video system components in the integrated rack for sync, video output and video input **shall** comply with Figure N.3.4.3.3-1 or equivalent.

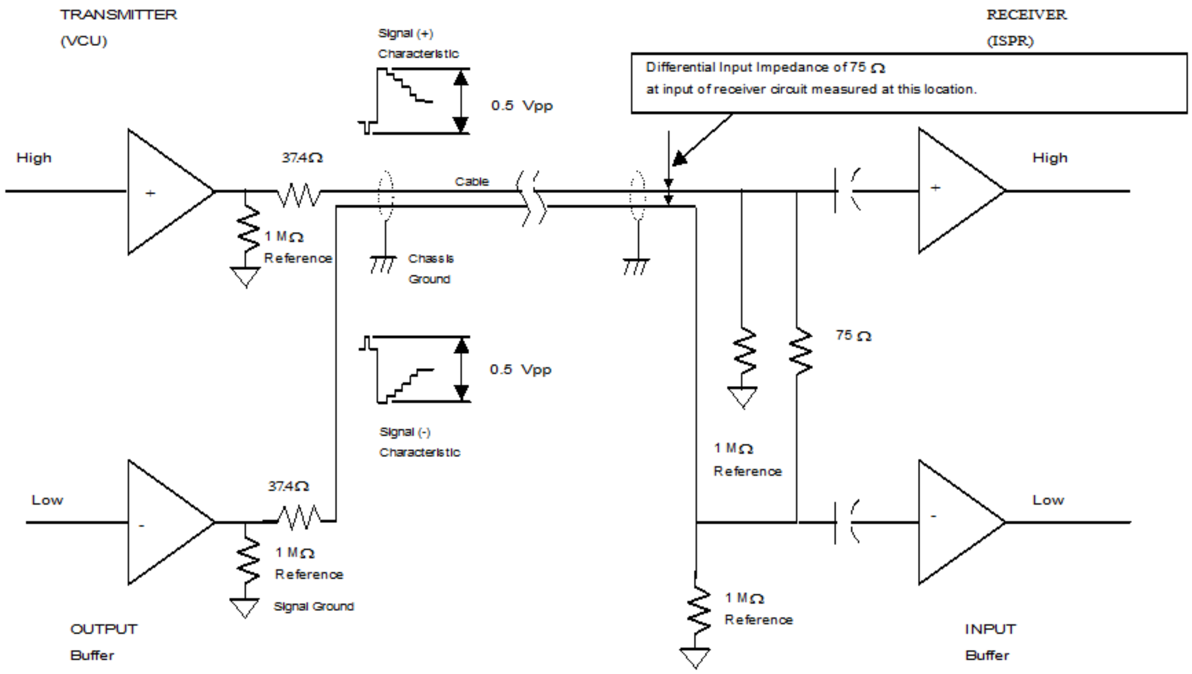


FIGURE N.3.4.3.3-1 VIDEO/SYNC SIGNAL INTERFACE CIRCUIT

Notes:

(1) Voltage in the circuit is not allowed to exceed the tolerance limits of ±5.50 Vdc even when a single failure occurs.

(2) The coupling capacitor upstream of input buffer may be omitted.

(3) Input load impedance of the receive circuit to cable with respect to ground is recommended to be greater than 6 KΩ.

N.3.4.3.4 CROSSTALK

The crosstalk in the integrated rack **shall** be less than -50dB.

N.3.4.4 NTSC ELECTRICAL CONNECTOR/PIN ASSIGNMENTS

A. Integrated rack connector P77 mating requirements to the UIP connector J77 are specified in Paragraph N.3.1.1.7.

B. The integrated rack electrical video system P77 connector **shall** meet the pin out interfaces of the UIP J77 connector as specified in Figure N.3.1.1.8-9.

N.3.5 THERMAL CONTROL INTERFACE REQUIREMENTS

N.3.5.1 INTERNAL THERMAL CONTROL SYSTEM (ITCS) INTERFACE REQUIREMENTS

N.3.5.1.1 ITCS PHYSICAL INTERFACE

Connectors for low temperature and moderate temperature water cooling supply and return mating to the UIP connectors are specified in Paragraph N.3.1.1.7.

N.3.5.1.2 ITCS INTERFACE PRESSURE DIFFERENTIAL

The maximum pressure drop across a payload in each module for the MTL and the LTL is defined in Table N.3.5.1.2-1.

The pressure differential of the payload, including both halves of each mated QD pair, *should* be 5.8 ±0.2 psid (40 ±1.4 kPa) at the payload's maximum design flow rate.

TABLE N.3.5.1.2-1 ITCS PRESSURE DROP

Loop/Lab	USL psid (kPa)	COL psid (kPa)	JEM psid (kPa)
MTL	Figure N.3.5.1.2-1	5.8 ± 0.2 (40 ± 1.4)	5.8 ± 0.2 (40 ± 1.4)
LTL	Figure N.3.5.1.2-1		5.8 ± 0.2 (40 ± 1.4)

Note: Both halves of each mated Quick Disconnect (QD) pair will be included as part of the payload pressure differential.

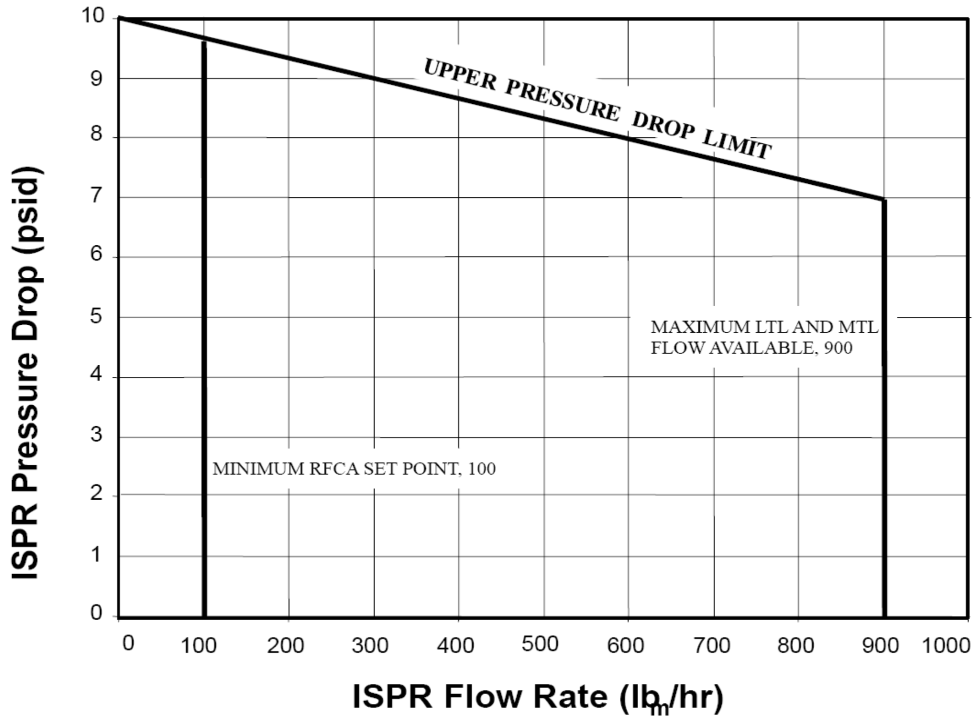


FIGURE N.3.5.1.2-1 USL AVAILABLE PRESSURE DROP VS. FLOW RATE

N.3.5.1.2.1 FLOW AND PRESSURE DROP DATA

Data Deliverable: Provide the pressure drop (psid or kPa) across the payload ITCS interface, including both halves of each mated QD pair, at the maximum desired flow rate.

N.3.5.1.3 ITCS COOLANT FLOW RATE

The payload can request to be supplied a specific flow rate within the ranges specified in Table N.3.5.1.3-1, ITCS Coolant Flow Rate Capability. Multiple flow rate settings can be accommodated provided the flow rate setting changes are properly coordinated with the Module Integrator. Each payload location utilizing a module-provided valve has an off or “zero-flow” capability. During nominal operations a payload will receive ITCS coolant from the interface at the requested rate plus or minus the system control capability.

The payload *should* be designed to meet the moderate and low temperature loop allowable flow rates specified in Table N.3.5.1.3-1.

TABLE N.3.5.1.3-1 ITCS COOLANT FLOW RATE CAPABILITY

Element:	System Control Capability	Moderate Temperature Loop		Low Temperature Loop	
		lb/hr (kg/hr)	lb/hr (kg/hr)	lb/hr (kg/hr)	lb/hr (kg/hr)
		Module Total	Available at Single P/L Location	Module Total	Available at Single P/L Location
USL	±5% > 350 lb/hr ±10% ≤ 350 lb/hr	1394[5] (632)	100 - 900 (45 - 408)	1390 (632)	100 - 900 (45 - 408)
COL	±10% of calibrated flow [1]	1,700 (770)	66 - 419 (30 - 190)	1,700 (770)	LTL not provided
JEM[2]	-0/+154 lb/hr MT -0/+176 lb/hr LT	218 - 1,415[3] (99-642)	100 - 436 (45 - 198)	343 - 686[4] (156 - 312)	100 - 512 (45 - 232)

Notes:

[1] The Columbus Module will provide a pressure drop across the interface of 5.8 psid (40 kPa) for all flow rates within the specified range when the Water Flow Selection Valve (WFSV) is fully open. Reduction in flow rate can be achieved either by partial closing of the WFSV, leading to a reduced pressure drop across the interface, or by internal flow control valves, if such valves are present. If the payload is utilizing internal flow control valves, the payload must be capable of accommodating this pressure drop for all flow rates equal to or less than the rack maximum flow rate. The Columbus Module will provide an accuracy of ± 10% corresponding to the flow rate calibrated for that rack on the ground at a pressure differential across the interface of 5.8 psid (40 kPa).

[2] The JEM will provide a pressure difference higher than 6.0 psid (41.4 kPa) across an integrated rack for all flow rates within the specified range. The payload will be capable of accommodating this pressure drop for all required flow rates. Any changes in MTL or LTL flow rate must be coordinated with JAXA Mission Control Center (MCC).

[3] Total available depends on MTL use by JEM airlock, Remote Manipulator System (RMS), Exposed Facility (EF), and Attached payloads as well as operating configuration (single or dual loop).

[4] Total available depends on flow through condensing heat exchangers and operating configuration (single or dual loop).

[5] The total flow indicated available for payloads has had 150 lbm/hr for the Galley and 300 lbm/hr for the Airlock subtracked.

N.3.5.1.4 ITCS ALLOWABLE LEAKAGE

The integrated rack **shall** not exceed the maximum rack leakage rate of water of 14×10^{-3} cm^3/hr (liquid) per each thermal loop at the MDP of 121 psia (834 kPa).

N.3.5.1.5 ITCS COOLANT QUANTITY

Integrated racks *should* contain no more than the 1.82 gallons (6.90 liters) on the MTL and 0.91 gallons (3.44 liters) on the LTL, referenced at 61 °C (141.8 °F).

N.3.5.1.5.1 ITCS COOLANT QUANTITY DATA

<u>Data Deliverable</u>: Provide the calculated volume of ITCS fluid contained within the payload systems, including jumpers, in liters.

N.3.5.1.6 PAYLOAD FLOW CONTROL TIME CONSTANT

The payload containing automated flow control systems **shall** be designed such that flow rate set point changes greater than five pounds mass flow per hour (5 lbm/hr) takes at least 100 seconds to reach 63.2% (i.e., $1-e^{-1}$) of the commanded change in flow rate.

N.3.5.1.7 PAYLOAD SIMULTANEOUS USE OF MTL AND LTL

Payloads in the USL in all ISPR locations may use both LTL and MTL simultaneously. However, the module only provides at each ISPR location a single Rack Flow Control Assembly (RFCA) for use on either the LTL or MTL. This can be configured for either loop. The payload must provide flow rate shut off and control for the loop not connected to the RFCA.

Payloads in the JEM at ISPR locations F1, F2, A1, and A2 can interface with both low temperature and moderate temperature coolant, and can be simultaneously supplied with both of them.

A. The payload simultaneously using of MTL and LTL **shall** provide commandable on and off flow control and control the flow rate on the loop which does not have the RFCA connected.

B. The payload simultaneously using of MTL and LTL *should* provide temperature and flow rate sensors on the loop which does not have the RFCA connected.

C. The payload simultaneously using of MTL and LTL *should* provide flow control device status to the PL MDM, including flow rate, and outlet temperature.

D. The payload simultaneously using MTL and LTL **shall** prevent the connection of MTL and LTL loops together.

N.3.5.1.8 QUICK-DISCONNECT AIR INCLUSION

Payload Quick Disconnects **shall** not exceed the maximum air inclusion of 0.30 cubic centimeters (cc) maximum per couple/uncouple cycle.

N.3.6 VACUUM SYSTEM REQUIREMENTS

N.3.6.1 VACUUM EXHAUST SYSTEM (VES)/WASTE GAS SYSTEM (WGS) REQUIREMENTS

The Vacuum Exhaust System only allows a single user at any given time. All payload venting operations are timelined to maintain this restriction.

N.3.6.1.1 VES/WGS PHYSICAL INTERFACE

Payload connectors for the VES/WGS mating requirements to the UIP connectors are specified in Paragraph N.3.1.1.7.

N.3.6.1.2 INPUT PRESSURE LIMIT

Payloads interfacing with the VES **shall** limit their vented exhaust gas at the rack-to-ISS interface to a pressure equal to or less than the MDP of the VES (276 kPa (40 psia)).

Note: It is recommended payloads reference SSP 51700 for proper fault tolerance.

N.3.6.1.3 INPUT TEMPERATURE LIMIT

Payloads interfacing with the VES **shall** only vent exhaust gases with an initial temperature between 16 °C (60 °F) to 45 °C (113 °F).

N.3.6.1.4 INPUT DEWPOINT LIMIT

Payloads interfacing with the VES **shall** only vent exhaust gases with an initial dewpoint of 16 °C (60 °F) or less.

N.3.6.1.5 ACCEPTABLE EXHAUST GASES

A. Payloads interfacing with the VES/WGS of the USL, COL, and JEM **shall** vent only exhaust gases listed in Tables N.3.6.1.5-1, N.3.6.1.5-2, or N.3.6.1.5-3.

TABLE N.3.6.1.5-1 EXHAUST GASES COMPATIBLE WITH THE USL VES WETTED MATERIALS (3 PAGES)

Gas	Max Concentration	Additional Constraint
Acetaldehyde	100%	
Acetic Acid	100%	
Acetonitrile	100%	
Acetylene	100%	
Acrolein	100%	
Acrylonitrile	100%	
Argon	100%	
Benzene	100%	Note 3
Benzonitrile	100%	Note 3
1,3-Butadiene	100%	
n-butane	100%	
Butene	100%	
1-Butene	100%	
2-Butanone	100%	
Cabin Air	100%	
Carbon Dioxide	100%	
Carbon Monoxide	100%	
Chlorobenzene	100%	Note 3
Chloroethane	100%	
Chloromethane	100%	
cis-2-Butene	100%	
1,3-Cyclopentadiene	100%	
Cyclopentanone	100%	Note 3
Cyanogen chloride	100%	
Cyanogen bromide	100%	Note 3
Decalin	100%	
n-Decane	100%	Note 3
1,1-Dichloroethane	100%	Note 3
1,1-Dichloroethene	100%	Note 3
Dichloromethane	100%	Note 3

TABLE N.3.6.1.5-1 EXHAUST GASES COMPATIBLE WITH THE USL VES WETTED MATERIALS (3 PAGES)

Gas	Max Concentration	Additional Constraint
Ethane	100%	
Ethene	100%	
Ethanol	100%	
Ethyl benzene	100%	Note 3
Ethyl isopropyl ether	100%	Note 3
Ethyl methyl ether	100%	
2-Ethyl-4-Methyl-1,3-Dioxolane	100%	Note 3
Ethyl n-Propyl Ether	100%	Note 3
Formaldehyde	100%	
Helium	100%	
n-hexanal	100%	Note 3
Hexane	100%	Note 3
Heptane	100%	Note 3
Hydrogen	100%	
Hydrogen cyanide	100%	
Hydrogen sulfide	100%	
Isopropanol	100%	
Isopropyl formate	100%	Note 3
Krypton	100%	
Methane	100%	
Methanol	100%	
Methyl acetate	100%	
Methyl acrylate	100%	Note 3
2-Methyl-2-butenal	100%	Note 3
1-(1-Methylethoyx)-2-Propanone	100%	Note 3
Methyl formate	100%	
Methyl methacrylate	100%	Note 3
2-Methyl propane	100%	
2-Methyl propenal	100%	
2-Methyl propene	100%	
Mixtures of gases in Appendix D1		Note 2
Neon	100%	
Nitrogen	100%	
Norflurane	100%	Note 3
Octane	100%	Note 3
o-Xylene	100%	Note 3
Oxygen	(not more than 30% by volume vented from the experiment chamber)	
Pentanal	100%	Note 3
Pentane	100%	
Perfluorohexane FC-72	100%	
Propadiene	100%	
Propane	100%	
Propanol	100%	
2-Propanone	100%	
Propene	100%	
n-Propyl acetate	100%	Note 3
Propyl formate	100%	Note 3

TABLE N.3.6.1.5-1 EXHAUST GASES COMPATIBLE WITH THE USL VES WETTED MATERIALS (3 PAGES)

Gas	Max Concentration	Additional Constraint
n-Propyl isopropyl ether	100%	Note 3
Propyne	100%	
Radon	100%	
Styrene	100%	Note 3
Sulfur dioxide	100%	
Sulfur hexafluoride	100%	Note 3
tert-Butyl alcohol	100%	
Tetralin	100%	
Toluene	100%	Note 3
1,1,1-Trichloroethane	100%	Note 3
Trichlorofluoroethane	100%	Note 3
1,2,4-Trimethylbenzene	100%	Note 3
2,2,4-Trimethyl-1,3-dioxolane	100%	Note 3
Vinyl acetate	100%	Note 3
Vinyl Chloride	100%	
Water Vapor	100%	
Xenon	100%	
m-Xylene	100%	Note 3

Note 1 (general): Venting cabin air is unrestricted.

Note 2: Combinations of all gases must be analyzed and are constrained as specified to Paragraph N.4.3.6.1.5.B. This table only represents the gases that are compatible with the USL VES wetted materials.

Note 3: Each proposed vent gas with a molecular weight greater than 75 amu must be analyzed in accordance with Paragraph N.4.3.6.1.5.C.

TABLE N.3.6.1.5-2 EXHAUST GASES COMPATIBLE WITH THE JEM WASTE GAS SYSTEM WETTED MATERIALS

GAS	Max Concentration	Additional Constraint
Nitrogen	100%	
Cabin Air	100%	
Noble Gases	100%	
Carbon Dioxide	100%	
Oxygen	Less than 24.1% by volume	

Note 1 (general): Venting cabin air is unrestricted

Note 2: Combinations of all gases must be analyzed and are constrained as specified to Paragraph N.4.3.6.1.5.B. This table only represents the gases that are compatible with the JEM WG wetted materials.

Note 3: Each proposed vent gas with a molecular weight greater than 75 amu must be analyzed in accordance with Paragraph N.4.3.6.1.5.C.

TABLE N.3.6.1.5-3 EXHAUST GASES COMPATIBLE WITH THE COLUMBUS MODULE WASTE GAS SYSTEM WETTED MATERIALS

GAS	Max Concentration	Additional Constraint
List not completed to date		

Note 1 (general): Venting cabin air is unrestricted.
Note 2: Combinations of all gases must be analyzed and are constrained as specified to Paragraph N.4.3.6.1.5.B. This table only represents the gases that are compatible with the Columbus WGS wetted materials.
Note 3: Each proposed vent gas with a molecular weight greater than 75 amu must be analyzed in accordance with Paragraph N.4.3.6.1.5.C.

B. Payloads interfacing with the VES/WGS **shall** only vent gases that are non-reactive with other vent gas mixture constituents.

C. Payloads interfacing with the VES/WGS **shall** provide a means of removing gases that would adhere to the ISS VES/WGS tubing walls at a wall temperature of 4 °C (40 °F) and at a pressure of 10^{-3} torr.

D. Payloads interfacing with the ISS VES/WGS **shall** remove particulates from vent gases that are larger than 100 micrometers in size.

N.3.6.1.6 PAYLOAD VACUUM SYSTEM ACCESS VALVE

Payloads interfacing with the ISS VES/WGS system **shall** provide a vacuum system access valve in the payload system to isolate the payload experiment chamber from the ISS VES/WGS system when the payload is not venting to the ISS VES/WGS. This requirement does not apply to payloads venting only the constituents of cabin air, noble gases or ISS pressurized gases.

Note: The Rack Isolation Valve (RIV) in the ISS VES/WGS system at the rack location must be open prior to opening the payload vacuum system access valve. The positions of the RIVs in the USL are available to the rack in the ancillary data.

N.3.6.1.7 LIMIT AMOUNT OF VENTED GASES

A. Payloads interfacing with the VES **shall** limit the total mass of vented gases (M_{tot}, kg), or the initial pressure (P_0, psi) and volume (V, liters) of their vented gases, over any 9 minute period to one of the following limits.

$$M_{tot} \leq 0.0344\sqrt{M_w}$$

$$P_0 V \leq \frac{12606}{\sqrt{M_w}}$$

where M_w is the average molecular weight (kg/kg·mole) of the vented gases.

B. Payloads interfacing with the VES **shall** limit the total mass of vented gases (M_{tot}, kg), or the initial pressure (P_0, psi) and volume (V, liters) of their vented gases, over any 110-minute period to one of the following limits.

$$M_{tot} \leq 0.0549\sqrt{M_w}$$

$$P_0 V \leq \frac{20107}{\sqrt{M_w}}$$

where M_w is the average molecular weight (kg/kg·mole) of the vented gases.

Note: Figure N.3.6.1.7-1, Total Mass Venting Limit, illustrates the application of the equations in subparagraphs A and B for the venting of air with an average molecular weight of 28.8 kg/kg-mole. Figure N.3.6.1.7-2, Pressure-Volume Venting Limit, illustrates the application of the equations in subparagraphs A and B for the venting of air with an average molecular weight of 28.8 kg/kg-mole. The purpose of these limits is to ensure that the Control Moment Gyros are not saturated, or ISS attitude rate limits are not exceeded, due to momentum caused by vent gas impingement upon ISS structures such as arrays and radiators.

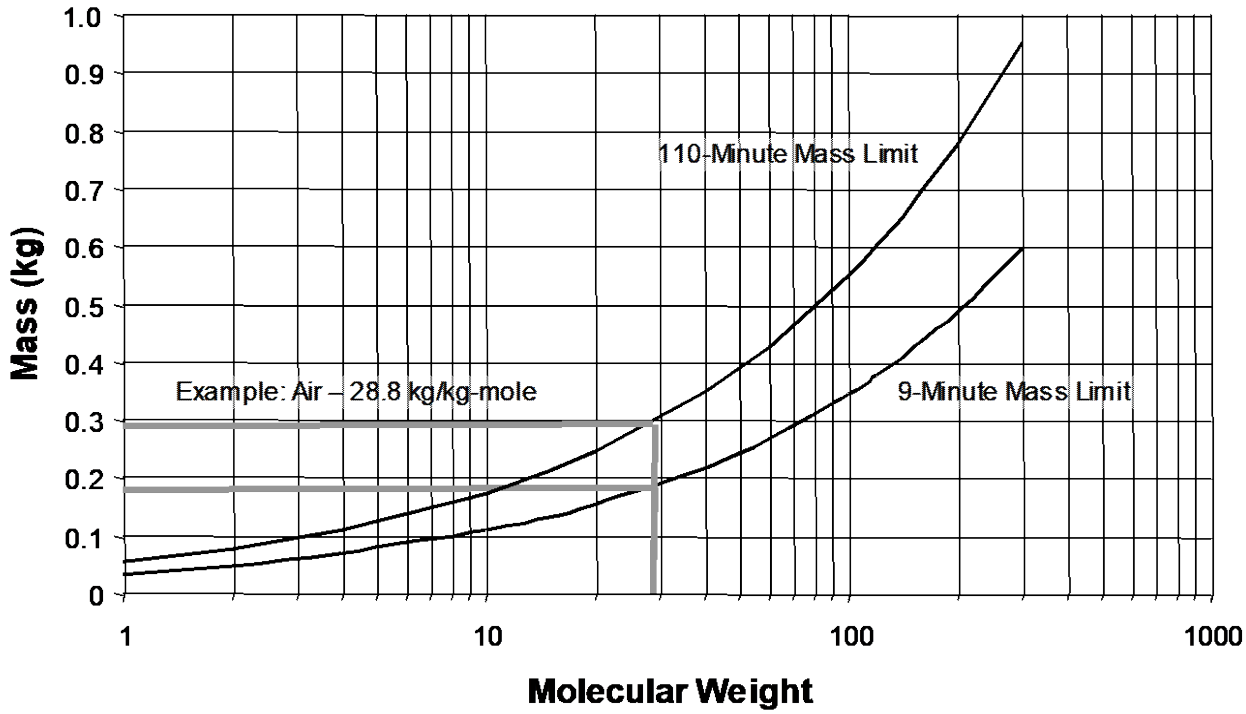


FIGURE N.3.6.1.7-1 TOTAL MASS VENTING LIMIT

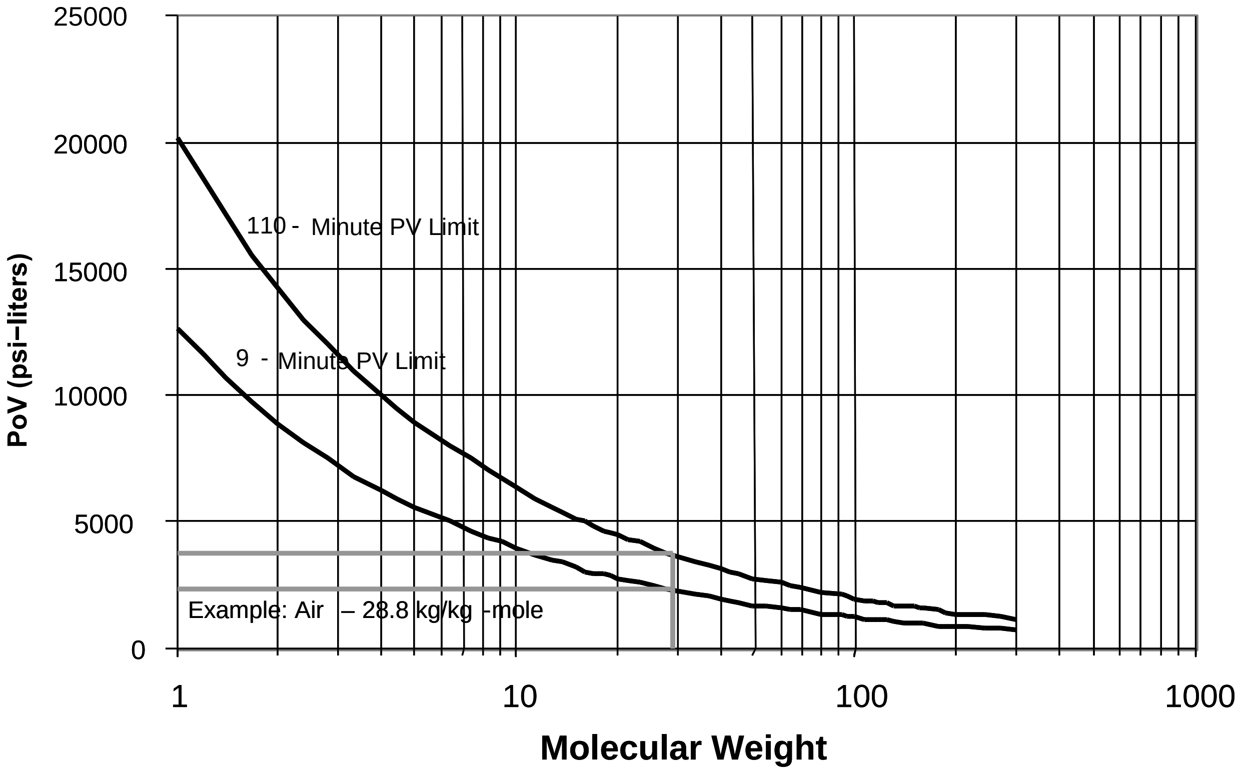


FIGURE N.3.6.1.7-2 PRESSURE - VOLUME VENTING LIMIT

C. Payloads interfacing with the VES *should* limit the total mass flow of each vented gas (ṁ, kg/s) to

$$\dot{m} \leq 6.45 \times 10^{-7}\sqrt{M_s T_0}$$

where M_s is the molecular weight (kg/kg·mole) of each molecular species vented, and T_0 is the temperature (K) of the vented gases at the payload outlet.

Note: This limits the external environment molecular column density to less than 1×10^{14} molecules/cm^2 along any unobstructed line of sight. Payloads venting more than this amount may be constrained with respect to venting schedule to ensure there is no impact to external payloads' sightlines if analysis of the external environment shows a potential science impact to sensitive external experiments.

N.3.6.1.8 LIMIT VES VENTING PROFILE

Payloads or systems interfacing with the USL VES *should* limit their venting profile so as to ensure the flow rates at the UIP remain at or below the flow rates listed in Table N.3.6.1.8-1 at the prescribed times, referenced from when the payloads' internal vacuum vent valve is opened.

TABLE N.3.6.1.8-1 VES WORST CASE FLOW RATES

Time	Maximum Acceptable Flow Rate at UIP	Pressure at VES PGT
1 to 5 minutes	5.320×10^{-3} kg/min (1.173×10^{-2} lbm/min)	66.66 Pa (500×10^{-3} torr)
5 to 15 minutes	1.658×10^{-4} kg/min (3.655×10^{-4} lbm/min)	10.67 Pa (80×10^{-3} torr)
Greater than 15 minutes	6.953×10^{-8} kg/min (1.533×10^{-7} lbm/min)	7.99 Pa (60×10^{-3} torr)

Note: The JEM WGS has the capability to exhaust 100 liters of 21 °C dry air from 101,000 Pa to 0.13 Pa within 2 hours. The nominal effective exhaust velocity at the JEM/Rack interface is 1.2 liters/second (molecular flow region).

N.3.6.1.9 VACUUM EXHAUST SYSTEM DATA DELIVERABLE

Data Deliverable: Provide a list of vented gases to include the constituent vented, the total mass vented, initial temperature, initial pressure, concentration of the constituent, mass flow rate, frequency and duration of venting operations, and pressure versus time curve at the payload interface.

N.3.6.2 VACUUM RESOURCE SYSTEM (VRS)/VACUUM VENT SYSTEM (VVS) REQUIREMENTS

N.3.6.2.1 VRS/VVS PHYSICAL INTERFACE

Payload connectors for the VRS/VVS mating requirements to the UIP connectors are specified in Paragraph N.3.1.1.7.

N.3.6.2.2 INPUT PRESSURE LIMIT

Payloads interfacing with the VRS/VVS **shall** limit their vented gases at the rack-to-ISS interface to a pressure equal to or less than 10^{-3} torr.

Note: It is recommended payloads reference SSP 51700 for proper fault tolerance.

N.3.6.2.3 ACCEPTABLE GASES

Vacuum gases which have been verified to be compatible with the VES/WGS are compatible with the VRS/VVS. Acceptable gases are defined in Tables N.3.6.1.5-1, N.3.6.1.5-2, and N.3.6.1.5-3.

Note: Gases at 10^{-3} torr or below are compatible with the VRS/VVS.

N.3.6.3 VACUUM OUTGASSING REQUIREMENTS

Payloads interfacing with the VES or VRS with non-metallic materials, which are exposed to pressures less than 1 torr via the USL, the Columbus Module or JEM Vacuum Systems, **shall** meet the vacuum outgassing requirements of Paragraph 4.2.7 of SSP 30233, Space Station Requirements for Materials and Processes.

N.3.7 PRESSURIZED GASEOUS NITROGEN INTERFACE REQUIREMENTS

N.3.7.1 NITROGEN INTERFACE CONTROL

A. Payloads interfacing to nitrogen *should* provide a valve to turn on and off the flow of nitrogen to the payload.

B. Payloads interfacing to nitrogen **shall** provide the means to control the flow of nitrogen to not exceed 5.43 kg/hr (12 lbm/hr) when connected to the nitrogen interface operating pressure range of 517 to 931 kPa (75 to 135 psia).

Note: The nominal ISS GN_2 Operating Pressure is 110 psia to 120 psia. When there is no flow of gas through the N_2 pressure regulator, called “lock-up”, on-orbit data shows that the line pressure has crept up as high as 128 psia. Then when additional flow is requested down-stream, the system could present a pressure spike as high as the lock-up pressure, 128 psia, until the gas begins to flow. The 135 psia maximum operating pressure requirement covers a 7 psia margin for operation which includes the nominal aging of pressure regulators. But the MDP remains 200 psia as stated in Paragraph N.3.7.2.

N.3.7.2 NITROGEN INTERFACE MDP

Payloads interfacing to nitrogen **shall** have a MDP of at least 1,379 kPa (200 psia).

N.3.7.3 NITROGEN INTERFACE TEMPERATURE

The nitrogen supply temperature range is 15.6 °C to 45 °C (60 °F to 113 °F).

N.3.7.4 NITROGEN LEAKAGE

Payloads **shall** have a nitrogen leakage rate no greater than 10^{-3} scc/s at MDP. Leakage is considered to be loss to the cabin atmosphere associated with quick disconnects, fittings, seals, valves, and permeation through materials from, and including, the UIP connection to the nitrogen on/off flow control point in the payload. All nitrogen flowing past the on/off flow control point is considered usage. The payload allocation for nitrogen comprises leakage and usage.

N.3.7.5 NITROGEN PHYSICAL INTERFACE

Payload connectors for the nitrogen system mating requirements to the UIP connectors are specified in Paragraph N.3.1.1.7.

N.3.7.6 NITROGEN QUANTITY

Data Deliverable: Provide quantity of nitrogen used by the payload and frequency of use.

N.3.7.7 PAYLOAD PRESSURIZED GAS SYSTEM

Data Deliverable: Provide schematic of payload pressurized gas system. Identify the major components of the system, such as shut off valve, relief valves, pressure regulators, tanks, etc. The symbols used for the schematic must adhere to JSC 10506, Mission Operations Directorate Drafting Standards.

N.3.8 JEM PRESSURIZED GASES

Argon, helium, and carbon dioxide are provided as JEM unique interfaces.

N.3.8.1 ARGON INTERFACE REQUIREMENTS

N.3.8.1.1 ARGON INTERFACE CONTROL

A. The payload *should* provide a valve, located within the payload envelope, to turn on and off the flow of argon to the payload.

B. The payload **shall** provide a means to control the flow of argon to not exceed 2.14 kg/hr (4.71 lbm/hr) when connected to the argon interface operating pressure range of 517 to 786 kPa (75 to 114 psia).

N.3.8.1.2 ARGON INTERFACE MDP

The MDP of the payload argon system **shall** be 1,379 kPa (200 psia).

N.3.8.1.3 ARGON INTERFACE TEMPERATURE

The argon supply temperature range is 13°C to 45°C (55.4°F to 113°F).

N.3.8.1.4 ARGON LEAKAGE

The integrated rack **shall** have an argon leakage rate no greater than 10^{-3} scc/s at MDP. Leakage is considered to be loss to the cabin atmosphere associated with quick disconnects, fittings, seals, valves, and permeation through materials from, and including, the standoff UIP connection to the argon on/off flow control point in the integrated rack. All argon flowing past the on/off flow control point is considered usage. The integrated rack allocation for argon will comprise leakage and usage.

N.3.8.1.5 ARGON PHYSICAL INTERFACE

Payload connectors for the argon system mating requirements to the UIP connectors are specified in Paragraph N.3.1.1.7.

N.3.8.1.6 ARGON QUANTITY

<u>Data Deliverable</u>: Provide quantity of argon used by the payload and frequency of use.

N.3.8.2 CARBON DIOXIDE INTERFACE REQUIREMENTS

N.3.8.2.1 CARBON DIOXIDE INTERFACE CONTROL

A. The integrated rack *should* provide a valve, located within the integrated rack envelope, to turn on and off the flow of carbon dioxide to the integrated rack.

B. The integrated rack **shall** provide a means to control the flow of carbon dioxide to not exceed 0.59 kg/hr (1.30 lbm/hr) when connected to the carbon dioxide interface operating pressure range of 517 to 786 kPa (75 to 114 psia).

N.3.8.2.2 CARBON DIOXIDE INTERFACE MDP

The MDP of the integrated rack carbon dioxide system **shall** be 1,379 kPa (200 psia).

N.3.8.2.3 CARBON DIOXIDE INTERFACE TEMPERATURE

The carbon dioxide supply temperature range is 13°C to 45°C (55.4°F to 113°F).

N.3.8.2.4 CARBON DIOXIDE LEAKAGE

The integrated rack **shall** have a carbon dioxide leakage rate no greater than 10^{-3} scc/s at MDP. Leakage is considered to be loss to the cabin atmosphere associated with quick disconnects, fittings, seals, valves, and permeation through materials from, and including, the standoff UIP connection to the carbon dioxide on/off flow control point in the integrated rack. All carbon dioxide flowing past the on/off flow control point is considered usage. The integrated rack allocation for carbon dioxide will comprise leakage and usage.

N.3.8.2.5 CARBON DIOXIDE PHYSICAL INTERFACE

Integrated rack connectors for the carbon dioxide system mating requirements to the UIP connectors are specified in Paragraph N.3.1.1.7.

N.3.8.2.6 CARBON DIOXIDE QUANTITY

Data Deliverable: Provide quantity of carbon dioxide used by the payload and frequency of use.

N.3.8.3 HELIUM INTERFACE REQUIREMENTS

N.3.8.3.1 HELIUM INTERFACE CONTROL

A. The integrated rack *should* provide a valve, located within the integrated rack envelope, to turn on and off the flow of helium to the integrated rack.

B. The integrated rack **shall** provide a means to control the flow of helium to not exceed 0.21 kg/hr (0.47 lbm/hr) when connected to the helium interface operating pressure range of 517 to 786 kPa (75 to 114 psia).

N.3.8.3.2 HELIUM INTERFACE MDP

The MDP of the integrated rack helium system **shall** be 1,379 kPa (200 psia).

N.3.8.3.3 HELIUM INTERFACE TEMPERATURE

The helium temperature range is 13°C to 45°C (55.4°F to 113°F).

N.3.8.3.4 HELIUM LEAKAGE

The integrated rack **shall** have a helium leakage rate no greater than 10-3 scc/s at MDP. Leakage is considered to be loss to the cabin atmosphere associated with quick disconnects, fittings, seals, valves, and permeation through materials from, and including, the standoff UIP connection to the helium on/off flow control point in the integrated rack. All helium flowing past the on/off flow control point is considered usage. The integrated rack allocation for helium will comprise leakage and usage.

N.3.8.3.5 HELIUM PHYSICAL INTERFACE

Integrated rack connectors for the helium system mating requirements to the UIP connectors are specified in Paragraph N.3.1.1.7.

N.3.8.3.6 HELIUM QUANTITY

Data Deliverable: Provide quantity of helium used by the payload and frequency of use.

N.3.9 ENVIRONMENT INTERFACE REQUIREMENTS

N.3.9.1 INTEGRATED RACK USE OF CABIN ATMOSPHERE

N.3.9.1.1 ACTIVE AIR EXCHANGE

Payloads *should* not use cabin air for cooling.

N.3.9.2 AVERAGE RACK FRONT SURFACE TEMPERATURE IN THE JEM

Integrated racks in the JEM **shall** maintain an average front surface temperature of less than 37 °C (98.6 °F).

N.3.10 FIRE PROTECTION INTERFACE REQUIREMENTS

N.3.10.1 PAYLOAD MONITORING AND DETECTION REQUIREMENTS

Integrated racks are classified as one of four types: 1) single forced airflow volumes, 2) multiple separate forced airflow volumes, 3) a combination forced airflow volume(s) / no forced airflow volumes(s), and 4) no forced airflow volumes. For a single forced airflow volume integrated rack, the ISS monitors and detects fire events within payloads containing potential fire sources by using a station approved rack smoke detector. For multiple separate forced airflow volumes (which do not exchange air with the other volumes), the main avionics area will monitor and detect fire events with the station approved smoke detector and other volumes with forced airflow will use parameter monitoring. For combination forced airflow volume(s) / no forced airflow volume(s), the forced airflow volume containing the main avionics area in the integrated rack will use parameter monitoring. For integrated racks that contain a potential fire source but do not have any forced airflow volumes, parameter monitoring will be used as an alternative. Volumes containing no potential fire sources do not require detection capabilities. Aisle mounted equipment (laptop computers, etc.) which rely on module smoke detectors for fire event detection, will not require internal fire event detection capabilities.

N.3.10.1.1 SMOKE DETECTION

N.3.10.1.1.1 SMOKE DETECTOR

Integrated racks that contain a potential fire source and have forced air circulation **shall** use an Allied Signal smoke detector P/N 2351520-2-1 for area type, or P/N 2351510-2-1 for duct type. Non-compliance with this requirement requires an NCR.

Note: Detection of a fire event with the smoke detector constitutes a Class 1 - Emergency per I.3.4.1.4.1.1.

The electrical power to the smoke detector is supplied from the rack internal power distribution.

The interface for the rack unique smoke detector is as depicted in the simplified schematic of Figure N.3.10.1.1.1-1, Principal Circuit for the Smoke Sensor Interface (reference SSP 41002, Figure 3.3.4.1.1-1).

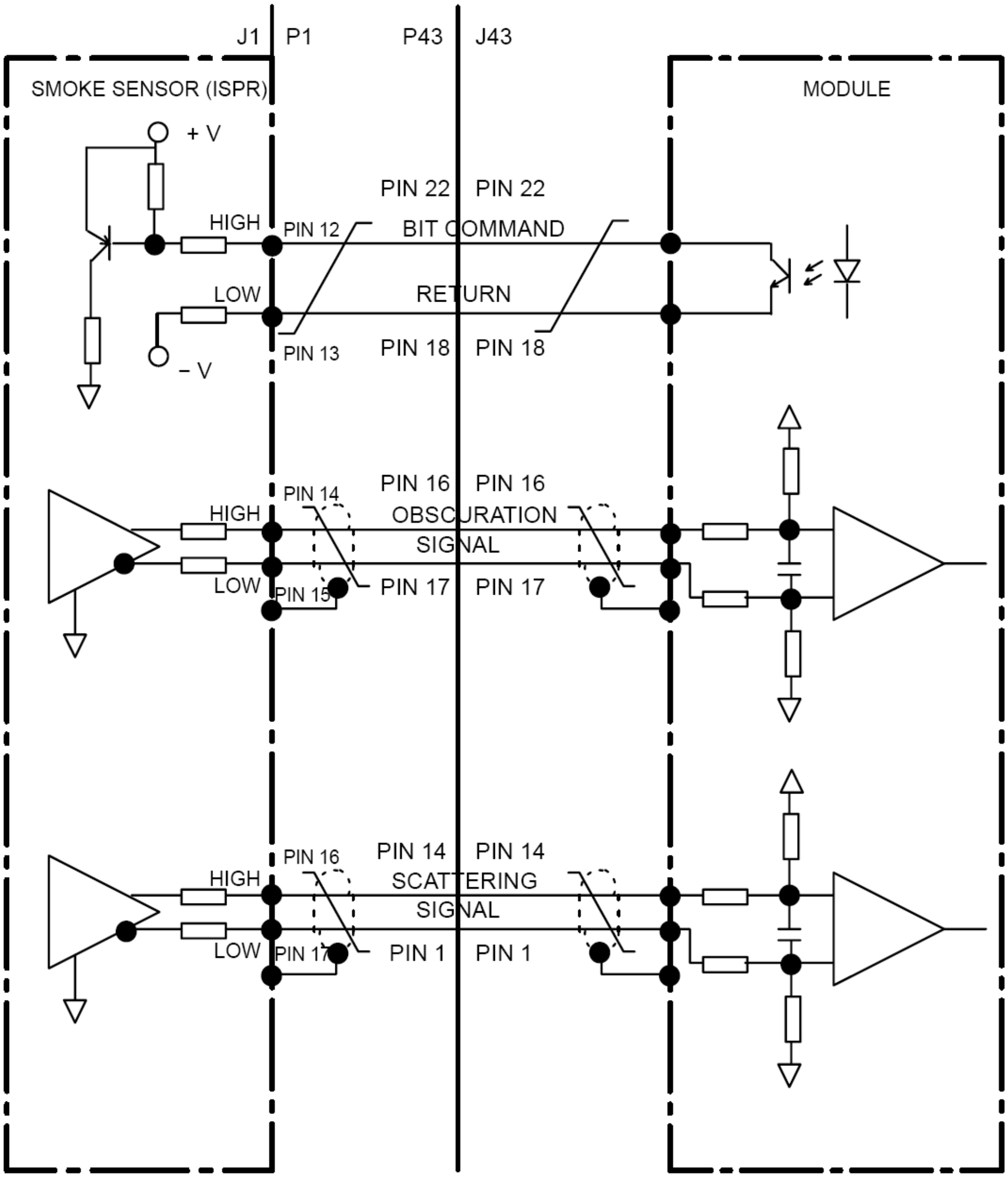


FIGURE N.3.10.1.1.1-1 PRINCIPAL CIRCUIT FOR THE SMOKE SENSOR INTERFACE

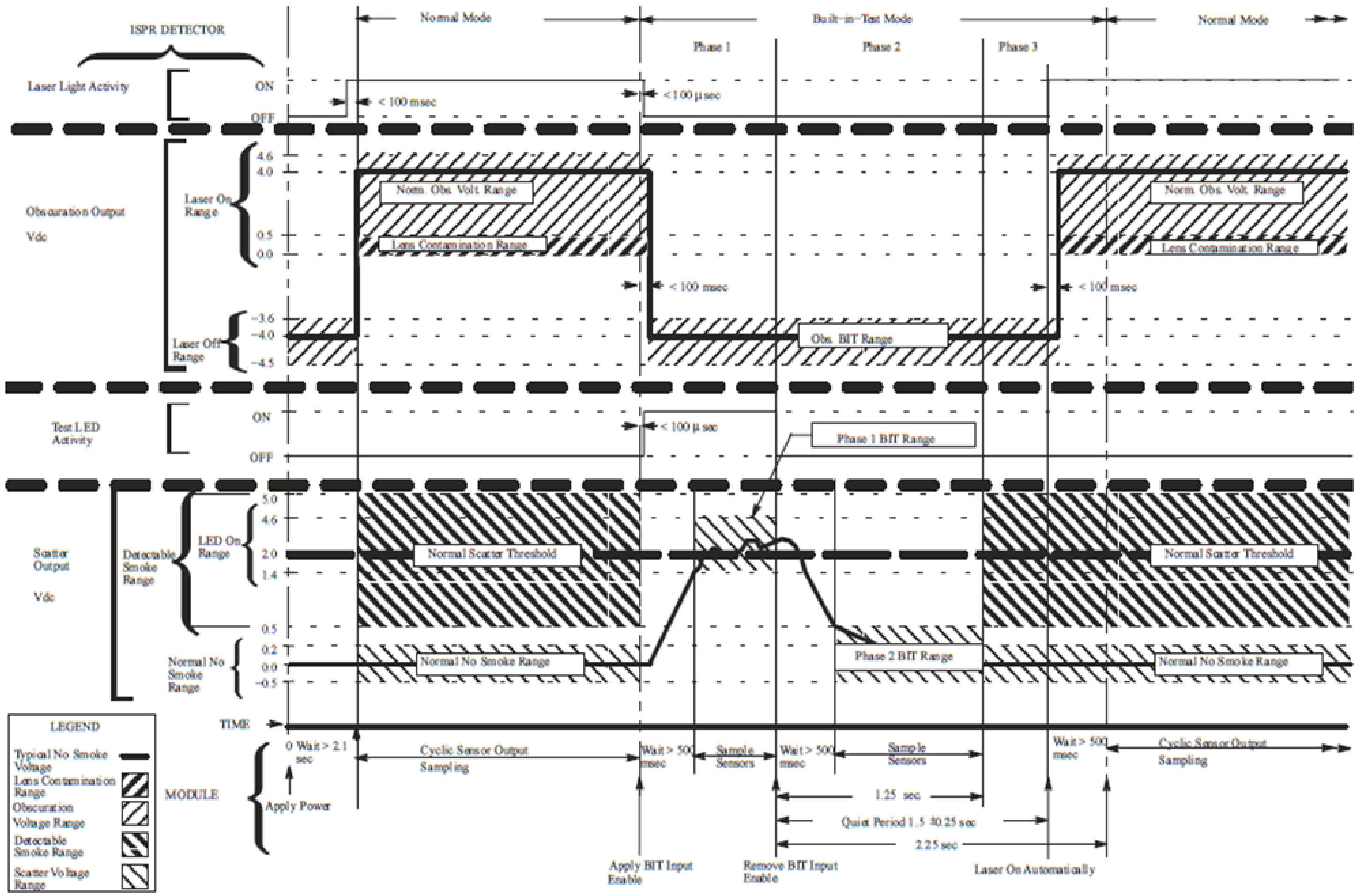
N.3.10.1.1.1.1 DISCRETE COMMAND BUILT-IN-TEST OBSCURATION OUTPUT AND SCATTER OUTPUT INTERFACE CHARACTERISTICS

The smoke detector obscuration output and scatter output interface characteristics **shall** be in accordance with the voltage ranges for BIT On, BIT Off, and Nominal modes as shown in Table N.3.10.1.1.1.1-1 and Figure N.3.10.1.1.1.1-1 (reference SSP 41002, Table 3.3.4.1.1.3-1 and Figure 3.3.4.1.1.3-1).

TABLE N.3.10.1.1.1.1-1 SMOKE DETECTION SUPPORT FUNCTIONAL CHARACTERISTICS

Type	Signal Name	Signal Type	Condition	Signal Range	Voltage Range (Signal Range) Nominal
Smoke Detector	BIT input	Discrete	Nominal	Open (high)	V= +5.0 Vdc
			BIT ON	Closed (low)	V< +5.0 Vdc
	Obscuration Output	Analog	Nominal	0 to 100% light attenuation	V= -4 to +4 Vdc
			BIT ON	Laser OFF	V< –3.8 Vdc
	Scatter output	Analog	Nominal	0 to 2% OBS/ ft	0 to 4.5 Vdc
			BIT ON	0.9 to 2.1% OBS/ ft	1.8 to 4.2 Vdc
			BIT Off (Quiet Period)	0% OBS/ ft	0 to 0.5 Vdc

Note: Figure N.3.10.1.1.1.1-1 takes precedence over Table N.3.10.1.1.1.1-1.



Note: Initial threshold values for JEM are different from these in this figure, but they will be adjusted by command from ground.

FIGURE N.3.10.1.1.1.1-1 SMOKE DETECTOR TIMING AND SIGNAL RANGES

N.3.10.1.1.2 FORCED AIR CIRCULATION INDICATION

Integrated racks requiring a smoke detector **shall** provide a signal in accordance with Table N.3.10.1.1.2-1 indicating the presence of airflow in the velocity range of 3 to 36.6 meters per minute (10 to 120 feet per minute) for the Area Smoke Detector (Allied Signal [Honeywell] P/N 2351520-2-1 or 2119818-3-1) or 18.3 to 603.5 meters per minute (60 to 1980 feet per minute) for the Duct Smoke Detector (Allied Signal [Honeywell] P/N 2351510-2-1 or 22119814-3-1) when the smoke detector is in use. Non-compliance with this requirement requires an NCR.

TABLE N.3.10.1.1.2-1 ELECTRICAL CHARACTERISTICS ENVELOPE OF AIRFLOW ANALOG SIGNAL

PARAMETER	ENG. UNIT	ANALOG SIGNALS
TYPE	N/A	Balanced
TRANSFER	N/A	DC Coupled
ANALOG VOLTAGE (line to line)	V	-5 to +5
RIPPLE AND NOISE	mV Peak (1)	±20
CAPACITY (Maximum)	nF	N/A
IMPEDANCE	ohm	≤ 1K
OVERVOLTAGE PROTECTION (Min)	V	±15
FAULT VOLTAGE EMISSION (Max)	V	±15
FAULT CURRENT LIMIT. (Maximum)	mA	±10 (2)

Notes: (1) Measurement Bandwidth ^{3} 50 MHz
(2) ISPR AAA= 30mA max

N.3.10.1.1.3 SMOKE INDICATOR

A. Integrated racks requiring a smoke detector **shall** provide a red Smoke Indicator LED in an easily visible location on the front of the rack that is powered by the ISS when the smoke detector senses smoke. Non-compliance with this requirement requires an NCR.

B. The Smoke Indicator LED **shall** be compatible with the interface characteristics specified in Table N.3.10.1.1.3-1, Smoke Indicator Interface Characteristics.

The signal to the LED is provided by the module to the rack via the J43 connector.

TABLE N.3.10.1.1.3-1 SMOKE INDICATOR INTERFACE CHARACTERISTICS

PARAMETER	UNIT	SOURCE (MODULE) (5)			DESTINATION (ISPR) (6)		
		COL	JEM	USL	COL	JEM	USL
TYPE	NA	Single-Ended	Single-Ended or Floating	Single-Ended or Floating	Floating	Floating	Floating
TRANSFER	NA	DC-Coupled	DC-Coupled	DC-Coupled	DC-Coupled	DC-Coupled	DC-Coupled
OFF STATE LEAKAGE CURRENT	mA	500 (max)	500 (max)	500 (max)	N/A	N/A	N/A
ON STATE VOLTAGE RANGE	V	12 to 18	12 to 16	12.9 to 17	N/A	N/A	N/A
LOAD CURRENT (max) (1)	mA	N/A	N/A	N/A	26	24	24
OVERVOLTAGE PROTECTION RANGE (2)	V	N/A	N/A	N/A	-2 to +20	-2 to +20	-2 to +22.5
FAULT VOLTAGE EMISSION (max)	V	20	20	22.5	N/A	N/A	N/A
FAULT CURRENT LIMIT (max)	mA	30	38 (4)	30	N/A	N/A	N/A
CAPACITANCE (3)	nF	N/A	N/A	N/A	<2	<2	<3.6

1) Allowable current a Payload may use in the indicated module.
2) Over-voltage protection for the load can include component selection that allows the circuit to tolerate voltage greater than 20 volts.
3) Allowable capacitance the Payload may have in the indicated module.
4) Assuming that the destination side is 0 (zero) ohms.
5) Interface characteristics of the module that may be used for analytical verification of the Payload interface characteristics. These module characteristics are not intended to be verified by the Payload.
6) Interface characteristics of the Payload while in the indicated module.

N.3.10.1.2 PARAMETER MONITORING

N.3.10.1.2.1 PARAMETER MONITORING USE

Integrated rack or subrack volumes that contain a potential fire source and do not exchange air with the rack smoke detector because no forced air circulation is present, or for metabolic or science isolation purposes **shall** provide sensors that monitor the volume to detect a potential fire event. Non-compliance with this requirement requires an NCR.

Note: Detection of a potential fire event in these volumes constitutes a Class 2 – Warning per Paragraph I.3.4.1.4.1.2.

N.3.10.1.2.2 PARAMETER MONITORING RESPONSE

N.3.10.1.2.2.1 PARAMETER MONITORING IN SUBRACK

A. The integrated rack **shall** provide manual and automatic capabilities to terminate forced air circulation (if present) and power to each subrack volume/payload that is monitored with parameter monitoring. Non-compliance with this requirement requires an NCR.

Note: For integrated racks where the payload MDM provides the monitoring function, the P/L MDM is capable of sending a command to the rack to command the rack to power off the subrack volume/payload to meet the automatic requirement if negotiated in the Software ICD if implemented by the payload.

B. The integrated rack **shall** respond to a potential fire event within a separate, subrack volume/payload that is monitored with parameter monitoring by sending data to indicate the location of the potential fire event, data indicating which parameter annunciated the potential fire event and data for evaluating the potential fire event condition to the payload MDM in the format specified in Paragraph I.3.4.1.4.A. Non-compliance with this requirement requires an NCR.

C. The integrated rack **shall** respond to a potential fire event within a separate, subrack volume/payload that is monitored with parameter monitoring by sending a Class 2 - Warning word to the payload MDM in the format specified in Paragraph I.3.4.1.4.B. Non-compliance with this requirement requires an NCR.

N.3.10.1.2.2.2 PARAMETER MONITORING IN INTEGRATED RACK

A. Integrated racks only using parameter monitoring **shall** provide manual and automatic capabilities to terminate forced air circulation (if present) and power to the integrated rack. Non-compliance with this requirement requires an NCR.

Note: Use of the PCS (connected to the Command and Control MDM) meets the manual requirement in all modules. For integrated racks where the payload MDM provides the monitoring function, the payload MDM is capable of sending a command to the module RPC that will power off the rack to meet the automatic requirement if negotiated in the unique software ICD if implemented by the payload and with the Module Integrator.

B. Integrated racks only using parameter monitoring **shall** respond to a potential fire event by sending data to indicate the location of the potential fire event, data indicating which parameter annunciated the potential fire event, and data for evaluating the potential fire event condition to the payload MDM in the format specified in Paragraph I.3.4.1.4.A. Non-compliance with this requirement requires an NCR.

C. The integrated rack **shall** respond to a potential fire event that is monitored with parameter monitoring by sending a Class 2 - Warning word to the payload MDM in the format specified in Paragraph I.3.4.1.4.B. Non-compliance with this requirement requires an NCR.

N.3.10.2 FIRE SUPPRESSION

N.3.10.2.1 PORTABLE FIRE EXTINGUISHER ACCESS PORT

Each integrated rack and payload volume required to have a PFE access port(s) **shall** provide a PFE access port(s) with the diameter based on the payload panel thickness as shown in Table N.3.10.2.1-1. Non-compliance with this requirement requires an NCR.

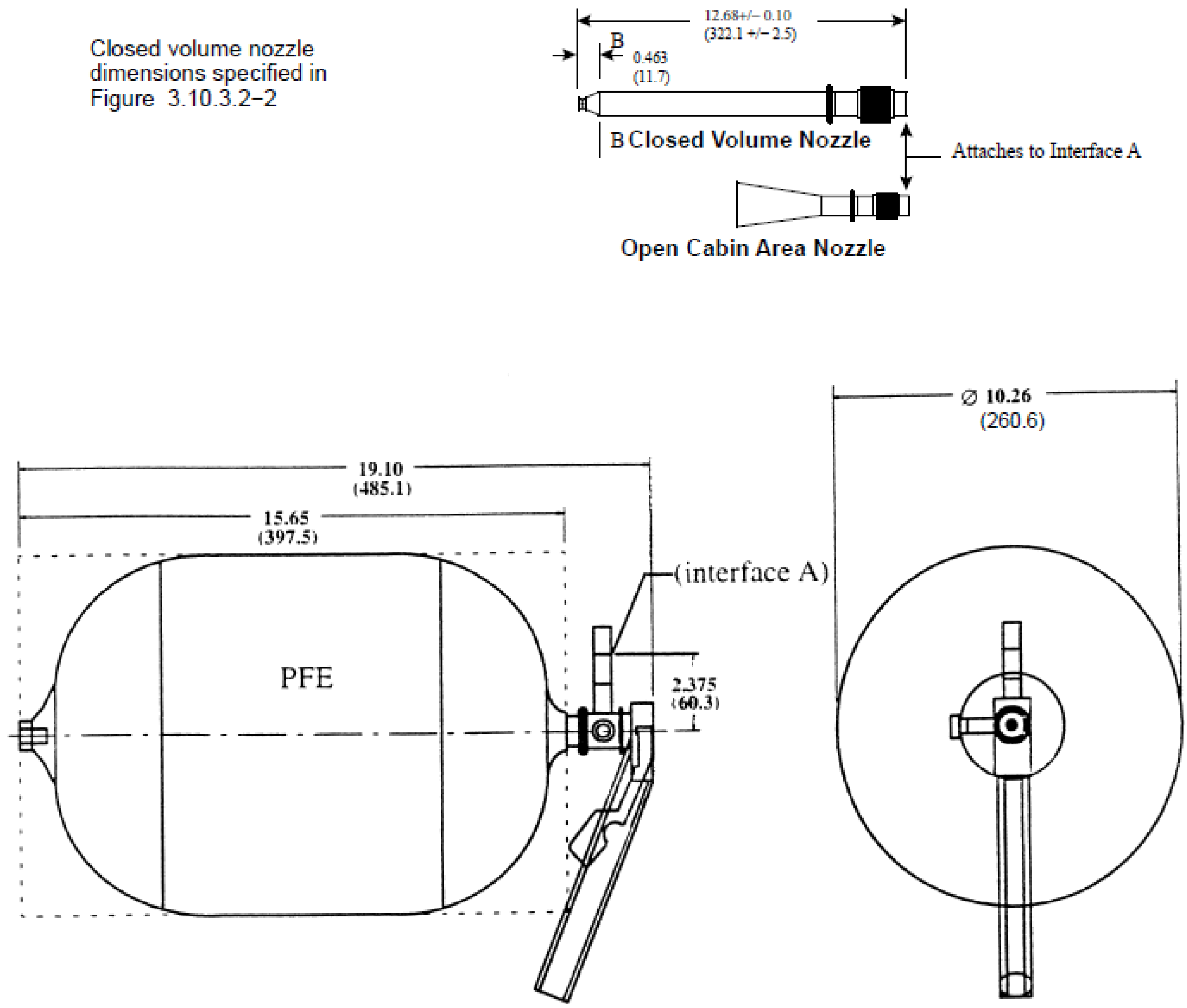
TABLE N.3.10.2.1-1 PFE PORT DIAMETER SELECTION

Payload Panel Thickness	PFE Port Diameter
≤ 3.175 mm (0.125 inch)	12.7 mm (0.5 inch) or 25.4 mm (1.0 inch)
> 3.175 mm (0.125 inch)	25.4 mm (1.0 inch)

N.3.10.2.2 FIRE SUPPRESSION ACCESS PORT ACCESSIBILITY

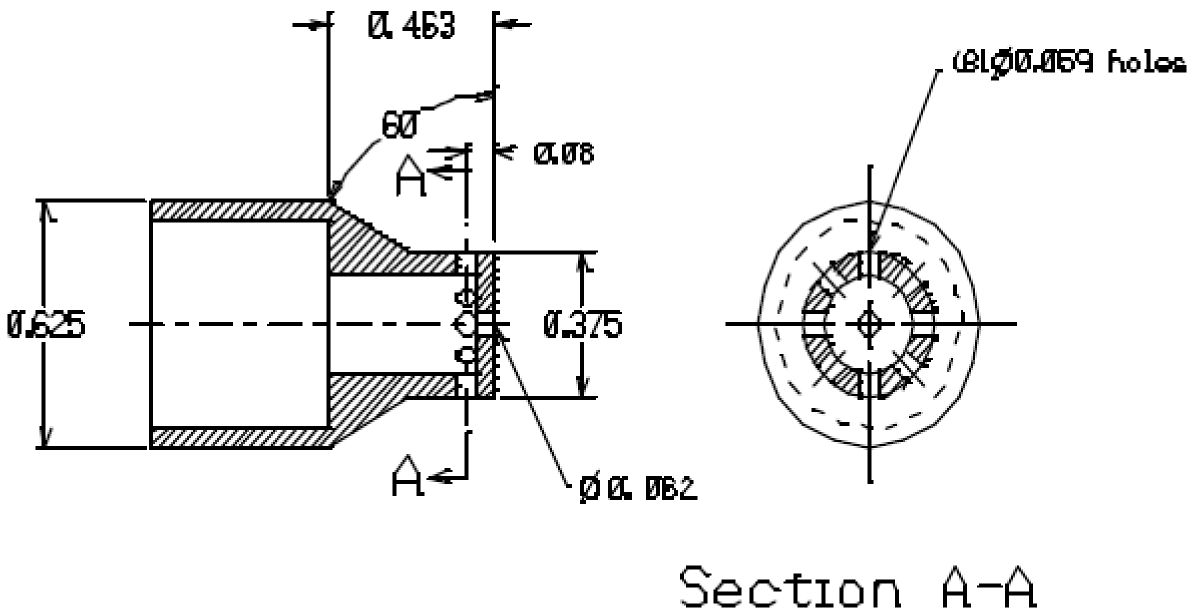
A. Integrated racks and subrack payload volumes required to have a PFE access port(s) **shall** have a front face designed to accommodate the PFE nozzle and bottle as specified in Figures N.3.10.2.2-1 and N.3.10.2.2-2. Non-compliance with this requirement requires an NCR.

B. Integrated racks and subrack payload volumes required to have a PFE access port(s) **shall** locate each PFE access port so it is clearly visible without having to move any equipment. Non-compliance with this requirement requires an NCR.



Note: Measurements from PFE centerline to point B with the closed cabin. Nozzle attached is approximately 14.59 inches (370.6 mm)

FIGURE N.3.10.2.2-1 MANUAL FIRE SUPPRESSION HARDWARE ENVELOPE



Note: Linear dimensions are in inches, angular dimensions are in degrees.

FIGURE N.3.10.2.2-2 CLOSED VOLUME PFE NOZZLE

N.3.10.2.3 FIRE SUPPRESSANT DISTRIBUTION

The internal layout of each integrated rack and payload volume requiring a PFE access port(s) **shall** allow PFE fire suppressant to be distributed to the entire volume that PFE access port serves, lowering the Oxygen concentration to or below 10.5% by volume at any point within the enclosure within one minute using a single PFE. Non-compliance with this requirement requires an NCR.

Note: The position of the integrated rack and payload volume internal components near the PFE access port(s) must not prevent fire suppressant to be discharged into the volume the PFE access port serves. PFE discharge characteristics are specified in Figure 3.1.1.2-1 and PFE closed volume nozzle dimensions are specified in Figure N.3.10.2.2-2.

N.3.10.3 PFE ACCESS PORT AND FIRE DETECTION INDICATOR LABELING

Integrated racks and subrack payload volumes required to have a PFE access port(s) **shall** cover each PFE access port with a standard issue decal based on the diameter of the access port. Part numbers for the appropriate "Decal, Fire Hole" decal as specified in JSC 27260 are shown in Table N.3.10.3-1.

TABLE N.3.10.3-1 PFE DECAL PART NUMBERS

PFE Access Port Diameter	"Decal, Fire Hole" Part Number
0.5 inch (12.7 mm)	SDD32100397-003
1.0 inch (25.4 mm)	SDD32100397-004

N.3.11 MATERIALS AND PROCESSES INTERFACE REQUIREMENTS

N.3.11.1 FLUID CHEMICAL COMPOSITION

A. Integrated racks and subrack payloads connecting to the ISS nitrogen fluid system **shall** be charged with nitrogen that meets the requirements for Grade A Nitrogen specified in MIL-PRF-27401, Performance Specification, Propellant Pressurizing Agent, Nitrogen, to a pressure no greater than 70 psia (480 kPa).

B. Integrated racks connecting to the ISS argon fluid system **shall** be charged with argon that meets the requirements specified in MIL-A-18455, Military Specification, Argon, Technical, to a pressure no greater than 70 psia (480 kPa).

C. Integrated racks connecting to the ISS carbon dioxide fluid system **shall** be charged with carbon dioxide that meets the requirements specified in BB-C-101, Federal Specification, Carbon Dioxide, to a pressure no greater than 70 psia (480 kPa).

D. Integrated racks connecting to the ISS helium fluid system **shall** be charged with helium that meets the requirements specified in MIL-PRF-27407, Performance Specification, Propellant Pressurizing Agent, Helium, to a pressure no greater than 70 psia (480 kPa).

N.3.11.2 FLUID SYSTEM CLEANLINESS

A. Integrated racks and subrack payload fluid systems connecting to the ISS nitrogen fluid system **shall** meet the fluid system cleanliness levels of 200A per MIL-STD-1246.

B. Integrated rack fluid systems connecting to the JEM argon fluid system **shall** meet the fluid system cleanliness levels of 300A per MIL-STD-1246.

C. Integrated rack fluid systems connecting to the JEM carbon dioxide fluid system **shall** meet the fluid system cleanliness levels of 300A per MIL-STD-1246.

D. Integrated rack fluid systems connecting to the JEM helium fluid system **shall** meet the fluid system cleanliness levels of 300A per MIL-STD-1246.

N.3.12 HUMAN FACTORS INTERFACES

N.3.12.1 GLOVEBOX OPERATION LIGHTING

Integrated racks with gloveboxes **shall** meet the glovebox operations lighting value as specified in Table N.3.12.1-1.

TABLE N.3.12.1-1 RACK REQUIRED ILLUMINATION LEVELS

Type of Task	Required Lux (Foot-Candles)*
Medium payload operations (not performed in the aisle) (e.g., payload change-out and maintenance)	325 (30)
Fine payload operations (e.g., instrument repair)	1075 (100)
Medium glovebox operations (e.g., general operations, experiment set-up)	975 (90)

* As measured at the task site

N.3.12.2 GLOVEBOX BRIGHTNESS RATIO

Lighting in gloveboxes, excluding spot illumination, *should* not exceed a brightness ratio of 3:1.

N.3.12.3 CONTINUOUS NOISE LIMITS

The Continuous Noise Source (see Glossary of Terms) for an integrated rack **shall** not exceed the limits specified in Table N.3.12.3-1 for all octave bands (NC-40 equivalent). The integrated rack noise level must include any supporting adjunct active portable equipment operated outside the integrated rack that is within or interfacing with the crew habitable volume. This requirement is to be assessed when the equipment is operating in the loudest expected configuration and mode of operation that can occur on-orbit under nominal crew, or hardware operation circumstances, during integrated rack setup operations, or during nominal operations where doors/panels are opened or removed.

Note: This acoustic requirement does not apply during failure or maintenance operations, or in those cases when the rack meets the Intermittent Noise Source requirements specified in Paragraph 3.12.3.2.

TABLE N.3.12.3-1 CONTINUOUS NOISE LIMITS

Rack Noise Limits Measured At 0.6 Meters Distance From The Test Article	
Frequency Band (Hz)	**Integrated Rack SPL (dB)**
63	64
125	56
250	50
500	45
1000	41
2000	39
4000	38
8000	37

N.4.0 VERIFICATION

N.4.1 RESPONSIBILITIES

The payload developer is responsible for providing verification for all applicable requirements in this appendix, as allocated to the payload through the payload unique ICD. The ISS Program is responsible for review and approval of the submitted verification.

N.4.2 VERIFICATION METHODS

Compliance with the requirements stated in Section N.3.0 are proven using one or more of the methods described in paragraph 4.2.

N.4.3 ISS TO INTEGRATED RACK INTERFACE VERIFICATION REQUIREMENTS

N.4.3.1 STRUCTURAL/MECHANICAL AND MICROGRAVITY INTERFACE REQUIREMENTS

N.4.3.1.1 STRUCTURAL/MECHANICAL INTERFACES

N.4.3.1.1.1 RACK WEIGHT

The integrated rack weight requirement **shall** be verified by a test and analysis involving measuring the weight of the integrated rack and an analysis that accounts for attached GSE and any changes during on-orbit operations. Verification **shall** be considered successful when the weight is measured to an accuracy of 2.3 kg (5 lbs) and is less than the specified maximum weight. The PD **shall** submit a data cert for the test and an analysis report providing the weight and cg summaries of the integrated rack.

Subrack payload changeout verification **shall** be accomplished by test, measuring the weight of the subrack. An analysis of the integrated on-orbit rack configuration **shall** be performed to confirm that the integrated rack does not exceed the specified maximum weight. Verification **shall** be considered successful when the analysis determines that the on-orbit rack configuration is less than the specified maximum weight.

Verification Submittal: Data Cert

N.4.3.1.1.2 ON-ORBIT KEEP-OUT ZONE FOR KBAR

Verification that the integrated rack complies with a keep-out zone *should* be by analysis. The analysis *should* include an inspection and evaluation of installation drawings/procedures. Verification *should* be considered successful when the analysis verifies that the integrated rack provides a keep-out zone to accommodate K bars part numbers 683-62201-3, -4, -33, and -44.

Verification Submittal: CoC

N.4.3.1.1.3 RACK ROTATION

An analysis *should* be conducted using the integrated rack and module data to evaluate the maximum rotation angle. The verification *should* be considered successful when the rotation angle is calculated to be at least 80 degrees.

Verification Submittal: CoC

N.4.3.1.1.4 RACK ROTATION WITH UTILITIES

The rack rotation *should* be verified by analysis. The analysis *should* be performed using lower-level component qualification data. The verification *should* be considered successful when the pressurized volume racks that are designed to rotate, are shown able to rotate as specified.

Verification Submittal: CoC

N.4.3.1.1.5 SEAT TRACKS

Verification that seat tracks are installed on the integrated rack per Figure N.3.1.1.5-1 **shall** be by inspection. The inspection **shall** be of the as-built hardware drawings to determine that seat tracks are installed per the defined requirements. The verification **shall** be considered successful if the inspection of the as-built drawings demonstrates that seat tracks are installed in the proscribed locations. Boeing ISPRs, P/N 683-50243-4, meet this requirement.

Verification Submittal: CoC

N.4.3.1.1.6 UMBILICAL PHYSICAL MATE

A demonstration *should* be conducted using the Payload Rack Checkout Unit (PRCU) or equivalent to show that the umbilicals can successfully reach their intended connector and the connectors are observed in a fully mated condition.

Verification Submittal: CoC

N.4.3.1.1.7 CONNECTOR PHYSICAL MATE

A. Verification that the payload connectors physically mate with the corresponding module connectors **shall** be by demonstration. The demonstration **shall** use module connectors with the part numbers specified in Table N.3.1.1.7-1 to verify that the connectors physically mate. The verification **shall** be considered successful when the demonstration shows the payload connectors physically mate with its corresponding module connectors.

Verification Submittal: CoC

B. Verification of the payload connectors with the requirements of SSQ 21635 **shall** be by inspection. The inspection **shall** be a review of payload connector design drawings. The inspection **shall** be considered successful when the review shows the drawings identify the SSQ 21635 or equivalent requirement for the rack connectors.

Verification Submittal: CoC

C. Verification that connectors provide protection to prevent damage when unmated **shall** be by inspection of drawings or flight hardware. Verification **shall** be considered successful with the inspection shows that protection for unmated connectors is provided.

Verification Submittal: CoC

N.4.3.1.1.8 UTILITY INTERFACE PANEL CONNECTOR PIN ASSIGNMENTS

A. Verification of J1 and J2 pin assignment **shall** be by inspection. The inspection **shall** be of payload drawings to verify the J1 and J2 pin assignments. The verification **shall** be considered successful when the inspection shows that the J1 and J2 pin assignments are as specified in Figure N.3.1.1.8-1.

Verification Submittal: CoC

B. Verification of J3 and J4 pin assignments **shall** be by inspection. The inspection **shall** be of payload drawings to verify the J3 and J4 pin assignments. The verification **shall** be considered successful when the inspection shows that the J3 and J4 pin assignments are as specified in Figure N.3.1.1.8-2 and Figure N.3.1.1.8-3.

Verification Submittal: CoC

C. Verification of J46 and J47 pin assignment **shall** be by inspection. The inspection **shall** be of payload drawings to verify the J46 and J47 pin assignments. The verification **shall** be considered successful when the inspection shows that the J46 and J47 pin assignments are as specified in Figure N.3.1.1.8-4 and Figure N.3.1.1.8-5.

Verification Submittal: CoC

D. Verification of J7 pin assignment *should* be by inspection. The inspection *should* be of payload drawings to verify the J7 pin assignments. The verification *should* be considered successful when the inspection shows that the J7 pin assignments are as specified in Figure N.3.1.1.8-6.

Verification Submittal: CoC

E. Verification of P43 appropriate pin assignment **shall** be by inspection. The inspection **shall** be of payload drawings to verify that the P43 pinout matches the corresponding J43 pinout. The verification **shall** be considered successful when the inspection shows that the P43 connector pinout is as specified in Figure N.3.1.1.8-7.

Verification Submittal: CoC

F. Verification of J16 pin assignment *should* be by inspection. The inspection *should* be of payload drawings to verify the J16 pin assignments. The verification *should* be considered successful when the inspection shows that the J16 pin assignments are as specified in Figure N.3.1.1.8-8.

Verification Submittal: CoC

G. Verification of J77 pin assignment **shall** be by inspection. The inspection **shall** be of payload drawings to verify the J77 pin assignments. The verification **shall** be considered successful when the inspection shows that the J77 pin assignments are as specified in Figure N.3.1.1.8-9.

Verification Submittal: CoC

N.4.3.1.2 MICROGRAVITY

NVR

N.4.3.1.2.1 QUASI-STEADY REQUIREMENTS

Verification *should* be by analysis. The analysis *should* be considered successful when it is shown that no impulse is greater than 10 lb·s (44.5 N·s) over any 10 to 500 second interval.

Verification Submittal: Analysis Report

N.4.3.1.2.2 VIBRATORY REQUIREMENTS

Verification **shall** be accomplished by test or analysis. Verification **shall** be considered successful when it is shown force levels are below Figure N.3.1.2.2-1 (Table N.3.1.2.2-1) or acceleration levels are below Figure N.3.1.2.2-2 (Table N.3.1.2.2-2). Guidance for verification of this requirement can be found in D684-13066-01, Payload Microgravity Verification Guidelines.

Verification Submittal: Analysis Report or Test Report

N.4.3.1.2.3 TRANSIENT REQUIREMENTS

Verification **shall** be by analysis or test. Verification **shall** be considered successful when the impulse delivered by an integrated rack or non-rack payload over any 10 second period is shown to be less than 10 lb·s (44.5 N·s) and when the sum of the impulse and vibration resulting from the impulse do not exceed the vibratory limits of 3.1.2.2 over any 100 second period. FEM time domain analysis is an acceptable verification method for this requirement. Acceleration or force response test data is acceptable if interface impedance considerations are included, including adjustment for possible modal frequency shift and interface structural amplification or attenuation.

Verification Submittal: Analysis Report or Test Report

N.4.3.1.3 PROTRUSION REQUIREMENTS

Verification that permanent hardware does not extend beyond the GSE plane of the payload rack **shall** be by inspection. The inspection **shall** be of the integrated rack hardware or the as-built drawings of the integrated rack and subrack hardware. The verification **shall** be considered successful when the inspection shows that there are no permanent protrusions that extend beyond the GSE plane defined by Figure N.3.1.3-1.

Verification Submittal: Data Cert

N.4.3.2 ELECTRICAL INTERFACE REQUIREMENTS

N.4.3.2.1 ELECTRICAL POWER CHARACTERISTICS

NVR

N.4.3.2.1.1 INTERFACE B STEADY-STATE VOLTAGE CHARACTERISTICS

NVR

N.4.3.2.1.2 RIPPLE VOLTAGE CHARACTERISTICS

N.4.3.2.1.2.1 RIPPLE VOLTAGE AND NOISE

Ripple Voltage and Noise requirements **shall** be verified by analysis.

The verification **shall** be considered successful when the CS-01 test shows the integrated rack connected to Interface B operate and are compatible with the EPS time domain ripple voltage and noise level of at least 2.5 Vrms within the frequency range of 30 Hz to 1 MHz.

Verification Submittal: Analysis Report

N.4.3.2.1.2.2 RIPPLE VOLTAGE SPECTRUM

Ripple Voltage Spectrum requirements **shall** be verified by analysis.

Verification **shall** be considered successful when analysis of the CS-01 and CS-02 test data shows the integrated rack connected to Interface B and EPCE connected to interface C operates and is compatible with the ripple voltage spectrum in Figure N.3.2.1.2.2-1 of this document.

Verification Submittal: Analysis Report

N.4.3.2.1.3 TRANSIENT VOLTAGES

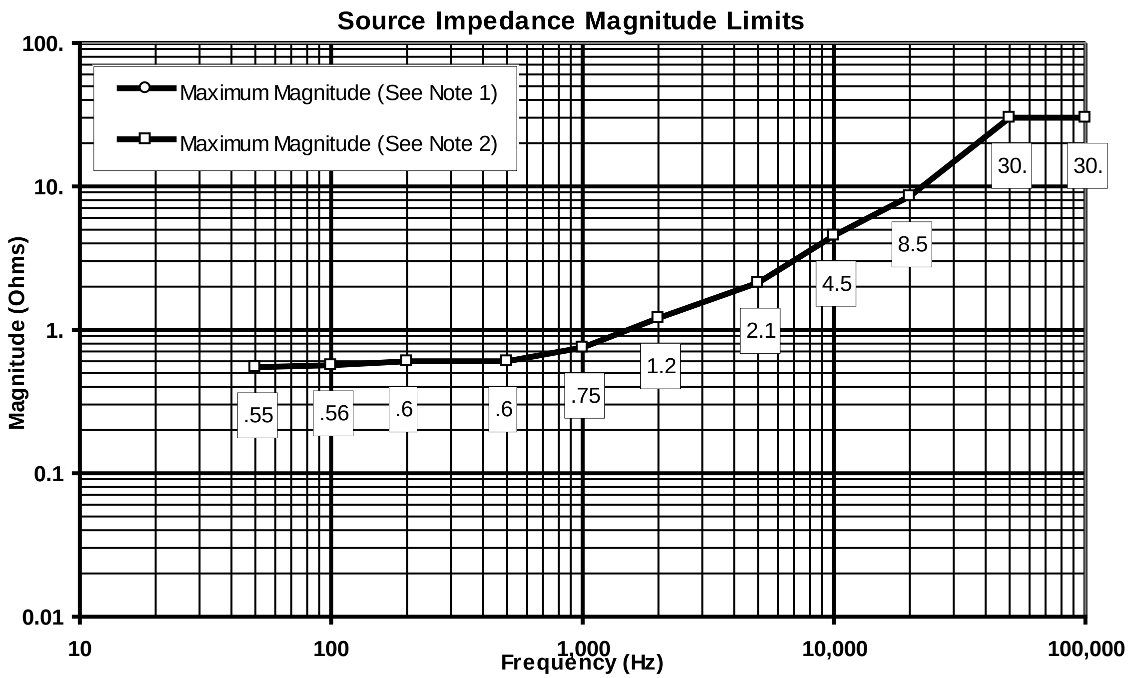
N.4.3.2.1.3.1 INTERFACE B

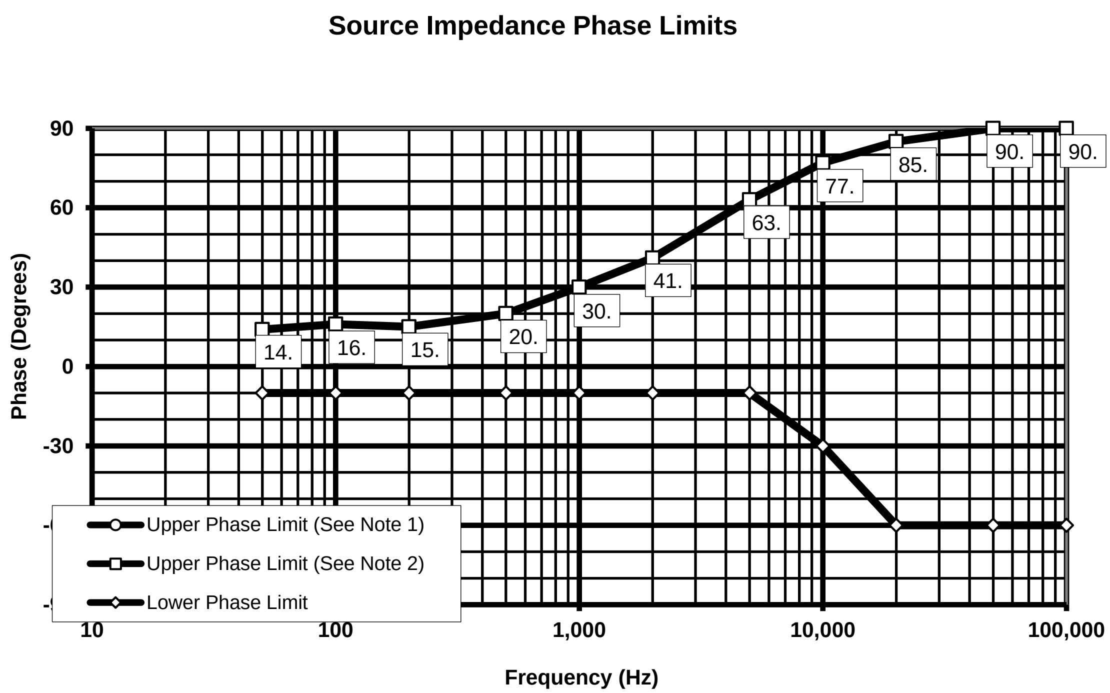
Transient Voltage requirements **shall** be verified by test or analysis.

Input voltage **shall** be 116 Vdc and 126 Vdc with the Interface B source impedance, as specified in Figures N.4.3.2.1.3.1-1, N.4.3.2.1.3.1-2, and N.4.3.2.1.3.1-3.

Verification of compatibility with the specified Transient Voltages **shall** be performed by test or analysis of the integrated rack operation across the transient envelope as specified in Figure N.3.2.1.3.1-1 of this document.

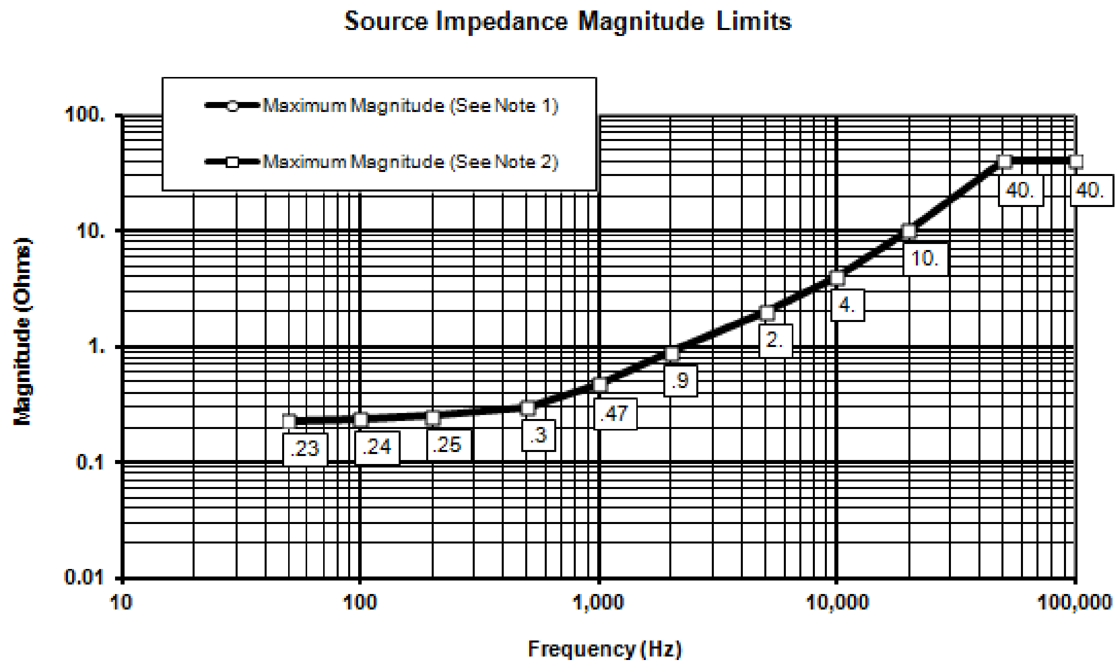
The verification **shall** be considered successful when the test or analysis shows the integrated rack is compatible with the EPS transient voltage characteristics as specified in Figure N.3.2.1.3.1-1.

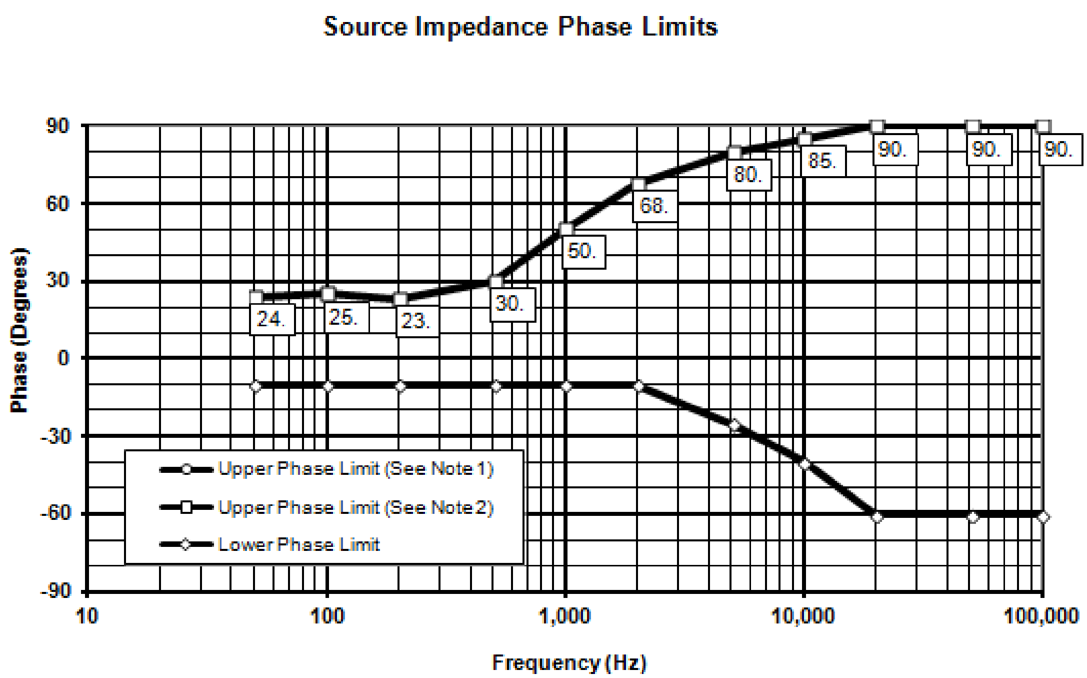




Notes:
1. Limit when total load on the Secondary Power Source is less than 400 watts.
2. Limit when total load on the Secondary Power Source is at least 400 watts.

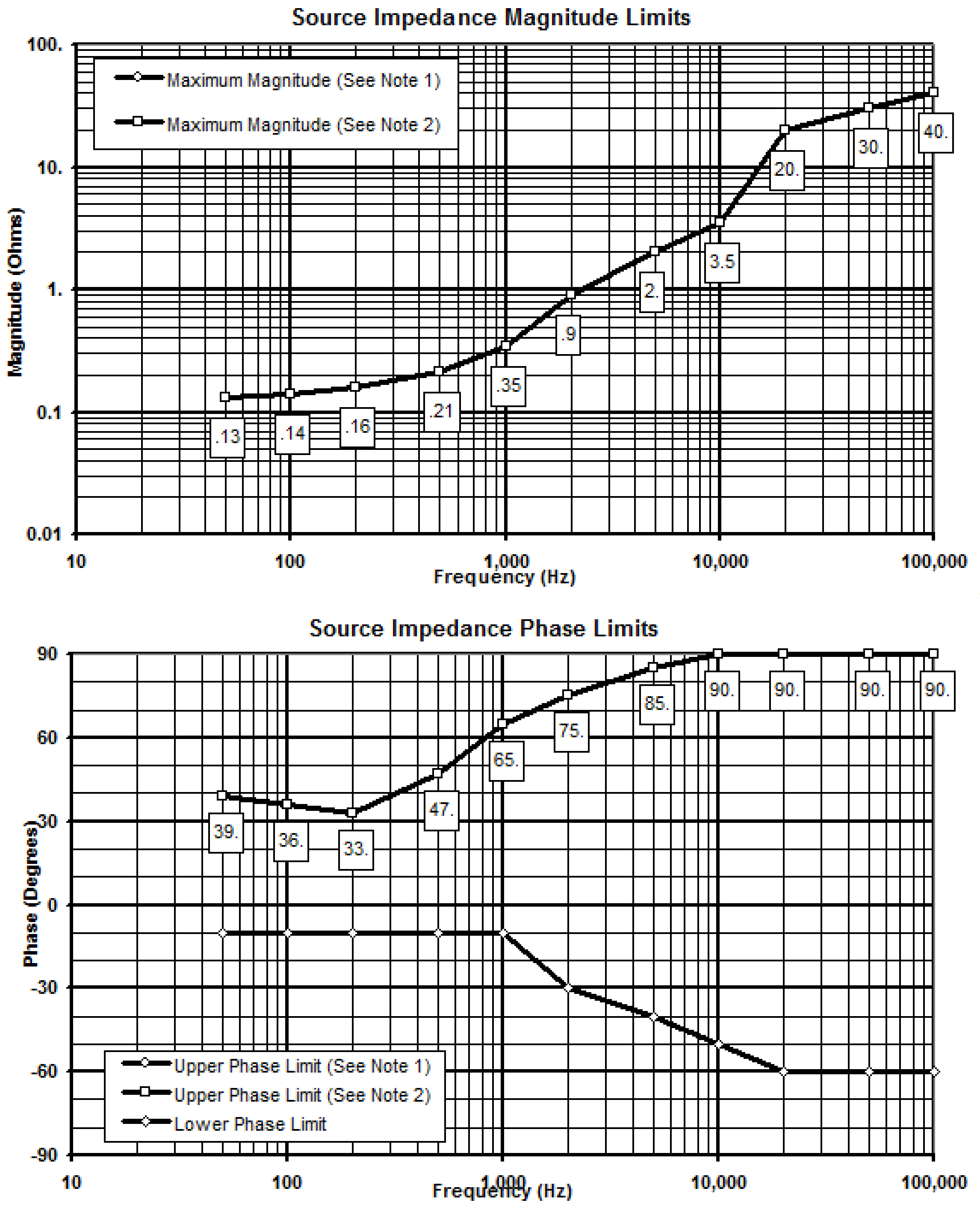
FIGURE N.4.3.2.1.3.1-1 1.44 KW INTERFACE B SOURCE IMPEDANCE, STANDARD





Notes:
1. Limit when total load on the Secondary Power Source is less than 400 watts.
2. Limit when total load on the Secondary Power Source is at least 400 watts.

FIGURE N.4.3.2.1.3.1-2 3 KW INTERFACE B SOURCE IMPEDANCE, STANDARD



Notes:
1. Limit when total load on the Secondary Power Source is less than 400 watts.
2. Limit when total load on the Secondary Power Source is at least 400 watts.

FIGURE N.4.3.2.1.3.1-3 6 KW INTERFACE B SOURCE IMPEDANCE, STANDARD

Verification Submittal: Test Report or Analysis Report

N.4.3.2.1.3.2 FAULT CLEARING AND PROTECTION

Fault Clearing and Protection *should* be verified by analysis.

The verification *should* be considered successful when analysis shows that the integrated rack at Interface B and EPCE at Interface C does not produce an unsafe condition or one that could result in damage to ISS equipment or payload hardware from the EPS transient voltages as specified in Figure N.3.2.1.3.2-1.

Note: The transient shown in the expanded view is a composite of three possible transient conditions; consequently, the analysis may consist of separate examination of the 12 microsecond transient, the 150 microsecond transient and the 300 microsecond transient.

Verification Submittal: Analysis Report

N.4.3.2.1.3.3 NON-NORMAL VOLTAGE RANGE

Verification of compatibility with Non-Normal Voltage Range conditions *should* be performed by analysis. The analysis *should* ensure the integrated rack will not produce an unsafe condition or one that could result in damage to ISS equipment external to the integrated rack when parameters are as specified in Paragraph N.3.2.1.3.3. Perform the analysis with all converters directly downstream of Interface B.

The verification *should* be considered successful when analysis shows the integrated rack is safe within ISS interface conditions as defined in Paragraph N.3.2.1.3.3.

Verification Submittal: Analysis Report

N.4.3.2.2 ELECTRICAL POWER INTERFACE

N.4.3.2.2.1 COMPATIBILITY WITH SOFT START/STOP RPC

Compatibility with Soft Start/Stop RPC(s) **shall** be verified by test.

Verification of initialization with soft start/stop performance characteristics **shall** be performed by test when the initial supply of power is provided to the equipment connected to the RPC(s). Input power to the integrated rack **shall** be delivered through a PRCU or equivalent. The integrated rack connected to Interface B **shall** be operated with multiple load combinations at levels ranging from 0% to 100% of the RPC rated conductivity.

The verification **shall** be considered successful when test shows the integrated rack can initialize operation with the soft start/stop RPC characteristics, representative of Figure N.3.2.2.1-1, as specified in Paragraph N.3.2.2.1.

Verification Submittal: Test Report

N.4.3.2.2.2 SURGE CURRENT

Surge Current **shall** be verified by test.

Verification of compatibility with Surge Current limits **shall** be performed by test using power representative of the ISS power environment at high and low input voltage values as specified. The power source used to perform the test **shall** be capable of providing a range of power between 0 kW to 6 kW at 116 Vdc to 126 Vdc for Interface B connected equipment. The integrated rack **shall** be operated under worst-case loading conditions that envelope operational loading and voltage ranges.

The verification **shall** be considered successful when test shows under high and low voltage conditions the integrated rack can perform all functional capabilities and prove compatibility by operating within the specified limits of Paragraph 3.2.2.4.

Verification Submittal: Test Report

N.4.3.2.2.3 REVERSE CURRENT

Integrated rack payloads **shall** verify the reverse current requirements per paragraph G.4.3.2.2.2.

N.4.3.2.2.4 CIRCUIT PROTECTION DEVICES

N.4.3.2.2.4.1 REMOTE POWER CONTROLLER (RPC) CHARACTERISTICS

NVR

N.4.3.2.2.4.2 RPC INTERFACE REQUIREMENTS

A. Analysis of the test data required by Paragraph N.3.2.2.2 **shall** be performed to show the integrated rack connected to an Interface B rack location operates with the characteristics shown and described in Figure N.3.2.2.4.1-1, Figure N.3.2.2.4.1-2, and Figure N.3.2.2.4.1-3 and in Paragraph N.3.2.2.4.2. The analysis **shall** be performed at initiation of power to the integrated rack and with multiple internal load combinations that include, but are not limited to subrack payloads. The verification **shall** be considered successful if the analysis results show the initial current flow, when powered “on”, to the integrated rack and current flow during the integrated rack operations with multiple internal load combinations including subrack payloads does not exceed the current magnitude and duration as defined and described in Figure N.3.2.2.4.1-1, Figure N.3.2.2.4.1-2, and Figure N.3.2.2.4.1-3 and in Paragraph N.3.2.2.4.2.

Verification Submittal: Analysis Report

B. Analysis of electrical circuit schematics **shall** be performed to show current limiting overcurrent protection exists for all internal loads drawing power from an Interface B power feed(s). The analysis **shall** be considered successful when results show current limiting overcurrent protection exists in the distribution paths to all load devices connected to an Interface B power feed(s).

Verification Submittal: Analysis Report

N.4.3.2.2.4.3 PAYLOAD TRIP COORDINATION WITH RPC

The integrated rack Trip Ratings **shall** be verified by analysis. An analysis **shall** be performed for the integrated rack connected to Interface B. The analysis will compare the current rating and trip characteristics of the circuit protection device in the integrated rack to the current rating and trip characteristics of the upstream RPC. The verification **shall** be considered successful when analysis shows that the circuit protection device in the integrated rack will trip before the upstream RPC.

Verification Submittal: Analysis Report

N.4.3.2.2.5 INTERFACE B COMPLEX LOAD IMPEDANCES

Integrated rack complex load impedance(s) **shall** be verified by test. Verification may be performed by the PRCU or equivalent only if the PRCU or equivalent meets the Interface C source impedance, as specified in Figure G.4.3.2.2.4-1, Standard Interface C Source Impedance, 10-12 Amperes Circuit Rating. All active converters directly downstream of Interface B **shall** be qualification or flight hardware. Loading of the downstream converter(s) can be simulated to provide full range of active converter loading. Load impedance **shall** be tested under conditions of high and low voltage to the integrated rack and with these conditions for the active converters directly downstream **shall** be exercised through the complete range of their loading. Selected combinations of converters that can influence the measured load impedance at Interface B **shall** be tested. The verification **shall** be considered successful when the test shows that all load impedances measured for high and low voltage conditions remain within specified limits. Note: The test report must include the following: 1. A brief description of the test setup and procedure. 2. Input impedances for each configuration tested, magnitude and phase between 100 Hz and 100 kHz, with a minimum of 20 points per decade being measured. Format: Graphical Data - plots of magnitude and phase versus frequency on a log scale. Identify with each plot: A. The combination of RPCs and switches that are powered (closed). B. Which electrical items are “on”, including items which have filters powered when the EPCE is “off”. C. The operational state or mode of each powered EPCE.

Verification Submittal: Test Report

N.4.3.2.2.6 LARGE SIGNAL STABILITY

Large signal stability **shall** be verified by test and analysis. A large signal stability test **shall** be conducted for the integrated rack connected to Interface B. An integrated analysis **shall** be provided by the rack integrator for representative maximum and minimum case loads to demonstrate that impedance variations will not impact system stability. The input and transient response waveform for the integrated rack **shall** be recorded from the start of the pulse through the time when the transient diminishes to and remains below 10 percent of the maximum amplitude of the response.

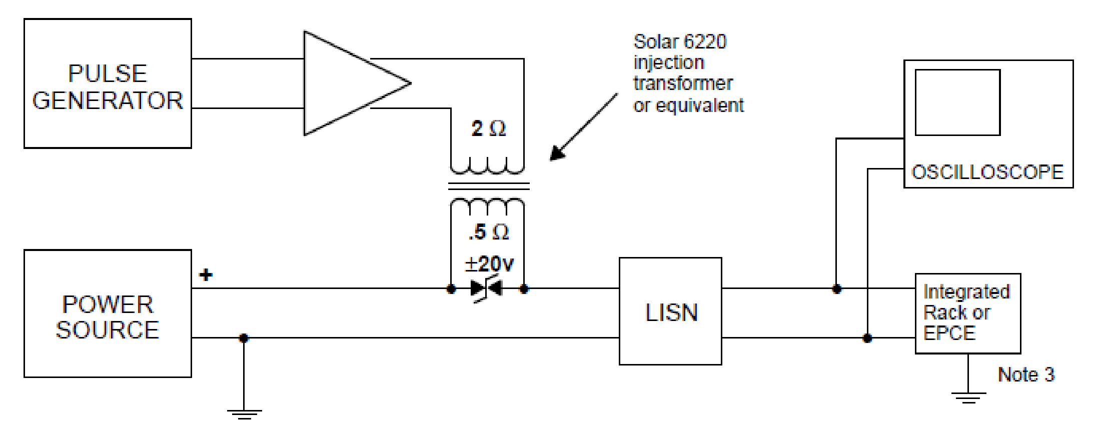
The required test conditions may be produced using a programmable power source or the setup shown in Figure N.4.3.2.2.6-1. The 25 ampere and 50 ampere LISN or equivalent is to be used for integrated racks connecting to Interface B as shown in Figure N.4.3.2.2.6-2. The pulse generator/amplifier must provide a source impedance of less than 0.2 Ω from 100 Hz to 10 kHz to the 2 Ω load of the primary side of the pulse transformer. Pulses of 100 ms, 125 ms and 150 ms (±10 ms) duration **shall** be applied. The pulse amplitude at the secondary side of the injection transformer will be between 10 V and 15 V. Pulse rise and fall times must not exceed 10 ms between 10% and 90% of the pulse amplitude. The resulting transient responses must remain within the EPS normal transient limits.

The following report data is to be provided.

1. Test configuration detail showing which EPCE was active for each test configuration.
2. Description of prototype, substitute, or missing flight EPCE items.
3. Current and voltage profiles for the input pulse and response.

The test and analysis **shall** be considered successful when results show transient responses, measured at the input to integrated rack, diminish to 10% of the maximum amplitude within 1.0 milliseconds and remain below 10% thereafter.

Verification Submittal: Test and Analysis Report



NOTES:
2. The output of the pulse generator must be applied to the transformer through a drive amplifier capable of providing an output impedance of 0.2 ohms, or less, from 100 Hz to 10 kHz.
3. The drive amplifier should be capable of delivering at least 75 watts rms into a 4 Ohm load and be suitable for EMC CS−01 tests.
4. Chassis of integrated rack must be grounded; portable equipment is not grounded.
5. Pulse generator, injection transformer and Zener diode may require adjustment to generate the test pulses and to protect the integrated rack or EPCE under test.

FIGURE N.4.3.2.2.6-1 STABILITY TEST SETUP, TRANSIENT RESPONSES

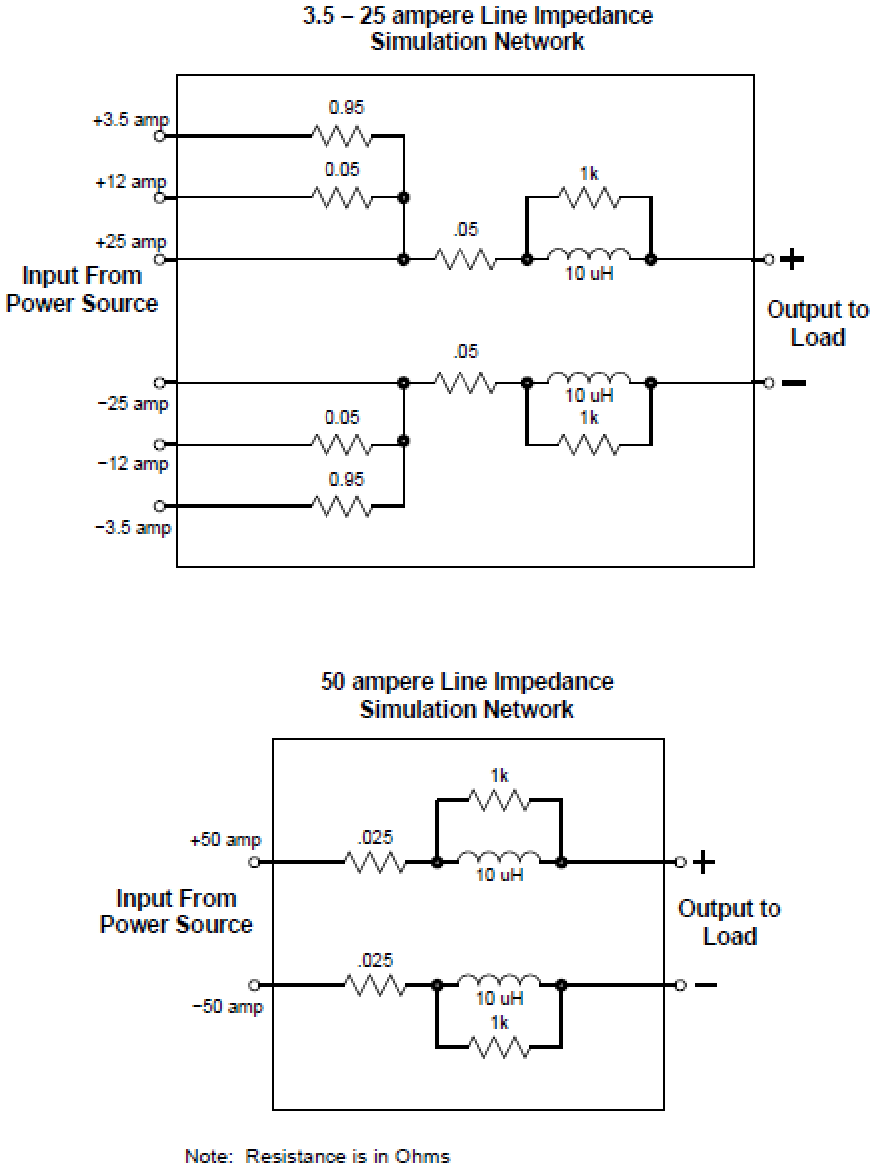


FIGURE N.4.3.2.2.6-2 ISS LINE IMPEDANCE SIMULATION NETWORK (LISN)

N.4.3.2.2.7 MAXIMUM LOAD STEP SIZE

Maximum load step size **shall** be verified by test.

Verification **shall** be by test for loads that will operate from feeds rated for more than 25 A or 3 kW. The test **shall** simulate all operational modes and related transitions for each power feed. The maximum change in power demand must be determined for each transition that is possible under normal operating conditions, and that can occur in less than 1 ms (measured between the 10% and 90% of transition points). In all cases, the power levels measured will be the average over any 10 ms, or greater, time interval. The test **shall** be considered successful if the test results show that a change in power does not exceed 3 kW.

Verification Submittal: Test Report

N.4.3.2.2.8 POWER OFF RESIDUAL VOLTAGE

Power off residual voltage level *should* be verified by test or inspection.

The test *should* involve applying a voltage at the rack power inlet with characteristics as described in Table N.3.2.2.8-1. The test *should* be considered successful when the payload has no unexpected response (such as rack power-on) occurring after applying the specified residual voltage. The inspection *should* consist of a review of the payload design drawings. The inspection *should* be considered successful when the drawings show the payload uses an SSPCM.

Verification Submittal: CoC

N.4.3.2.2.8.1 INTEGRATED RACK WIRE SIZE FOR MAIN AND AUXILIARY POWER FEEDS

Wire size for the wire/cable from UIP to the primary circuit protection device(s) in the integrated rack **shall** be verified by inspection or analysis. Inspection or analysis of cable drawings **shall** be performed to show that the wire gauge meets the requirements specified in Paragraph N.3.2.2.8. The verification **shall** be considered successful when the inspection or analysis shows that 4 gauge wires are used for main and auxiliary connections from UIP to the primary circuit protection device(s) in the integrated rack.

Verification Submittal: CoC

N.4.3.2.2.9 RACK MAINTENANCE SWITCH (RACK POWER SWITCH)

A. Verification **shall** be by inspection. Verification of the switch characteristics, and the location of the switch **shall** be by inspection of the payload drawings and switch hardware documentation. Verification **shall** be considered successful when the inspection shows the integrated rack is equipped with a guarded, two position, manually operated lever lock switch meeting the circuit characteristics of Table N.3.2.2.9-1, and is installed in a visible and accessible location on the front of the rack.

Verification Submittal: CoC

B. Verification for correct operation of the rack maintenance switch **shall** be by test, with the use of the PRCU or equivalent. The test **shall** be considered successful when the test shows the switch provides an OPEN circuit while in the DOWN position and provides a CLOSED circuit while in the UP position.

Verification Submittal: Test Report

C. Verification **shall** be by inspection.Verification **shall** be considered successful when the inspection of the drawings reveal that the proper label has been used. Review and approval, **shall** be granted by the ISS Payload Label Approved Team.

Verification Submittal: CoC

N.4.3.2.2.10 ELECTRICAL STANDALONE STABILITY

The Electrical Standalone Stability of the payload **shall** be verified by test and analysis. Tests **shall** be performed and data submitted for conducted susceptibility and radiated susceptibility, in addition to that for conducted emissions and radiated emissions. This data **shall** be evaluated against the limits of SSP 30237.

The verification **shall** be considered successful when analysis of test data for the requirements identified in the following paragraphs are met:

- Paragraph 3.2.2.1 of SSP 30237 (CS01)
- Paragraph 3.2.2.2 of SSP 30237 (CS02)
- Paragraph 3.2.2.3 of SSP 30237 (CS06)

Verification Submittal: Analysis Report (A brief summary of the results of EMI/EMC tests). A detailed report independent of EMI/EMC request for waiver is necessary to show that stand-alone stability exists if EMI/EMC waivers or deviations are required.

N.4.3.2.3 RACK ELECTROMAGNETIC COMPATIBILITY

NVR

N.4.3.2.3.1 RACK BONDING STRAP

Verification **shall** be by analysis and inspection. The verification **shall** be considered successful when an analysis of the bond current carrying capability shows that the bond interface can carry fault currents until upstream switchgear clears the electrical fault. The verification **shall** be considered successful when inspection of drawings and quality records (Quality records include workmanship resistance measurements) indicates that proper bonding processes, procedures, and materials are identified for the bond interface.

Verification Submittal: CoC and Analysis Report

N.4.3.2.3.2 ARIS ISPR BONDING

NVR

N.4.3.3 COMMAND AND DATA HANDLING INTERFACE REQUIREMENTS

Command and Data Handling requirements for payloads are addressed in Appendix I.

N.4.3.3.1 MIL-STD-1553B (LRDL)

Verification of MIL-STD-1553B requirements **shall** be performed per section I.4.3.4, including all applicable sub-paragraphs.

N.4.3.4 PAYLOAD NTSC VIDEO INTERFACE REQUIREMENTS

NVR

N.4.3.4.1 PAYLOAD NTSC VIDEO CHARACTERISTICS FOR FIBER OPTIC VIDEO

A. Verification of the Payload NTSC Video Characteristics *should* be by test of the integrated rack with the PRCU or equivalent in accordance with Table N.3.4.1-1. The verification *should* be considered successful when the test demonstrates that the received video performance characteristics comply with Table N.3.4.1-1.

Note: TIA/EIA-250-C, Electrical Performance for Television Transmission Systems, provides the method of measurements for each parameter.

Verification Submittal: CoC

B. Verification of the Payload NTSC Video signal to crosstalk noise ratio Characteristics for paragraph N.3.4.1.B *should* be by test of the integrated rack with the PRCU or equivalent using a flat-field test signal. The verification *should* be considered successful when the test demonstrates that the video signal to crosstalk noise ratio is greater than or equal to 60 dB while using a low pass filter (f_c = 4.2 MHz), when any one of the following conditions apply

(1) The integrated rack has two or more video signals following the same physical path as an electrical signal.

(2) The integrated rack contains two or more channels of electrical modulated or baseband video

(3) The integrated rack is transmitting and receiving video signals to include the sync and control signal. This requirement is not applicable for integrated racks transmitting only one signal and receiving no signal.

Note: Use a flat-field test signal to acquire the peak-to-peak amplitude of crosstalk measurement. Ensure the test signal's amplitude is accurately adjusted to 100 IRE units at the sending end prior to commencement of the test. Similarly ensure the waveform monitor at the receiving end is properly calibrated. Ref. paragraph 3.19 of NTC Report No. 7, Video Testing Technical Performance Objectives for useful figures.

Verification Submittal: CoC

N.4.3.4.2 NTSC FIBER OPTIC VIDEO

N.4.3.4.2.1 PULSE FREQUENCY MODULATION NTSC FIBER OPTIC VIDEO CHARACTERISTICS

Verification of the pulse frequency modulation NTSC fiber optic video characteristics for Paragraph N.3.4.2.1 *should* be by test of the integrated rack with a video test system in accordance with TIA/EIA-250-C, per the paragraphs specified in Table N.3.4.1-1, while receiving the PFM NTSC Fiber Optic Video Characteristics in Table N.3.4.2.1-1.

Verification Submittal: CoC

N.4.3.4.2.2 INTEGRATED RACK NTSC PFM VIDEO TRANSMITTED OPTICAL POWER

Verification *should* be to test the integrated rack with fiber optic power meter. The perturbations optical power from the test setup are not included in the stated power requirement. The perturbations from the test are to be documented. This test *should* be considered successful when the requirement is met or exceeded after the test setup variations are removed from the result.

Verification Submittal: CoC

N.4.3.4.2.3 INTEGRATED RACK NTSC PFM VIDEO AND SYNC SIGNAL RECEIVED OPTICAL POWER

Verification *should* be to test the integrated rack with a calibrated fiber optic source testing at the minimum power. The perturbations optical power from the test setup are not included in the stated power requirement. The perturbations from the test are to be documented. This test *should* be considered successful when the requirement is met or exceeded after the test setup variations are removed from the result.

Verification Submittal: CoC

N.4.3.4.2.4 FIBER OPTIC CABLE CHARACTERISTICS

Verification *should* be by inspection of the integrated rack fiber optic cable. Verification *should* be considered successful when it is shown that the integrated rack fiber optic cable meets Table N.3.4.2.4-1, Fiber Optic Cable Characteristics.

Verification Submittal: Data providing electrical video characteristics

N.4.3.4.2.5 PFM NTSC VIDEO FIBER OPTIC CABLE BEND RADIUS

Verification *should* be by inspection of the integrated rack PFM NTSC video fiber optic cable routing, installation and handling procedures. Verification *should* be considered successful when the inspection shows that the routing, installation and handling procedures do not cause the cable to be bent in a tighter radius.

Verification Submittal: CoC

N.4.3.4.2.6 PFM NTSC OPTICAL CONNECTOR/PIN ASSIGNMENTS

A. NVR

B. Verification of P16 appropriate pin assignment *should* be by inspection. The inspection *should* be an inspection of payload drawings to verify that the P16 pinout matches the corresponding J16 pinout. The verification *should* be considered successful when the inspection shows that the P16 connector pinout is appropriate.

Verification Submittal: CoC

N.4.3.4.3 NTSC ELECTRICAL VIDEO INTERFACES

N.4.3.4.3.1 CABLES

Verification of the cables required for transmission of sync and control signals and video and status signals *should* be by inspection of the flight drawings. Verification *should* be considered successful when the inspection shows that the cable meets the requirements of SSQ 21655 (NDBC-TFE-22-2SJ-75).

Verification Submittal: CoC

N.4.3.4.3.2 SIGNAL STANDARD

Verification of the integrated rack's ability to send and receive video, status, and sync signals *should* be by test. The signal degradation from Output video to Input video can be simulated by using a 60 meter long SSQ 21655 (NDBC-TFE-22-25J-75) cable. A test *should* be performed using the PRCU or equivalent to verify that ISPR input/output video, status, and sync signals are in accordance with RS-170A at the UIP interface as defined in Figure N.3.4.3.2-1, Interface B.

Verification Submittal: CoC

N.4.3.4.3.3 INTERFACE CIRCUIT

Verification of interface circuit of video system component in the ISPR for sync, video output and video input **shall** be by analysis. The analysis **shall** show that the input load impedance of the receive circuit to cable is greater than 6 K ohms measured from signal to ground while the circuit is active, and voltage in the circuit **shall** not exceed the tolerance limits of ± 5.5 V. The verification **shall** be considered successful when the analysis shows that the video system interface circuit complies with Figure N.3.4.3.3-1.

Verification Submittal: CoC

N.4.3.4.3.4 CROSSTALK

Verification of crosstalk **shall** be by test. The test **shall** use NTC Report No. 7 method and record the actual crosstalk value in dB. Verification **shall** be considered successful when the test value is less than the requirement.

Verification Submittal: CoC

N.4.3.4.4 NTSC ELECTRICAL CONNECTOR/PIN ASSIGNMENTS

A. NVR

B. Verification of P77 appropriate pin assignment **shall** be by inspection. The inspection **shall** be an inspection of payload drawings to verify that the P77 pinout matches the corresponding J77 pinout. The verification **shall** be considered successful when the inspection shows that the P77 connector pinout is appropriate.

Verification Submittal: CoC

N.4.3.5 THERMAL CONTROL INTERFACE REQUIREMENTS

N.4.3.5.1 INTERNAL THERMAL CONTROL SYSTEM (ITCS) INTERFACE REQUIREMENTS

N.4.3.5.1.1 ITCS PHYSICAL INTERFACE

NVR

N.4.3.5.1.2 ITCS INTERFACE PRESSURE DIFFERENTIAL

Verification that the pressure differential measured across the ITCS supply and return interfaces *should* be by test with both halves of each mated QD pair included as part of the payload pressure differential. The verification *should* be considered successful if the test results are within the values specified.

Verification Submittal: Test Report

N.4.3.5.1.2.1 FLOW AND PRESSURE DROP DATA

Data Deliverable

N.4.3.5.1.3 ITCS COOLANT FLOWRATE

Verification of compatibility with the design flow rate *should* be by analysis or test using the PRCU or equivalent test equipment. The PD *should* provide the PRCU or equivalent test equipment flow rate measurements for all modes of operations. The verification *should* be considered successful if the analysis or test results provide the integrated rack flow rate measurements for all modes of operation at or below the coolant flow rate limits specified.

Verification Submittal: Analysis Report or Test Report

N.4.3.5.1.4 ITCS ALLOWABLE LEAKAGE

Verification that each ITCS fluid loop, including all payload equipment and connections as well as the supply and return interfaces, and connections at the UIP, does not exceed the leakage requirement **shall** be by test. The leakage test **shall** be performed at MDP or above. If helium, or some other medium, is used in testing, the results **shall** be converted to an equivalent water leakage. The verification **shall** be considered successful if the test results show the integrated rack leakage rate to be equal to or less than 14×10^{-3} cm^3/hr of liquid per each thermal loop. Appendix S provides guidance for payload leak testing during qualification and acceptance testing.

Note: The conversion factor for helium leakage to an equivalent water leakage is 1 cm^3/hr of water = 233 cm^3/hr of helium at a pressure of 121 psia.

Verification Submittal: Test Report

N.4.3.5.1.5 ITCS COOLANT QUANTITY

Verification that the maximum allowable payload coolant quantity is not exceeded *should* be by test or analysis of the payload design drawings. The verification *should* be considered successful if the test or analysis results show the integrated rack coolant quantity to be within the limits specified.

Verification Submittal: Test Report or Analysis Report

N.4.3.5.1.5.1 ITCS COOLANT QUANTITY DATA

Data Deliverable

N.4.3.5.1.6 PAYLOAD FLOW CONTROL TIME CONSTANT

Verification that the payload control system time constant is of the specified duration **shall** be by test. The verification **shall** be considered successful if the test results show the integrated rack time constant for set point changes resulting in flow rate changes greater than five pounds mass flow per hour (5 lbm/hr) takes the specified time to reach 63.2% (i.e., $1\text{-}e^{-1}$) of the commanded change in flow rate.

Verification Submittal: Test Report

N.4.3.5.1.7 PAYLOAD SIMULTANEOUS USE OF MTL AND LTL

A. Verification of simultaneous flow requirements **shall** be by inspection of drawings. The verification **shall** be considered successful when the inspection of drawing shows the design includes valves, orifices, or other flow control components that will allow the flow to be commanded on and off and will provide flow of cooling fluid at the desired flow rate on the cooling loop that is not connected to the RFCA.

Verification Submittal: CoC

B. Verification of that temperature and flow rate sensors are provided on the loop which does not have the RFCA connected *should* be by inspection of drawings. The verification *should* be considered successful when the inspection of drawing shows the design includes temperature and flow rate sensors.

Verification Submittal: CoC

C. Verification that the payload can send flow control device status to the Payload (PL) MDM, including flow rate, and outlet temperature *should* be by test. The test *should* be conducted in the PRCU or equivalent. The verification *should* be considered successful when the flow control device status data is included in the Health and Status data to the Payload MDM.

Verification Submittal: Test Report

D. Verification that the MTL and LTL are prevented from connection together **shall** be by inspection of drawings. The verification **shall** be considered successful when the inspection of drawing shows the design prevents the connection of MTL and LTL loops together.

Verification Submittal: CoC

N.4.3.5.1.8 QUICK-DISCONNECT AIR INCLUSION

Verification that air inclusion into the QD during coupling and uncoupling does not exceed 0.30 cc per couple/uncouple cycle for part numbers other than those listed in Table N.3.1.1.7-1, **shall** be by test or analysis of QD certification data. If air is not used in testing of the QD, the results **shall** be converted to an equivalent volume of air. The verification **shall** be considered successful if the test results show the integrated rack QD air inclusion does not exceed 0.30 cc per couple/uncouple cycle. If the QD used is a dash number of the parts listed in Table N.3.1.1.7-1, then verification **shall** be a CoC stating compliance.

Verification Submittal: CoC

N.4.3.6 VACUUM SYSTEM REQUIREMENTS

N.4.3.6.1 VACUUM EXHAUST SYSTEM (VES)/WASTE GAS SYSTEM (WGS) REQUIREMENTS

NVR

N.4.3.6.1.1 VES/WGS PHYSICAL INTERFACE

NVR. Physical mating verification requirements are specified in section N.4.3.1.1.7.

N.4.3.6.1.2 INPUT PRESSURE LIMIT

Payload vented gas pressure **shall** be verified by test and analysis. The test **shall** utilize a PRCU or equivalent to measure the vented gas pressure at the interface plane. The payload volumes that are connected to ISS VES/WGS **shall** be pressurized to the expected experiment pressures for the test. The analysis **shall** show that the payload design limits the pressure to 276 kPa (40 psia) or less.

Verification Submittal: Test Report or Analysis Report

N.4.3.6.1.3 INPUT TEMPERATURE LIMIT

Payload temperature **shall** be verified by test or analysis. The test **shall** utilize a PRCU or equivalent to measure the initial temperature at the interface plane. The payload volumes that are connected to the VES **shall** be pressurized to the expected pressures for the test. The experiment **shall** be subjected to the same heat generating operations that will be experienced on-orbit and vented at the same relative time during the experiment operation as would be experienced on-orbit. The analysis **shall** show that the initial temperature at the interface plane is within the allowable temperature range while subjected to the same heat generating operations that will be experienced on-orbit and vented at the same relative time during the experiment operation as would be experienced on-orbit.

Verification Submittal: Test Report or Analysis Report

N.4.3.6.1.4 INPUT DEWPOINT LIMIT

Payload temperature **shall** be verified by test or analysis. The test **shall** utilize a PRCU or equivalent to measure the dewpoint at the interface plane. The payload volumes that are connected to the VES **shall** be pressurized to the expected pressures for the test. The experiment **shall** be subjected to the same heat generating operations that will be experienced on-orbit and vented at the same relative time during the experiment operation as would be experienced on-orbit. The analysis **shall** show that the dewpoint at the interface plane is within the allowable temperature range while subjected to the same heat generating operations that will be experienced on-orbit and vented at the same relative time during the experiment operation as would be experienced on-orbit.

Verification Submittal: Test Report or Analysis Report

N.4.3.6.1.5 ACCEPTABLE EXHAUST GASES

A. Verification that exhaust gases vented into the Vacuum Exhaust System/Waste Gas System (VES/WGS) of the USL, COL, and JEM are compatible with the wetted surface materials of the respective laboratory(ies) in which the payload will operate **shall** be by inspection. Gases documented in Tables N.3.6.1.5-1, N.3.6.1.5-2, and N.3.6.1.5-3 have been analyzed for compatibility with the ISS VES/WGS wetted materials. The PD **shall** review the payload's proposed vent gases and determine whether or not the gases are listed as acceptable in Tables N.3.6.1.5-1, N.3.6.1.5-2, or N.3.6.1.5-3. Verification **shall** be considered successful when the proposed exhaust gases are shown to be listed as acceptable in Tables N.3.6.1.5-1, N.3.6.1.5-2, or N.3.6.1.5-3 for the respective laboratory(ies) in which the payload will operate.

Note: Gases not listed in Tables N.3.6.1.5-1, N.3.6.1.5-2, or N.3.6.1.5-3 can be evaluated for compatibility with the ISS VES/WGS wetted materials by the PD and approved or disapproved by the ISS Program through the exception process. The ISS VES/WGS wetted materials are listed in SSP 41002, Paragraph 3.2.7.2, and the EXPRESS rack wetted materials are listed in Appendix F, paragraph F.3.6.1.5.B..

Verification Submittal: CoC

B. Verification that payload gases vented to the ISS VES/WGS are non-reactive with other vent gas mixture constituents **shall** be by analysis. An analysis **shall** determine what gases will be vented to the ISS VES/WGS and, assuming the worst case reactions possible, **shall** determine all reactions that are possible among the vent gas constituents. An analysis **shall** calculate the worst case temperature change associated with the possible vent gas reactions in accordance with the equation:

$$20 \geq \frac{\Sigma_{\text{ALL REACTIONS}}\left[\left[\frac{(\Sigma x_p H_p - \Sigma x_{r1} H_r)}{n_{lim}}\right] m_{lim}\right]}{\Sigma x_p m_p c_{pp} + \Sigma x_{r2} m_r c_{pr} + \Sigma x_d m_d c_{pd}}$$

H_p = Enthalpy of formation of the products (J/mol)
H_r = Enthalpy of formation of the reactants (J/mol)
X_{r1} = Number of moles of the reactants
X_{r2} = Number of moles of the unreacted reactants
X_p = Number of moles of the products
X_d = Number of moles of the diluent
n_{lim} = Molecular Weight of the limiting reactant in the reaction (g/mol)
m_{lim} = Mass of the limiting reactant in the reaction (g)
m_p = Mass of each product gas in the vent mixture (g)
m_r = Mass of each unreacted reactant gas in the vent mixture (g)
m_d = Mass of each diluent gas in the vent mixture (g)
c_{pp} = Constant Pressure Heat Capacity of each product gas at the vented condition (J/ (g*K))
c_{pr} = Constant Pressure Heat Capacity of each unreacted gas at the vented condition (J/(g*K))
c_{pd} = Constant Pressure Heat Capacity of each diluent gas at the vented condition (J /(g*K))

Note: The exact equation used may vary slightly depending on the units of the data available for the given gases. These variations must be limited to units conversions only. The final units of the equation will be a measure of temperature, measured in Celsius or Kelvin.

For each possible reaction in the vent gas mixture, all gases associated with the reaction **shall** be included in the calculation in the numerator. All possible reactions in the vent gases mixture **shall** be calculated and summed together in the numerator. All gases in the vented mixture must be included in the denominator of the analysis. Unreacted reactants may be summed in the denominator as a diluent, when rich or lean mixtures are expected for a given reaction. When lean or rich mixtures are expected for one reaction, an analysis **shall** show that the excess reactant gases will not react with another gas in the vent mixture (the original reaction considered must be the worst case, i.e. most energy released, reaction).

If trace elements (up to the SMAC value) are present and do not participate in a reaction, they may be excluded from this analysis.

Verification **shall** be considered successful when the analysis shows the gases vented to the ISS VES/WGS are non-reactive according to the equation specified above (the equation meets the inequality).

Note: Venting of cabin air or the ISS pressurized gases, Nitrogen, Carbon Dioxide, Argon or Helium, or mixtures of these gases are considered acceptable and do not require verification if they are not mixed with other gases.

Verification Submittal: Analysis Report

C. Verification that payloads venting to the ISS VES/WGS provide a means of removing gases that would adhere to the VES/WGS tubing walls at a wall temperature of 4 °C (40 °F) and a pressure of 10^{-3} torr **shall** be by analysis. An analysis **shall** determine whether or not the gas mixture contains gases with a molecular weight greater than 75 amu or gases which have a boiling point greater than 100 °C (212 °F) at atmospheric pressure.

Each proposed vent gas with a molecular weight greater than 75 amu or a boiling point greater than 100 °C (212 °F) at atmospheric pressure **shall** be analyzed to determine whether or not the vapor pressure is below a pressure of 10^{-3} torr at 4 °C (40 °F). This analysis **shall** be conducted gas-by-gas. If any proposed vent gases are determined to have a vapor pressure below 10^{-3} torr at 4 °C (40 °F), an analysis **shall** be conducted to determine whether or not the payload provides a means to remove these gases from the vent gas mixture prior to venting to the ISS VES/WGS.

Or alternatively, each proposed vent gas with a molecular weight greater than 75 amu or a boiling point greater than 100 °C (212 °F) at atmospheric pressure **shall** be analyzed to determine whether or not the boiling temperature is above 4 °C (40 °F) at a pressure of 10^{-3} torr. This analysis **shall** be conducted gas-by-gas. If any proposed vent gases are determined to have a boiling temperature above 4 °C (40 °F) at 10^{-3} torr, an analysis **shall** be conducted to determine whether or not the payload provides a means to remove these gases from the vent gas mixture prior to venting to the ISS VES/WGS.

The Clausius-Clapeyron equation or Antoines equation may be used to verify this requirement. Note that it is not required to use these equations, but they may be helpful.

Verification **shall** be considered successful when the analysis shows the gases that will be exposed to the ISS VES/WGS will not adhere to the ISS VES/WGS tubing walls at a wall temperature of 4 °C (40 °F) at 10^{-3} torr. Gases that will be exposed to the ISS VES/WGS will not adhere to the ISS VES/WGS tubing walls when each vent gas is shown to have a vapor pressure above 10^{-3} torr ar 4 °C (40 °F) or a boiling temperature below 4 °C (40 °F) at a pressure of 10^{-3} torr and /or, any gases found with a vapor pressure below 10^{-3} torr at 40C (40 °F) or a boiling temperature above 4 °C (40 °F) at a pressure of 10^{-3} torr are removed from the gas mixture.

Note: Cabin air and the ISS Pressurized gases, nitrogen, argon, helium and carbon dioxide, may be vented to the ISS VES/WGS without verification of this requirement.

Verification Submittal: Analysis Report

D. Verification that the payload venting to the ISS VES/WGS removes particulates from vent gases that are larger than 100 micrometers **shall** be by analysis. An analysis **shall** determine whether or not the vent gases will contain particulate contamination larger than 100 microns. If the analysis shows that particulate contamination greater than 100 microns will be introduced into, or generated in, the vent gases, an analysis **shall** determine whether or not a means for removing the particles above 100 microns before venting to the ISS VES/WGS is included in the payload design. Verification **shall** be considered successful when the analysis shows the vent gases will not contain particulate contamination greater than 100 microns.

Note: ISS Cabin Atmosphere and the ISS Pressurized gases, nitrogen, argon, helium and carbon dioxide, may be vented to the ISS VES/WGS in the condition delivered to the payload if it’s shown that particulate contamination is not generated within the payload.

Verification Submittal: Analysis Report

N.4.3.6.1.6 PAYLOAD VACUUM SYSTEM ACCESS VALVE

Verification that payload using the VES/WGS system provides a vacuum system access valve to isolate the experiment chamber from the ISS VES/WGS system **shall** be by inspection and analysis.

An analysis of the payload list of vent gases **shall** determine whether or not the payload will vent gases other than the constituents of cabin air, noble gases or ISS pressurized gases. If the analysis shows only the constituents of cabin air, noble gases or ISS pressurized gases will be vented from the payload, the payload vacuum system access valve is not required.

For payloads found to be venting gases other than the constituents of cabin air, noble gases or ISS pressurized gases, an inspection of the payload as-build drawings or flight hardware **shall** be performed. This inspection **shall** determine whether or not the payload system contains a vacuum system access valve that isolates the experiment chamber from the ISS VES/WGS system.

Verification **shall** be considered successful when the inspection and analysis shows that a vacuum system access valve, isolating the experiment chamber from the ISS VES/WGS, is provided if the payload will vent gases other than the constituents of cabin air, noble gases or ISS pressurized gases. The payload vacuum system access valve is not required if the payload is venting only the constituents of cabin air, noble gases or ISS pressurized gases.

Verification Submittal: Analysis Report

N.4.3.6.1.7 LIMIT AMOUNT OF VENTED GASES

A. Verification that the payload limits their vented gases over any 9-minute period **shall** be by analysis. The analysis **shall** compare the amount of gas to be vented to the provided equations, using an average molecular weight if multiple gases are included in the vented gas. The verification **shall** be considered successful when the analysis shows that the amount of gas vented is below either the mass limit or pressure-volume limit for any 9-minute period. No verification is required if Paragraph N.3.6.1.8 is successfully met.

Verification Submittal: Analysis Report

B. Verification that the payload limits their vented gases over any 110-minute period **shall** be by analysis. The analysis **shall** compare the amount of gas to be vented to the provided equations, using an average molecular weight if multiple gases are included in the vented gas. The verification **shall** be considered successful when the analysis shows that the amount of gas vented is below either the mass limit or pressure-volume limit for any 110-minute period. No verification is required if Paragraph N.3.6.1.8 is successfully met.

Verification Submittal: Analysis Report

C. Verification that the payload limits their vented gases flow rate to less than or equal to the specified rate *should* be by analysis. The analysis *should* calculate the flow rate of each gas to be vented using the provided equation. The verification *should* be considered successful when the analysis shows that the flow rate of each gas vented is equal to or less than the mass flow rate limit.

Verification Submittal: Analysis Report

N.4.3.6.1.8 LIMIT VES VENTING PROFILE

Verification that a payload or system venting profile maintains flow rates at or below those defined in Table N.3.6.1.8-1 *should* be accomplished by test or analysis. The test *should* utilize a PRCU or equivalent to measure the venting flow rate versus time at the UIP when the payload is opened to a simulated vacuum. The analysis *should* involve an analytical simulation accounting for internal design factors as well as planned venting scenarios to produce a blow-down curve. The verification *should* be considered successful when the test or analysis results show that the flow rates at the prescribed times do not exceed the acceptable flow rate limits defined in Table N.3.6.1.8-1.

Verification Submittal: Data Report

N.4.3.6.1.9 VACUUM EXHAUST SYSTEM DATA DELIVERABLE

<u>Data Deliverable</u>

N.4.3.6.2 VACUUM RESOURCE SYSTEM (VRS)/VACUUM VENT SYSTEM (VVS) REQUIREMENTS

N.4.3.6.2.1 VRS/VVS PHYSICAL INTERFACE

NVR. Physical mating verification requirements are specified in section N.4.3.1.1.7.

N.4.3.6.2.2 INPUT PRESSURE LIMIT

Payload vented gas pressure **shall** be verified by test. The test **shall** utilize a PRCU or equivalent to measure the vented gas pressure at the interface plane. The payload volumes that are connected to ISS VRS/VVS **shall** be pressurized to the expected experiment pressures for the test. The test **shall** be considered successful when the payload design is shown to limit the pressure to 10^{-3} torr or less.

Verification Submittal: Test Report or Analysis Report

N.4.3.6.2.3 ACCEPTABLE GASES

NVR

N.4.3.6.3 VACUUM OUTGASSING REQUIREMENTS

Verification that payloads interfacing with the VES or VRS with non-metallic materials, which are exposed to pressures less than 1 torr via the USL, Columbus Module or JEM Vacuum Systems, meet the vacuum outgassing requirements of Paragraph 4.2.7 of SSP 30233 **shall** be by inspection. Verification **shall** be considered successful when inspection of design drawings and materials lists reveals that non-metallic materials used meet either of the following criteria:

(1) Non-metallic materials have an “A” rating for thermal vacuum stability in the Materials and Processes Technical Information System (MAPTIS) database.

(2) Non-metallic materials have an “B” rating for thermal vacuum stability in the MAPTIS database, but have been cured to meet the “A” requirements and the cure data is specified in the materials list.

Verification Submittal: CoC

N.4.3.7 PRESSURIZED GASEOUS NITROGEN INTERFACE REQUIREMENTS

N.4.3.7.1 NITROGEN INTERFACE CONTROL

A. Verification of nitrogen on and off flow control *should* be by test. The verification *should* be considered successful when the test results confirm that the payload valve can turn on and off the flow of nitrogen.

Verification Submittal: CoC

B. Verification **shall** be accomplished by test or analysis of the payload. Verification **shall** be considered successful when the test or analysis shows that the payload can control the flow to not exceed the maximum allowable nitrogen flow rate when connected to nitrogen supplied at the maximum and minimum of the specified pressure range.

Verification Submittal: Test Report or Analysis Report

N.4.3.7.2 NITROGEN INTERFACE MDP

The MDP of payload volume(s) connected to the Nitrogen system **shall** be verified by test and analysis guidelines identified in SSP 52005, Paragraph 5.3.2.1. The verification **shall** be considered successful when the test or analysis results show that the payload can meet or exceed the requirements in SSP 52005.

Verification Submittal: Test Report or Analysis Report

N.4.3.7.3 NITROGEN INTERFACE TEMPERATURE

NVR

N.4.3.7.4 NITROGEN LEAKAGE

Verification of payload nitrogen leakage at MDP **shall** be by test at MDP or by test at MEOP and analysis to MDP. The verification **shall** be considered successful when the test or test and analysis results show that the leakage sources from the UIP panel connection to nitrogen on/off flow control in the payload does not exceed the allowable leakage rate at MDP. Appendix S provides guidance for payload leak testing during qualification and acceptance testing.

Verification Submittal: Test Report

N.4.3.7.5 NITROGEN PHYSICAL INTERFACE

NVR

N.4.3.7.6 NITROGEN QUANTITY

<u>Data Deliverable</u>

N.4.3.7.7 PAYLOAD PRESSURIZED GAS SYSTEM

<u>Data Deliverable</u>

N.4.3.8 JEM PRESSURIZED GASES

NVR

N.4.3.8.1 ARGON INTERFACE REQUIREMENTS

N.4.3.8.1.1 ARGON INTERFACE CONTROL

A. Verification of argon on and off flow control *should* be by test. The verification *should* be considered successful when the test results confirm that the payload valve can turn on and off the flow of argon.

Verification Submittal: CoC

B. Verification of argon flow rate control **shall** be by test or analysis. The verification **shall** be considered successful when the test or analysis results confirm the payload can control the flow to not exceed the maximum allowable argon flow rate when connected to argon supplied at the maximum and minimum of the specified pressure range.

Verification Submittal: Test Report or Analysis Report

N.4.3.8.1.2 ARGON INTERFACE MDP

The MDP of payload volumes connected to the Argon system **shall** be verified by test and analysis per the guidelines identified in SSP 52005, Paragraph 5.3.2.1. The verification **shall** be considered successful if the test and analysis results show that the payload can meet or exceed the requirements in SSP 52005.

Verification Submittal: Test Report or Analysis Report

N.4.3.8.1.3 ARGON INTERFACE TEMPERATURE

NVR

N.4.3.8.1.4 ARGON LEAKAGE

Verification of payload argon leakage at MDP **shall** be by test at MDP or by test at MEOP and analysis to MDP. Verification **shall** be considered successful when the test or test and analysis results show that the leakage sources from the standoff UIP panel connection to the argon on/off flow control in the payload does not exceed the allowable leakage rate at MDP. Appendix G provides guidance for payload leak testing during qualification and acceptance testing.

Verification Submittal: Test Report

N.4.3.8.1.5 ARGON PHYSICAL INTERFACE

NVR

N.4.3.8.1.6 ARGON QUANTITY

<u>Data Deliverable</u>

N.4.3.8.2 CARBON DIOXIDE INTERFACE REQUIREMENTS

N.4.3.8.2.1 CARBON DIOXIDE INTERFACE CONTROL

A. Verification of carbon dioxide on and off flow control *should* be by test. The verification *should* be considered successful when the test results confirm that the payload can turn on and off the flow of carbon dioxide.

Verification Submittal: CoC

B. Verification of carbon dioxide flow rate control **shall** be by test or analysis. The verification **shall** be considered successful when the test or analysis results confirm that the payload can control the flow to not exceed the maximum allowable carbon dioxide flow rate when connected to carbon dioxide supplied at the maximum and minimum of the specified pressure range.

Verification Submittal: Test Report or Analysis Report

N.4.3.8.2.2 CARBON DIOXIDE INTERFACE MDP

The MDP of payload volumes connected to the Carbon Dioxide system **shall** be verified by test and analysis per the guidelines identified in SSP 52005, Paragraph 5.3.2.1. The verification **shall** be considered successful if the test and analysis results show that the payload can meet or exceed the requirements in SSP 52005.

Verification Submittal: Test Report or Analysis Report

N.4.3.8.2.3 CARBON DIOXIDE INTERFACE TEMPERATURE

NVR

N.4.3.8.2.4 CARBON DIOXIDE LEAKAGE

Verification of payload carbon dioxide leakage at MDP **shall** be by test at MDP or by test at MEOP and analysis to MDP. The verification **shall** be considered successful when the test or test and analysis results show that the leakage sources from the standoff UIP panel connection to the carbon dioxide on/off flow control in the payload does not exceed the allowable leakage rate at MDP. Appendix G provides guidance for payload leak testing during qualification and acceptance testing.

Verification Submittal: Test Report

N.4.3.8.2.5 CARBON DIOXIDE PHYSICAL INTERFACE

NVR

N.4.3.8.2.6 CARBON DIOXIDE QUANTITY

<u>Data Deliverable</u>

N.4.3.8.3 HELIUM INTERFACE REQUIREMENTS

N.4.3.8.3.1 HELIUM INTERFACE CONTROL

A. Verification of helium on and off flow control *should* be by test. The verification *should* be considered successful when the test results confirm that the payload valve can turn on and off the flow of helium.

Verification Submittal: CoC

B. Verification of helium flow rate control **shall** be by test or analysis. The verification **shall** be considered successful when the test or analysis results confirm that the payload can control the flow to not exceed the maximum allowable helium flow rate when connected to helium supplied at the maximum and minimum of the specified pressure range.

Verification Submittal: Test Report or Analysis Report

N.4.3.8.3.2 HELIUM INTERFACE MDP

The MDP of payload volumes connected to the Helium system **shall** be verified by test and analysis per the guidelines identified in SSP 52005, Paragraph 5.3.2.1. The verification **shall** be considered successful if the test and analysis results show the payload can meet or exceed the requirements in SSP 52005.

Verification Submittal: Test Report or Analysis Report

N.4.3.8.3.3 HELIUM INTERFACE TEMPERATURE

NVR

N.4.3.8.3.4 HELIUM LEAKAGE

Verification of payload helium leakage at MDP **shall** be by test at MDP or by test at MEOP and analysis to MDP. Verification **shall** be considered successful when the test or test and analysis results show that the leakage sources from the standoff UIP panel connection to the helium on/off flow control in the payload does not exceed the allowable leakage rate specified at MDP. Appendix S provides guidance for payload leak testing during qualification and acceptance testing.

Verification Submittal: Test Report

N.4.3.8.3.5 HELIUM PHYSICAL INTERFACE

NVR

N.4.3.8.3.6 HELIUM QUANTITY

<u>Data Deliverable</u>

N.4.3.9 ENVIRONMENT INTERFACE REQUIREMENTS

N.4.3.9.1 INTEGRATED RACK USE OF CABIN ATMOSPHERE

N.4.3.9.1.1 ACTIVE AIR EXCHANGE

Verification that payloads do not exchange heat with the cabin atmosphere *should* be by inspection. The verification *should* be considered successful when inspection of the flight drawings shows that the rack and subrack payloads do not dump heat to the cabin.

Verification Submittal: CoC

N.4.3.9.2 AVERAGE RACK FRONT SURFACE TEMPERATURE IN THE JEM

Verification that the average rack front surface temperature limit will not be exceeded during all modes of operation **shall** be by analysis or test. All verification analysis **shall** use the thermal boundary conditions for thermal analysis in Table 3.9.3-2. The verification **shall** be considered successful when the analysis or test results show the integrated rack surface average temperature is less than the specified limit.

Verification Submittal: CoC

N.4.3.10 FIRE PROTECTION INTERFACE REQUIREMENTS

N.4.3.10.1 PAYLOAD MONITORING AND DETECTION REQUIREMENTS

NVR

N.4.3.10.1.1 SMOKE DETECTION

N.4.3.10.1.1.1 SMOKE DETECTOR

Verification that the integrated rack requiring smoke detection uses the specified smoke detector **shall** be by inspection. Verification **shall** be considered successful when the inspection shows the integrated rack is using an ISS provided smoke detector (Allied Signal P/N 2351520-2-1 or P/N 2119818-3-1 for area type, or Allied Signal P/N 2351510-2-1 or P/N 2119814-3-1 for duct type).

Verification Submittal: CoC

N.4.3.10.1.1.1.1 DISCRETE COMMAND BUILT-IN-TEST OBSCURATION OUTPUT AND SCATTER OUTPUT INTERFACE CHARACTERISTICS

Verification of the smoke detector BIT Test obscuration output and scatter interface outputs **shall** be by demonstration and inspection. The demonstration in the PRCU or equivalent **shall** verify the following parameters:

a. Normal Obscuration Voltage
b. BIT On Obscuration Voltage (LASER Off)
c. Normal Scatter Voltage
d. BIT On Scatter Voltage (LED On)
e. BIT On Scatter Voltage (LED Off)

The verification **shall** be considered successful when the smoke detector is demonstrated to be functional and the inspection of voltages for these parameters are within the ranges specified in Table N.3.10.1.1.1.1-1 and Figure N.3.10.1.1.1.1-1.

Verification Submittal: Data Certification showing results of the smoke detector BIT Test

N.4.3.10.1.1.2 FORCED AIR CIRCULATION INDICATION

Verification that the integrated rack provides a signal or data indicating the presence of airflow to the smoke detector when the smoke detector is in use **shall** be by test. Verification **shall** be considered successful when the test shows signal strength meets the interface characteristics in Paragraph N.3.10.1.1.2.

Verification Submittal: Test Report showing the analog signal value that corresponds to the minimum fan speed needed to provide the smoke detector with the minimum air flow.

N.4.3.10.1.1.3 SMOKE INDICATOR

A. Verification that the integrated rack using a smoke detector provides a red Fire Detection Indicator LED in an easily visible location on the front of the rack **shall** be by inspection. The inspection **shall** be considered successful when it is shown the LED is positioned in an obvious, easily viewed location on the aisle side of the rack.

Verification Submittal: Data cert providing the size and location of the fire detection indicator.

B. Verification of the smoke indicator electrical interface **shall** be by analysis and test. Verification **shall** be by analysis of the discrete components and circuit for the interface characteristics. Verification of function **shall** be to test the integrated rack with the PRCU, for function of the smoke indicator on P43. No test on the luminance of the indicator is required. Verification of the **smoke** indicator electrical interface capacitance **shall** be by analysis. The verification **shall** be considered successful when the calculation of total capacitance of the “Smoke Indicator” LED on the schematics, drawings or specifications is less than the capacitance value in Table N.3.10.1.1.3-1.

Verification Submittal: Analysis and Test Report. The report must include an electrical schematic of the smoke indicator circuit.

Note: The following is an example of analysis:

For racks using the Rack Power Switch Assembly (683-50370), the analysis below is for dash three and five, as shown in Figure N.4.3.10.1.1.3-1.

- The maximum capacitance is verified by analysis of the specification data. The total capacitance will not exceed the sum of the zener part and the LED part.
  - The LED part number 683-29448-2 has a maximum capacitance of less than 100 pico-farad.
  - The Zener part number JANTXV1N6331 has a maximum capacitance of 275 pico-farad.
  - The Resistor part number is RER60F6340R.
- The worst case maximum capacitance of 375 pico-farad produced in the Rack Power Switch Assembly (683-50370) is below the 2 nF (2000 pico-farad) requirement.

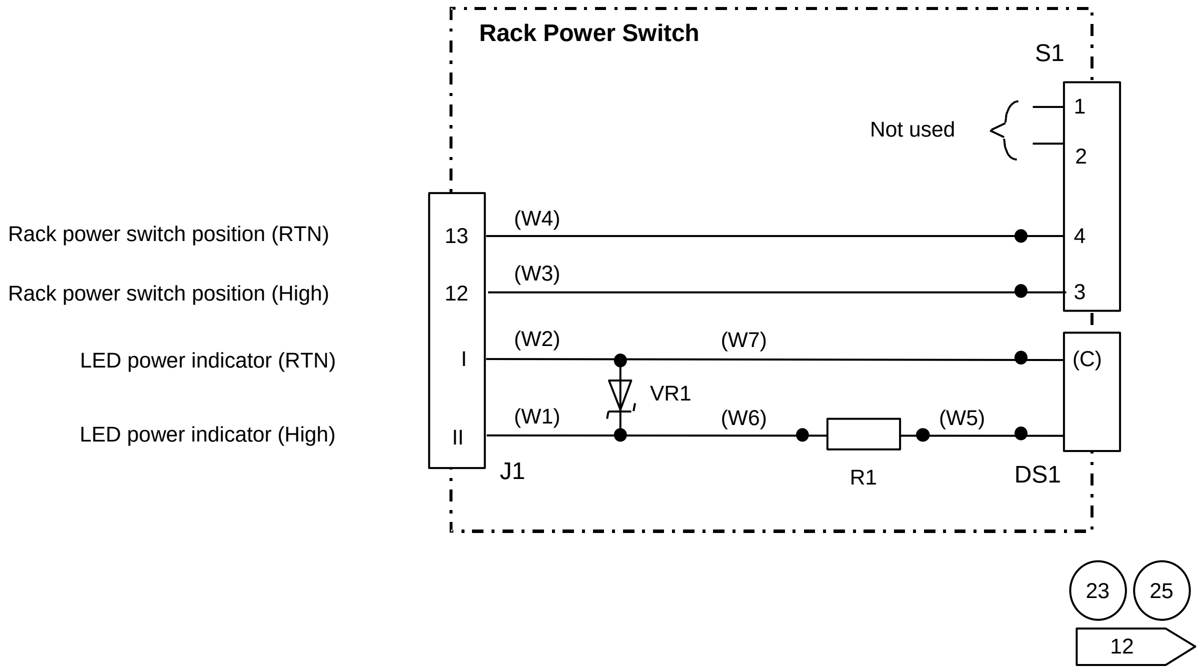


FIGURE N.4.3.10.1.1.3-1 CONNECTION DIAGRAM FOR -3 AND -5 ASSEMBLY

N.4.3.10.1.2 PARAMETER MONITORING

N.4.3.10.1.2.1 PARAMETER MONITORING USE

Verification that the integrated rack or subrack volumes which contain a potential fire source and do not exchange air with the rack smoke detector provide sensors that monitor that volume to detect a fire event **shall** be by inspection. An inspection of drawings or hardware **shall** be conducted to determine whether or not the volume contains the sensors to detect a fire event as approved by the ISRP during the phased safety reviews. Verification **shall** be considered successful when the inspection shows there are sensors, as approved by the ISRP during the phased safety reviews, to detect a fire event in a volume that contains a potential fire source and does not exchange air with the rack smoke detector.

Verification Submittal: CoC

N.4.3.10.1.2.2 PARAMETER MONITORING RESPONSE

N.4.3.10.1.2.2.1 PARAMETER MONITORING IN SUBRACK

A. Verification that the integrated rack provides manual and automatic capabilities to terminate forced air circulation (if present) and power to each subrack volume/payload that is monitored with parameter monitoring **shall** be by test. A test **shall** be conducted to determine whether or not forced air circulation (if present) and electrical power can be manually and automatically terminated in the subrack volume/payload when a potential fire event condition is indicated by the parameter monitoring sensors. Verification **shall** be considered successful when the test shows forced air circulation (if present) and electrical power can be terminated manually and automatically when a potential fire event condition is indicated by the parameter monitoring sensors.

Verification Submittal: Test Report

B. Verification that the integrated rack responds to a potential fire event within a separate, subrack volume/payload that is monitored with parameter monitoring by sending data to indicate the location of the potential fire event, data indicating which parameter annunciated the potential fire event and the data for evaluating the potential fire event to the payload MDM in the format specified in Paragraph I.3.4.1.4.A **shall** be by test and analysis. For the initial configuration of the integrated rack, a test with the PRCU or equivalent **shall** determine whether or not the rack health and status data is formatted to indicate the location of a potential fire event, data indicating which parameter annunciated the potential fire event and the data for evaluating the potential fire event when one is indicated by parameter monitoring sensors.

For subrack volumes/payloads that are changed out, a test of the interface to the integrated rack's controller or equivalent and an analysis to determine the interface to the Payload MDM is correct **shall** be conducted. Verification **shall** be considered successful when the test and analysis shows data is sent in the format specified in Paragraph I.3.4.1.4.A to indicate the location of a potential fire event, data indicating which parameter annunciated the potential fire event and the data for evaluating the potential fire event when one is indicated by the parameter monitoring sensors.

Verification Submittal: Test Report

C. Verification that the integrated rack responds to a potential fire event within a separate subrack volume/payload that is monitored with parameter monitoring by sending a Class 2 - Warning word to indicate the occurrence of the potential fire event to the payload MDM in the format specified in Paragraph I.3.4.1.4.B **shall** be by test and analysis. For the initial configuration of the integrated rack, a test with the PRCU or equivalent **shall** determine whether or not the rack health and status data is formatted to indicate the occurrence and location of a potential fire event when one is indicated by parameter monitoring sensors.

For subrack volumes/payloads that are changed out, a test of the interface to the integrated rack's controller or equivalent and an analysis to determine the interface to the Payload MDM is correct **shall** be conducted. Verification **shall** be considered successful when the test and analysis shows that the Class 2 - Warning word is sent in the format specified in Paragraph I.3.4.1.4.B to indicate the occurrence of a potential fire event when one is indicated by the parameter monitoring sensors.

Verification Submittal: Test Report

N.4.3.10.1.2.2.2 PARAMETER MONITORING IN INTEGRATED RACK

A. Verification that integrated racks only using parameter monitoring provide manual and automatic capability to terminate forced air circulation (if present) and power to the integrated rack **shall** be by test. A test with the PRCU or equivalent **shall** be conducted to determine whether or not forced air circulation (if present) and electrical power can be manually and automatically terminated in the integrated rack when a potential fire event is indicated by the parameter monitoring sensors. Verification **shall** be considered successful when the test shows forced air circulation (if present) and electrical power can be terminated manually and automatically when a potential fire event is indicated by the parameter monitoring sensors.

Verification Submittal: Test Report

B. Verification that integrated racks only using parameter monitoring responds to a potential fire event by sending data to indicate the occurrence and location of the potential fire event to the payload MDM in the format specified in Paragraph I.3.4.1.4.A **shall** be by test. A test with the PRCU or equivalent **shall** determine whether or not the rack health and status data is formatted to indicate the occurrence and location of a potential fire event when one is indicated by parameter monitoring sensors. Verification **shall** be considered successful when the test shows data is sent in the format specified in Paragraph I.3.4.1.4 to indicate the occurrence and location of a potential fire event when one is indicated by the parameter monitoring sensors.

Verification Submittal: Test Report

C. Verification that the integrated rack responds to a potential fire event that is monitored with parameter monitoring by sending a Class 2 - Warning word to indicate the occurrence of the potential fire event to the payload MDM in the format specified in Paragraph I.3.4.1.4.B **shall** be by test and analysis. For the initial configuration of the integrated rack, a test with the PRCU or equivalent **shall** determine whether or not the rack health and status data is formatted to indicate the occurrence and location of a potential fire event when one is indicated by parameter monitoring sensors. Verification **shall** be considered successful when the test and analysis shows that the Class 2 - Warning word is sent in the format specified in Paragraph I.3.4.1.4.B to indicate the occurrence of a potential fire event when one is indicated by the parameter monitoring sensors.

Verification Submittal: Test Report

N.4.3.10.2 FIRE SUPPRESSION

N.4.3.10.2.1 PORTABLE FIRE EXTINGUISHER ACCESS PORT

Verification that each integrated rack and subrack payload volume provides the appropriate PFE access port(s) **shall** be by inspection of the drawings or flight hardware. Verification **shall** be considered successful when the inspection of the drawings or flight hardware shows a PFE access port(s) with the appropriate diameter from Table N.3.10.3-1 is provided for payloads which have been determined to require a PFE access port by the ISRP.

Verification Submittal: Data Cert.

N.4.3.10.2.2 FIRE SUPPRESSION ACCESS PORT ACCESSIBILITY

A. Verification that the design of each integrated rack and payload volume permits the PFE nozzle to interface with the PFE access port(s) **shall** be by demonstration or analysis. Verification **shall** be considered successful when the demonstration or analysis shows the design of the integrated rack and payload volume, including protrusions, allows the PFE nozzle to interface with the PFE access port(s) on the front face of the payload, without relying on areas adjacent to the payload.

Verification Submittal: CoC

B. Verification that the PFE access port(s) is visible without moving any equipment **shall** be by inspection. The inspection **shall** consist of a review of the flight outfitting drawings to show that PFE access port(s) is visible without moving any equipment. The verification **shall** be considered successful when the inspection shows that the PFE access port(s) is visible without moving any equipment (e.g., acoustic enclosures, hoses, wires).

Verification Submittal: CoC

N.4.3.10.2.3 FIRE SUPPRESSANT DISTRIBUTION

Verification that the internal layout of each integrated rack and payload volume allows PFE fire suppressant to be distributed to the entire volume that PFE access port(s) serves, lowering the Oxygen concentration to or below 10.5% by volume at any point within the enclosure within one minute using a single PFE **shall** be by analysis or test. The analysis **shall** be performed on each integrated rack and payload volume to determine if the internal layout prevents suppressant from flowing to any volume internal to the volume that PFE access port(s) serves. The analysis can reference development test data as long as the configuration in the development test is shown to be similar to the flight configuration. The test **shall** be performed to determine if the PFE fire suppressant, as specified in Figure 3.1.1.2-1, is distributed to the entire volume that PFE access port(s) serves, lowering the Oxygen concentration to or below 10.5% by volume at any point within the enclosure within one minute using a single PFE. Verification **shall** be considered successful when the analysis or test shows the internal layout of each integrated rack and payload volume allows ISS PFE fire suppressant to be distributed to the entire volume a PFE access port(s) serves, lowering the Oxygen concentration to or below 10.5% by volume at any point within the enclosure within one minute using a single PFE.

Verification Submittal: Test Report or Analysis Report

N.4.3.10.3 PFE ACCESS PORT AND FIRE DETECTION INDICATOR LABELING

Verification that the PFE access port(s) is labeled with a SDD32100397-003 or SDD32100397-004 decal, based on Table N.3.10.3-1, **shall** be by inspection. Verification **shall** be considered successful when the inspection shows the appropriate SDD32100397-003 or SDD32100397-004 decal has been placed over the PFE access port(s).

Note: IPLAT will perform label verification.

Verification Submittal: CoC

N.4.3.11 MATERIALS AND PROCESSES INTERFACE REQUIREMENTS

N.4.3.11.1 FLUID CHEMICAL COMPOSITION

A. Verification of nitrogen fluid physical and chemical characteristics **shall** be by test. A test **shall** be performed to ensure that the payload nitrogen fluid system has been flushed with no fewer than four volume change-outs and pressurized to less than the 70 psia with nitrogen meeting the fluid physical and chemical characteristics specified in MIL-PRF-27401.The verification **shall** be considered successful when the test results show that the nitrogen provided to the rack meets the fluid chemistry requirements in MIL-PRF-27401, that no fewer than four volume change-outs of the nitrogen fluid system was performed, and that the final pressure of the rack is less than 70 psia (480 kPa).

Verification Submittal: Test Report

B. Verification of argon fluid physical and chemical characteristics **shall** be by inspection and test. An inspection **shall** verify that the certification of the argon supplied to the argon fluid system satisfies the fluid physical and chemical characteristics specified in MIL-A-18455. A test **shall** be performed to ensure the argon fluid system has been flushed with no fewer than four volume change-outs of argon and pressurized to less than the 70 psia. The verification **shall** be considered successful if the inspection results show that the argon provided to the rack meets the fluid chemistry requirements in MIL-A-18455, that no fewer than four volume change-outs of the argon fluid system was performed, and that the final pressure of the rack is less than 70 psia (480 kPa).

Verification Submittal: Test Report

C. Verification of carbon dioxide fluid physical and chemical characteristics **shall** be by inspection and test. An inspection **shall** verify that the certification of the carbon dioxide supplied to the carbon dioxide fluid system satisfies the fluid physical and chemical characteristics specified in BB-C-101. A test **shall** be performed to ensure the carbon dioxide fluid system has been flushed with no fewer than four volume change-outs of carbon dioxide and pressurized to less than the 70 psia. The verification **shall** be considered successful if the inspection results show that the carbon dioxide provided to the rack meets the fluid chemistry requirements in BB-C-101, that no fewer than four volume change-outs of the carbon dioxide fluid system was performed, and that the final pressure of the rack is less than 70 psia (480 kPa).

Verification Submittal: Test Report

D. Verification of helium fluid physical and chemical characteristics **shall** be by inspection and test. An inspection **shall** verify that the certification of the helium supplied to the helium fluid system satisfies the fluid physical and chemical characteristics specified in MIL-PRF-27407. A test **shall** be performed to ensure the helium fluid system has been flushed with no fewer than four volume change-outs of helium and pressurized to less than the 70 psia. The verification **shall** be considered successful if the inspection results show that the helium provided to the rack meets the fluid chemistry requirements in MIL-PRF-27407, that no fewer than four volume change-outs of the helium fluid system was performed, and that the final pressure of the rack is less than 70 psia (480 kPa).

Verification Submittal: Test Report

N.4.3.11.2 FLUID SYSTEM CLEANLINESS

A. Verification that the integrated rack or subrack payload nitrogen system meets the fluid system cleanliness levels of 200A per MIL-STD-1246 **shall** be by inspection. The inspection **shall** consist of a review of the nitrogen system as-built drawings and/or manufacturing documentation to ensure that appropriate precision cleaning and hardware control requirements are in place and that the as-built hardware meets or exceeds those requirements. The verification **shall** be considered successful when the inspection shows that the appropriate precision cleaning and hardware control requirements are in place to insure that MIL-STD-1246 fluid system cleanliness levels of 200A are established and maintained.

Verification Submittal: CoC

B. Verification that the integrated rack argon system meets the fluid system cleanliness levels of 300A per MIL-STD-1246 **shall** be by inspection. The inspection **shall** consist of a review of the argon system as-built drawings and/or manufacturing documentation to insure that appropriate precision cleaning and hardware control requirements are in place and that the as-built hardware meets or exceeds those requirements. The verification **shall** be considered successful if the inspection shows that the appropriate precision cleaning and hardware control requirements are in place to insure that MIL-STD-1246 fluid system cleanliness levels of 300A are established and maintained.

Verification Submittal: CoC

C. Verification that the integrated rack carbon dioxide system meets the fluid system cleanliness levels of 300A per MIL-STD-1246 **shall** be by inspection. The inspection **shall** consist of a review of the carbon dioxide as-built drawings and/or manufacturing documentation to insure that appropriate precision cleaning and hardware control requirements are in place and that the as-built hardware meets or exceeds those requirements. The verification **shall** be considered successful if the inspection shows that the appropriate precision cleaning and hardware control requirements are in place to insure that MIL-STD-1246 fluid system cleanliness levels of 300A are established and maintained.

Verification Submittal: CoC

D. Verification that the integrated rack helium system meets the SSP 30573, fluid system cleanliness levels of 300A per MIL-STD-1246 **shall** be by inspection. The inspection **shall** consist of a review of the helium system as-built drawings and/or manufacturing documentation to insure that appropriate precision cleaning and hardware control requirements are in place and that the as-built hardware meets or exceeds those requirements. The verification **shall** be considered successful if the inspection shows that the appropriate precision cleaning and hardware control requirements are in place in insure that MIL-STD-1246 fluid system cleanliness levels of 300A are established and maintained.

Verification Submittal: CoC

N.4.3.12 HUMAN FACTORS INTERFACES

N.4.3.12.1 GLOVEBOX OPERATION LIGHTING

The glovebox operation lighting level identified in Table N.3.12.1-1 **shall** be verified by test. The test **shall** be considered successful when illumination level as identified in Table N.3.12.1-1 measured at the task site(s) is met. The illumination level in a glovebox payload **shall** be determined by taking the average of a minimum of nine measurements (3-by-3 matrix) equally spaced encompassing the base of the work area surface.

Verification Submittal: CoC

N.4.3.12.2 GLOVEBOX BRIGHTNESS RATIO

Verification of the brightness ratio in a glovebox *should* be by demonstration. The demonstration *should* be considered successful when the minimum to maximum illumination levels, taken from the nine measurements in item B, does not exceed a brightness ratio of 3:1.

Verification Submittal: CoC

N.4.3.12.3 CONTINUOUS NOISE LIMITS

Verification of Continuous Noise Sources (See Glossary of Terms) for integrated racks **shall** be performed by test or test and analysis.

SPL test measurements **shall** be made at 0.6 meters for all sides of the integrated rack using the actual flight equipment (each serialized unit) even though prototype or qualification units may have been tested previously. The test configuration **shall** include any adjunct equipment, such as integrated rack-provided external computers, fans, etc., added in support of the rack system. The SPL test **shall** use a Type 1 Sound Level Meter (SLM) in accordance with publication IEC 61672-1, Electroacoustics-Sound Level Meters-Part 1: Specifications. The preferred instrument for acoustic verification is the Type 1 integrating-averaging sound level meter. This meter can either be of the handheld or component system variety.

Octave band filters used for verification measurements will meet the Class 1 specifications in accordance with publication IEC 61260-1, Electroacoustics-Octave-Band and Fractional-Octave-Band Filters, over the frequency range required for verification.

The SPL **shall** be measured at the loudest location 0.6 meters from the equipment surface in each of eight octave bands: 63 Hz, 125 Hz, 250 Hz, 500 Hz, 1000 Hz, 2000 Hz, 4000 Hz, and 8000 Hz.

Analysis for integrated racks whose subrack equipment or ORUs will be changed out, **shall** be verified using a test-correlated analytical model, or some other method that is approved and documented. The analytical model **shall** include system noise sources and anticipated subrack payload complement and ORU noise sources. The test-correlated model process is shown in Figure N.4.3.12.3-1.

The verification **shall** be considered successful when the results from the test data or the test-correlated analytical model, including additions, deletions or configuration changes to any subrack equipment or ORUs within the integrated rack, shows either of the two following conditions is satisfied:

(1) The octave band SPLs at the loudest A-weighted overall SPL location exposed directly to the crew-habitable volume and 0.6 meter from the integrated rack are at or below the levels for each of the eight octave bands: 63 Hz, 125 Hz, 250 Hz, 500 Hz, 1000 Hz, 2000 Hz, 4000 Hz, and 8000 Hz as specified in Table N.3.12.3-1, or

(2) The spatial average of the octave band SPLs measured at multiple locations exposed directly to the crew-habitable volume and 0.6 meter from the integrated rack surface are at or below the levels for each of the eight octave bands: 63 Hz, 125 Hz, 250 Hz, 500 Hz, 1000 Hz, 2000 Hz, 4000 Hz, and 8000 Hz as specified in Table N.3.12.3-1. SPL spatial averaging, as used in method (2), can only be used on racks with only one face adjacent to the habitable volume, and is subject to the following:

(a) Spatial averaging cannot be used if any measured octave band value is more than 6 dB above the requirements specified in Table N.3.12.3-1.

(b) Spatial averaging encompasses at least six but not more than 28 measurement locations, with at least 2 horizontally distributed and at least 3 vertically distributed sets of locations. Each measurement location is to be positioned at the center of equally defined areas, found by dividing up the entire rack front face area. See Figure N.4.3.12.3-2 (Acoustic Spatial Averaging Template) for an example with six locations.

(c) Acoustic spatial averaging is to be performed on the acoustic-pressure-squared values at the various locations in each octave band. The following equation illustrates how to calculate the average of octave band sound pressure levels (SPLs in dB) using six locations:

$$SPL_{Ave} = 10 \log [(10^{(SPL1/10)} + 10^{(SPL2/10)} + 10^{(SPL3/10)} + 10^{(SPL4/10)} + 10^{(SPL5/10)} + 10^{(SPL6/10)})/6]$$

Verification Submittal: Test and Analysis with Report

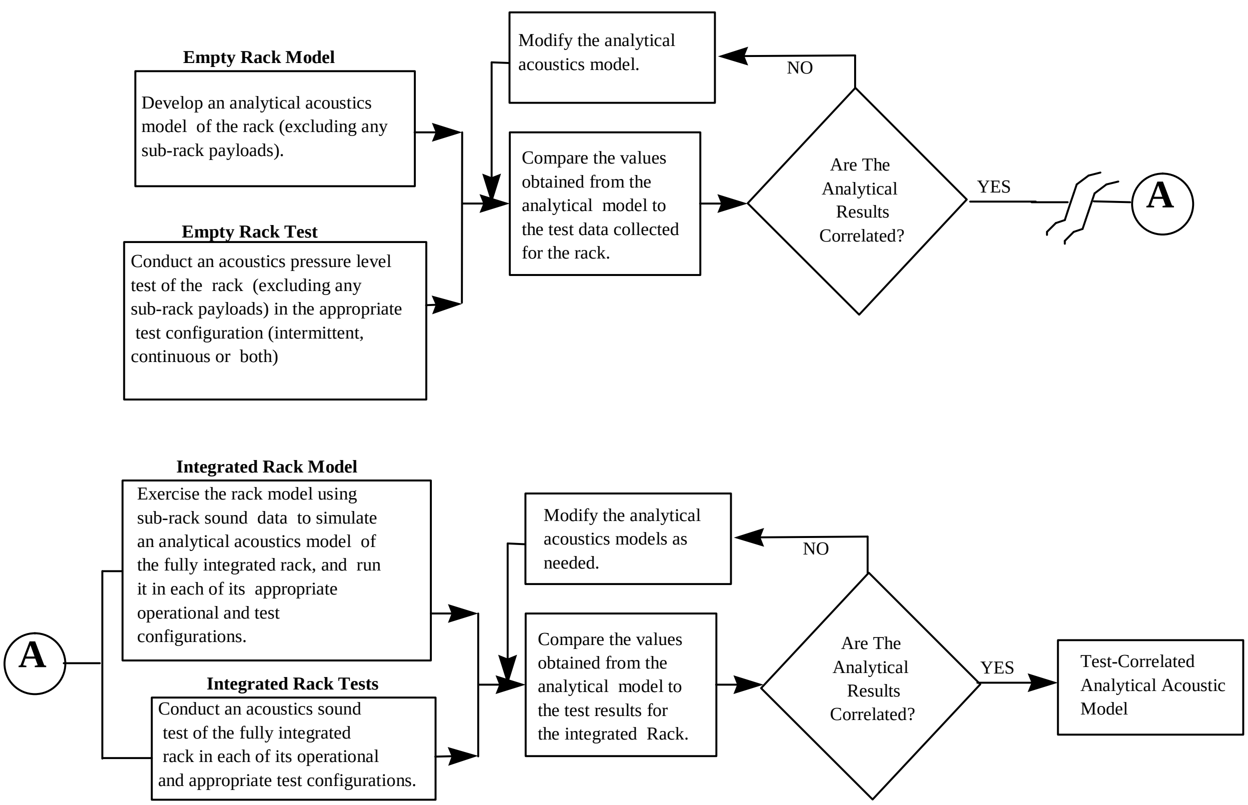


FIGURE N.4.3.12.3-1 TEST-CORRELATED MODEL PROCESS

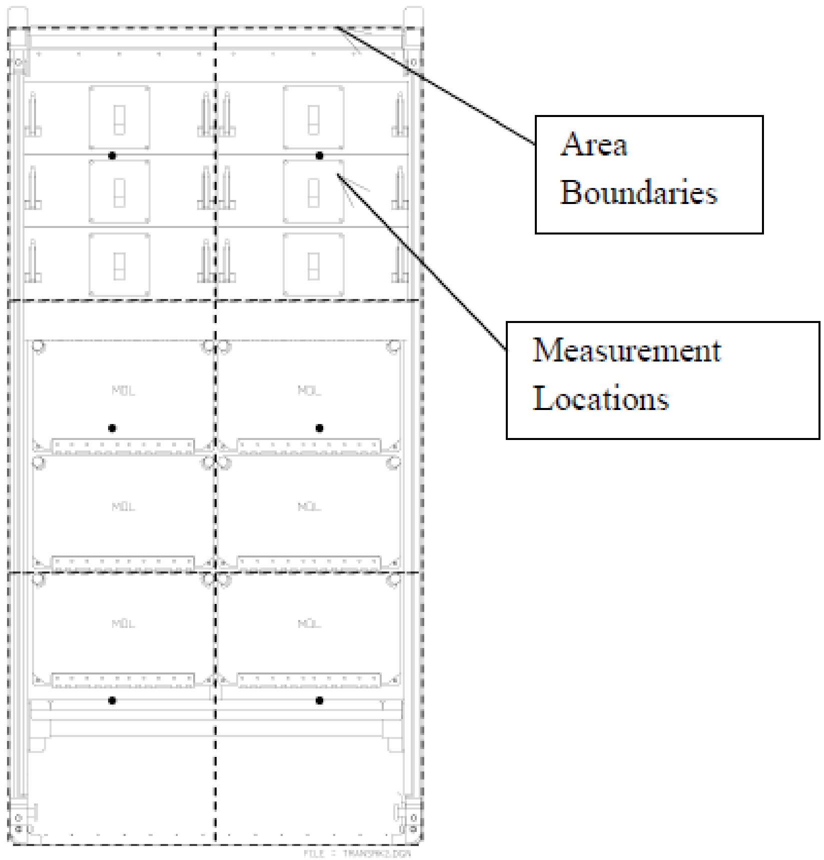


FIGURE N.4.3.12.3-2 SAMPLE ACOUSTIC SPATIAL AVERAGING TEMPLATE FOR 6 MEASUREMENT LOCATIONS

APPENDIX O

INSTRUCTIONS FOR LABELS AND DECALS

APPENDIX O - INSTRUCTIONS FOR LABELS AND DECALS

O.1.0 INTRODUCTION

The IPLAT reviews and approves labels for ***all payload equipment that the crew will interface with during nominal operations, planned maintenance, and contingency operations.*** IPLAT reviews labels against the instructions contained herein.

Labels reviewed by IPLAT **include**, but are not limited to:

- Rack/subrack front panel type hardware
- All experiment equipment, loose or mounted other than in rack/subrack formation
- Cables, fluid lines, hoses, etc., with which the crewmember interfaces
- All internal and external ORUs and the cables and hoses that connect to them
- All equipment controls, switches, ports, LEDs, stowage containers, etc.
- Interfaces to the ISS UIP, including cable and hose ports
- Items IPLAT does not review:
- Items which the crew will not interface with (e.g. internal circuit boards, etc.)
- Labels contained within software displays, procedures, cue cards. These are handled by the U.S. Payload Operations Data File Control Board (USPODFCB) or appropriate Operations Data File (ODF) control board.

Appendix O provides instructions for the approval of payload labels.

The term “label” used throughout these instructions refers to any one of the following:

Silk-screened labels: Markings that are silk-screened, with ink, onto hardware.

Decals: Peel-off labels with adhesive backing that are applied onto hardware.

Ink-stamped labels: Markings, stamped with ink, onto the hardware.

Engraved or etched labels: Markings carved onto the hardware surface.

Placards: Cards that are inserted into pockets.

Any other method of applying markings onto hardware.

O.2.0 ISS PAYLOAD LABEL APPROVAL PROCESS

IPLAT is required to review all payload labels from a human engineering perspective. IPLAT reviews both U.S. and IP payload labels.

The PD is required to provide drawings with label placement (location), orientation, content, and format; information sufficient to enable IPLAT to determine that the instructions herein are met.

IPLAT will guide the PD through the process of approving labels for flight crew interfaces, as shown in Figure O.2.0-1. The development of labels is a joint process requiring the cooperative efforts of IPLAT and the PD. The process for developing labels begins with the PD providing pre-released engineering drawings, and ends with the delivery of flight certified labels.

IPLAT reviews labels against the approved Operations Nomenclature (OpNom). OpNom is the operationally relevant term used to describe hardware. For U.S. payloads, OpNom is approved by the USPODFCB. For IP payloads, the appropriate ODFCB (Operations Data File Control Board) approves their OpNom.

IPLAT performs two label evaluations, an initial and a final label evaluation. Upon receiving the drawings, or other materials, IPLAT has 10 working days to complete the initial label evaluation. IPLAT will provide feedback that documents any requirement violations, and suggested solutions.

The final label evaluation can be completed in one of two ways: 1) via approval of released engineering drawings, or 2) review of digital images certified to be of the flight hardware with labels installed. With the first approach, labels are to be ordered after IPLAT has issued the JSC Form 2994, ISS Label Approval/Change Form. With the second approach, labels must be installed before pictures can be submitted to IPLAT for approval. This approach is to be done in close coordination with IPLAT to ensure the correct labels are applied to the hardware, in the correct locations. IPLAT has 10 working days to complete the final label evaluation. If the labels meet the requirements, IPLAT returns JSC Form 2994, approved, to the PD. JSC Form 2994 is the PD's official verification that the labels meet the requirements, and is required to be included in the payload's verification record.

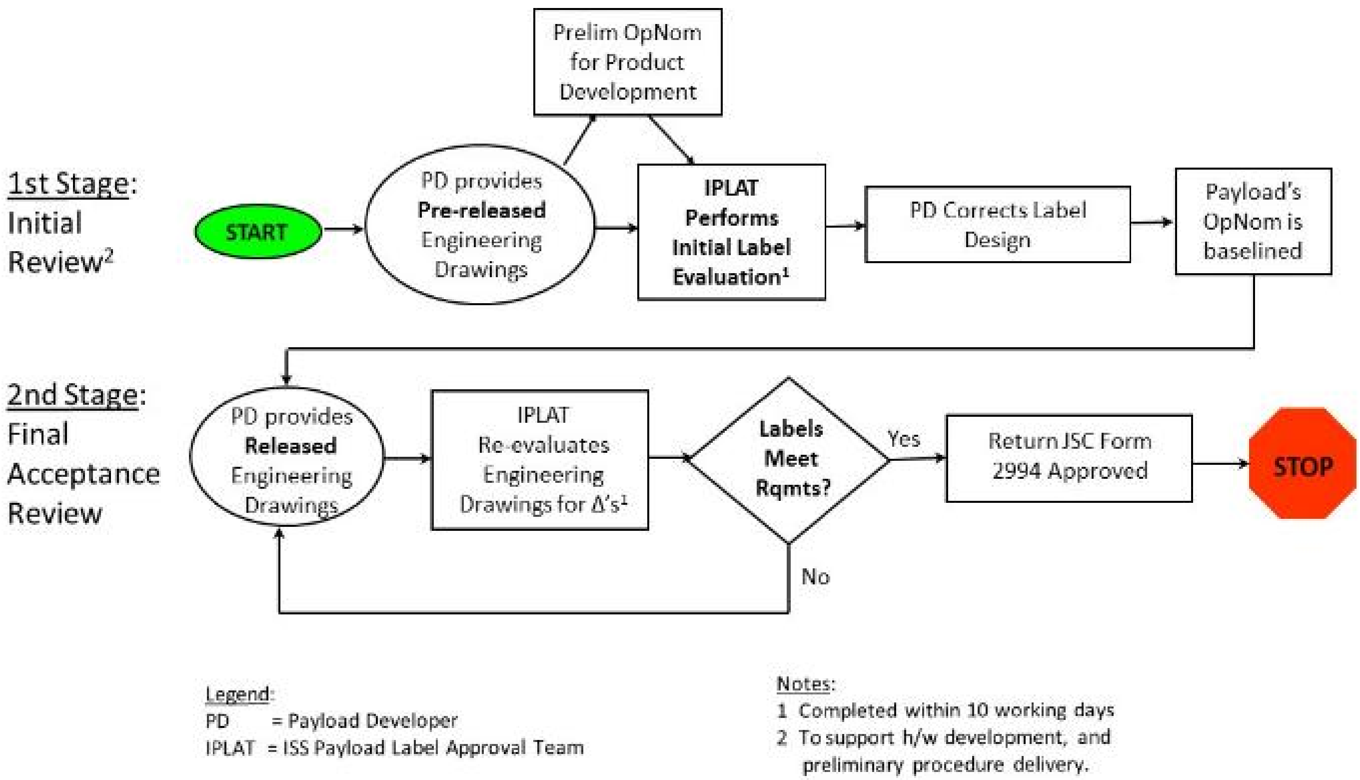


FIGURE O.2.0-1 IPLAT PAYLOAD LABEL APPROVAL PROCESS

O.3.0 IPLAT APPROVAL INSTRUCTIONS

IPLAT will use the following instructions in reviewing and providing the approval of payload labels.

Instructions that say "is/are required to" are required to be implemented for approval.

Instructions that say "is/are recommended to" have flexibility to be tailored to the payload's specific situation.

Table O.3.5-1, Labeling Instructions Applicability Matrix (in Section O.3.5 at the end of Appendix O) is intended to assist the payload developer in understanding which instructions are applicable for their hardware.

The following definitions will be used throughout this section:

> "Passive", as it relates to payload hardware, is defined as hardware that cannot itself be powered, such as cables and hoses, consumables, etc.
>
> "Active", as it relates to payload hardware, is defined as hardware that can be powered and performs a specific payload function.
>
> "Non-rack self-contained payloads" refers to a category of equipment that becomes powered, or active, but is not mounted on the front of a rack like a subrack payload.
>
> "Loose Equipment" is defined as passive, unpowered equipment generally found in payload stowage (e.g. cables, consumables such as biocide wipes, science samples, tools, etc.)

O.3.1 OPERATIONS NOMENCLATURE (OPNOM)

Labels are required to conform to the ODFCB approved OpNom, SSP 50254 and applicable partner annexes. This includes payload names, items in stowage list of contents, cables/hoses, loose equipment, acronyms, and abbreviations.

O.3.2 BARCODES

PDs are required to coordinate with NASA/JSC organization OC for Inventory Management System (IMS) barcodes.

All equipment are required to have an IMS barcode in accordance with SSP 50007, Space Station Inventory Management System Bar Code Label Requirements and Specification. IMS barcodes placeholders are recommended to be present on engineering drawings, if the standard hardware ID label (with IMS barcode included) is not used. If the PD orders their IMS barcodes from the Decal Design & Production Facility (DDPF), the Decal Catalog decal part number is recommended to be included in a note on the engineering drawing.

O.3.3 PLACEMENT (LOCATION) AND ORIENTATION

O.3.3.1 PLACEMENT

A. All labels are required to be placed on the payload hardware in accordance to the label location drawings.

B. Payloads Operated from Rack Front Panels – Labels for Payloads operated from the front panel of racks are required to be placed in accordance to Figure O.3.3.1-1.

(1) Rack hardware ID label – The rack hardware ID label is required to be placed in the upper left corner of the rack. If the IMS barcode is attached separately, it is required to be placed to the right of the hardware ID label.

(2) Subrack hardware ID label – The subrack hardware ID label is required to be placed in the upper left corner of the subrack. If the IMS barcode is attached separately, it is recommended to be placed to the right of the hardware ID label.

(3) The Rack UIP is required to be labeled "Rack UIP". This label is required to be placed in the upper left corner of the Rack UIP.

C. Non-rack self-contained payloads, ORUs – The hardware ID label is recommended to be placed in the upper left corner of the dominant face of the payload. If the IMS barcode is attached separately, it is recommended to be placed to the right of the hardware ID label.

D. Loose Equipment. See Figure O.3.3.1-2 for examples.

(1) The hardware ID label is recommended to be placed in the upper left corner of the dominant face of the payload. If the IMS barcode is attached separately, it is recommended to be placed to the right of the hardware ID label.

(2) For cases where an item only has room for the OpNom or a barcode, but not both, a label with the OpNom takes precedence.

E. Control Panel Labels

(1) Positions - Labels are required to be centered above connectors, switches, LEDs, displays, controls, etc. Labels may be placed in other locations when they cannot dimensionally fit in the required location, or if they would be obstructed by items like cables and hoses, or to preclude inappropriate association with adjacent items. See Figure O.3.3.1-3 for examples.

F. Part Numbers and Serial Numbers

(1) Part Numbers and Serial Numbers are recommended to be placed together for ease of identification. If they are included in the hardware ID label, they are required to be placed below the line.

(2) "P/N" and "S/N", which are the standard OpNom representations for Part Number and Serial Number, respectively, are recommended to be used.

G. Orientation – All markings and labels are required to be oriented with respect to the local worksite plane so that they read from left to right. Rotating the label 90 degrees when the text is long, is permissible when the marking or label does not fit in the required orientation.

H. Visibility – All labels are required to be placed on equipment so that they are visible when the equipment is used or accessed. Markings are recommended to be located such that they are perpendicular to the operator's normal line of sight whenever feasible and cannot be less than 45 degrees from the line of sight.

I. Association Errors – The arrangement of markings on panels is required to protect against errors of association of one object's marking with adjacent objects.

J. Subrack Location Codes:

(1) At the Rack Level - Subrack location codes are required to be placed along the inside surface of the seat track at intervals equal to the individual rack's smallest drawer unit (e.g.: 4 PU (7 inches) for U.S. payloads, different for IP racks), as shown in Figure O.3.3.1-1. Each letter/number pair is required to be 0.18 in tall and placed at the top of the particular drawer interval. Locations other than the inside of the seat track are permissible only if there is a permanent obstruction that would cover the labels.

(2) For Control Panels That Control Multiple Subracks – Each subrack's controls are required to be mapped to its location using the letter/number code (e.g. "A1", "A2", "B1", "B2", etc.), and a graphic (matrix with appropriate box checked) showing the individual locker's location in the rack. See Figure O.3.3.1-3 for examples.

K. Access Panels - Maintenance access panels are required to be labeled to assist the crew in locating the panel for maintenance activities.

(1) Access panel identification labels are recommended to be located in the upper left corner position on the panel with respect to the local vertical orientation.

(2) Access panel identification labels for access panels on the side or back of a rack are recommended to be labeled as in Figure O.3.3.1-1 and include:

- The OpNom for the rack (e.g. "SRF").

- Its height location using the subrack location code becomes part of the OpNom (e.g. "C3") .

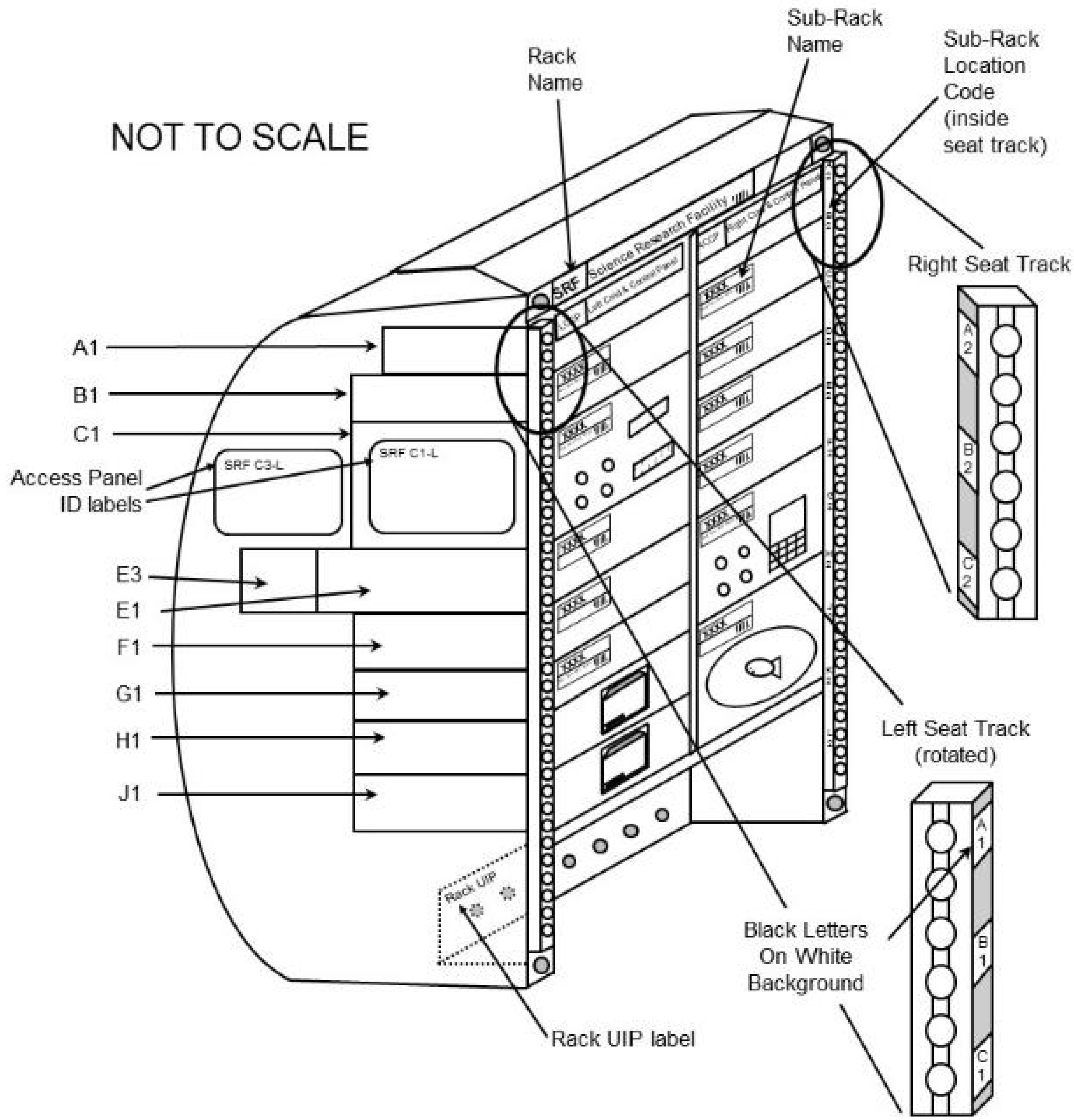
- Its left, right, or back location on the rack preceded by a hyphen (e.g. "-L" for left, "-R" for right, "-B" for back).

For example, a completed access panel label might be "SRF C3-L" or "SRF C3-R".

L. Alignment Marks/Interface Identification

(1) Alignment Marks – Alignment marks or other orientation markings are required to be used to aid the crew with the installation/mating of equipment when the hardware requires a specific orientation.

(2) Visibility – Alignment marks, arrows, or other labels showing required orientation are required to be visible during alignment and attachment.



Rack Name Label - Located in the upper left corner of rack. 0.48 in minimum. IMS barcode is included.
Subrack Name Label - Located in the upper left corner of the subrack. Between 0.28-0.36 in. IMS barcode is included.
Subrack Location Codes - Located on the inside of the seat track. Letters A thru N, excluding I (0.18 in). Letter/number pairs to be placed at intervals equal to the individual rack's smallest drawer unit (e.g.4 PU (7 inches) for U.S. payloads, different for IP racks).
Rack UIP - This panel is required to be labeled the "Rack UIP". The procedures are required to refer to the panel as "Rack UIP" also. Electrical and fluid/gas connector ports are required to be labeled.
Access Panels are required to be labeled.

FIGURE O.3.3.1-1 RACK LABEL PLACEMENT

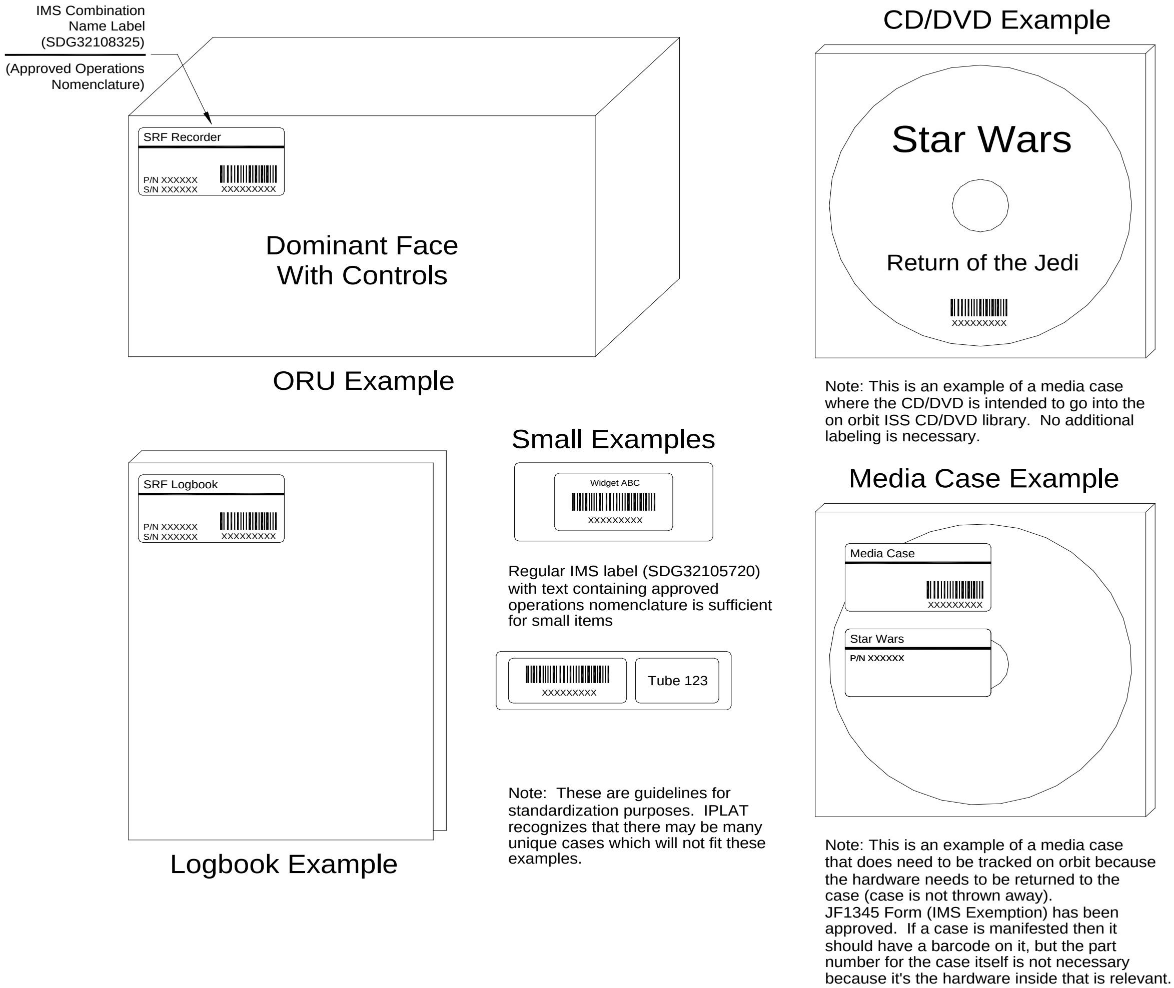
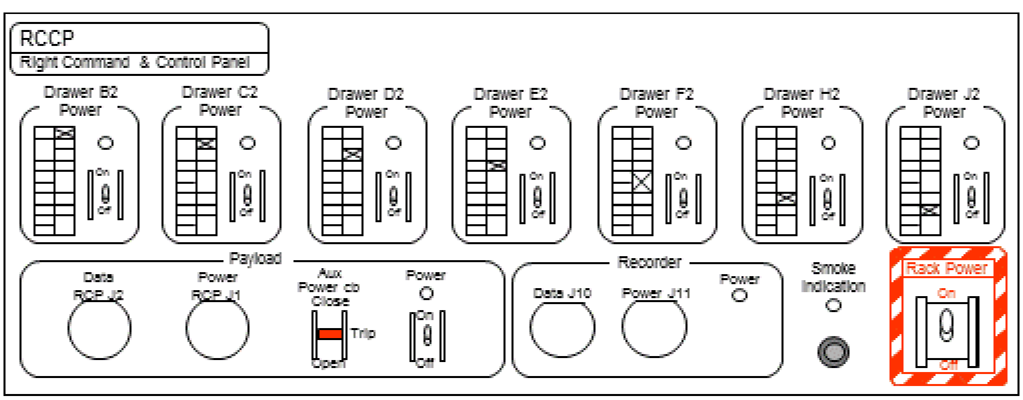


FIGURE O.3.3.1-2 HARDWARE LABEL PLACEMENT GUIDELINES



This panel is at the A2 position in Figure O.3.3.1-1.

FIGURE O.3.3.1-3 CONTROL PANEL LABELING

O.3.3.2 ORIENTATION

A. Payload labeling, displays, and controls are to have a consistent rack vertical orientation arrangement with the rack vertical axis origin at the bottom of the rack hinge point.

B. Payload labels required for operations with the rack(s) rotated are recommended to be oriented with respect to required crew positions.

O.3.4 CONTENT AND FORMAT

O.3.4.1 GROUND ASSEMBLY AND HANDLING

Labels used for ground assembly and handling cannot interfere with on-orbit crew interface labeling and are required to be either covered or marked out if the labels provide no function for the crew. Product marking for ground assembly and handling is recommended to be in accordance with MIL–STD–130, Identification Marking of U.S. Military Property, Section 4, except Paragraph 4.1.c.

O.3.4.2 FUNCTION CONSIDERATIONS

Labels for crew interfaces are required to contain information regarding the operational interface (e.g. the purpose, the function, and/or the functional result of the use of equipment items). Engineering characteristics or nomenclature may be described as a secondary consideration.

Instrument labels, for example, are recommended to be labeled in terms of what is being measured or controlled. Calibration data may be included where applicable.

O.3.4.3 LABELING STANDARDIZATION

A. Standard decals needed by the PD are available in JSC 27260. Decals are to either be obtained from the DDPF, or be designed to be identical to them. Examples of labels found in the catalog are: IMS Combination Name Lables, fire hole, toxicology, hazardous, caution and warning, rack power switch, fire indicators, cable/hose labels, etc. The DDPF is also available to PDs for fabricating labels not found in JSC 27260.

B. Labeling is recommended to be standardized between and within systems.

C. The instructions for the IMS Combination Name Label are listed below. Figure O.3.4.3-1 shows examples of payload hardware ID labels.

   (1) Each label is to contain a horizontal line. A vertical line may be used for vertical space limitations.

   (2) ONLY the OpNom for the item to which the label will be applied is to appear above the line or to the left of the line.

   (3) The payload’s acronym (if applicable) is recommended to be spelled out on the main unit’s hardware ID label. This is recommended to be placed directly below the line.

   (4) The part number and serial number (if applicable) are below the line, and below the spelled out payload name.

(5) If the Inventory Management System (IMS) barcode is integrated with the hardware ID label, it is to fall below the line, and be placed in the lower right hand corner of the label.

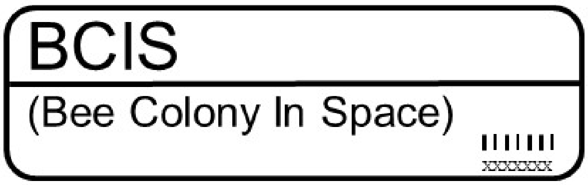
(6) On control panel name labels, the OpNom is recommended to be above the line. The spelled out name, if needed, is recommended to be applied under the line.

(7) No other text, other than that mentioned above, is to appear on the hardware ID label.

Figure O.3.4.3-2 shows an example of a hazardous response label integrated with an IMS bar code label.

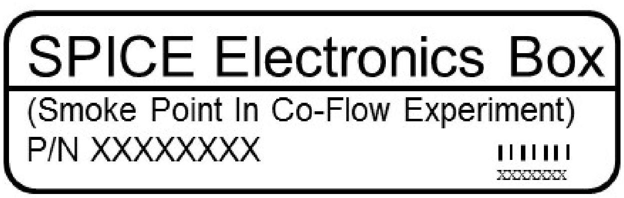
a) Rack "main unit" IMS Combination Name Label example

b) Rack "main unit" IMS Combination Name Label example - vertical space limited



c) Subrack "main unit" IMS Combination Name Label example

d) Subrack "main unit" IMS Combination Name Label example - vertical space limited

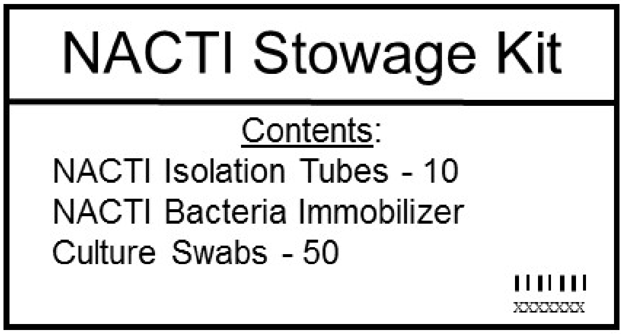


e) Example of "main unit" IMS Combination Name Label for a "Non-rack self-contained payload"

f) Example of subordinate equipment IMS Combination Name Label

Note: These standard labels can be ordered from the Decal Design & Production Facility (DDPF) through the BITS (Barcode Inventory Tracking System) group.

FIGURE O.3.4.3-1 HARDWARE ID LABELS (TO SCALE) (PAGE 1 OF 2)



g) IMS Stowage Kit Contents Label

Note: These standard labels can be ordered from the Decal Design & Production Facility (DDPF) through the BITS (Barcode Inventory Tracking System) group.

FIGURE O.3.4.3-1 HARDWARE ID LABELS (TO SCALE) (PAGE 2 OF 2)

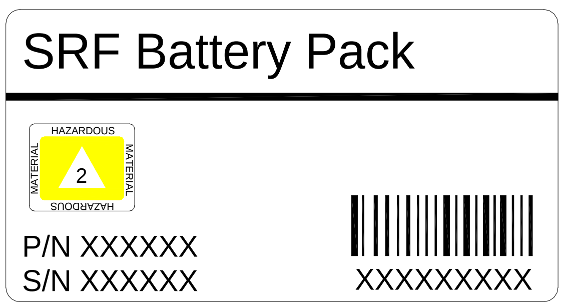


FIGURE O.3.4.3-2 EXAMPLE OF HAZARD RESPONSE LABEL INTEGRATED WITH IMS BAR CODE LABEL

D. Casing: All labels on a payload are recommended to be in mixed case, including abbreviations. This includes Hardware ID labels, control panel labels, cable/hose labels, stowage containers and their contents, loose equipment, etc. Acronyms are recommended to be in upper case to allow crew to distinguish them from abbreviations.

E. Size

(1) Sizes of label text are recommended to be per Table O.3.4.3-1:

(2) Size Categories – Characters used in hierarchical labeling (e.g. rack name, subrack name, controls groupings, port names, etc.) are recommended to be graduated in size per Table O.3.4.3-1. There is recommended to be at least a 25 percent difference in the character height between each of these categories.

(3) Size of Decals – The size of decals are recommended to be designed such that the “white space” between label text and the outer edges of the decal do not exceed 0.25 inches. This is to minimize the footprint of decals, which can cause visual clutter or physical interferences on-orbit.

TABLE O.3.4.3-1 CHARACTER HEIGHT - 710 MM (28 IN) VIEWING DISTANCE

MARKINGS	CHARACTER HEIGHT1
Rack Name (examples “a” and b” of Figure O.3.4.3-1)	0.48 in, or 12 mm (min) for OpNom 0.24 in, or 6mm for spelled out name
Subrack Name (examples “c” and d” of Figure O.3.4.3-1)	0.28-0.36 in, or 7-9 mm for OpNom 0.18 in, or 4mm for spelled out name
Non-rack Self Contained Payloads (examples “e” and f” of Figure O.3.4.3-1)	0.12-0.36 in, or 3-9 mm for OpNom 0.10 in-0.18 in, or 2.5-4mm for spelled out name
Loose Equipment, ORUs	0.12 in or 3 mm (min) 0.10 in or 2.5 mm for part/serial number
Control Panel Names	0.22-0.28 in, or 5-7 mm for OpNom 0.12 in-0.18 in, or 3-4mm for spelled out name
Stowage Kit Contents Label	0.20-0.24 in, or 5-6 mm for kit OpNom 0.12 in-0.14 in, or 3-4mm for individual contents’ OpNom
Controls (e.g., switches, connector ports, etc. on a control panel)	0.10 in-0.20 in, or 2.5-5 mm
For critical markings, with position variable (e.g., numerals on counters and settable or moving scales)	0.20-0.31 in, or 5-8 mm
For critical markings, with position fixed (e.g., numerals on fixed scales, controls, and switch markings, or emergency instructions.	0.16-0.31 in, or 4-8 mm

[1]See Figure O.3.4.3-1 for examples.

O.3.4.4 READABILITY

A. Labels are recommended to be as concise and direct as possible.

B. Language

(1) Labels are required to be written in the English language.

(2) If dual languages are used, English is required to be used first and with lettering at least 25% larger than the secondary language.

C. Labels are recommended to be designed so as to minimize visual clutter.

D. Displays and Controls Title Selection - Physical Hardware

(1) When verbs are used to label physical hardware (buttons, switches, controls, etc.), the present tense is recommended to be used. For example: “Open”or “Close”, “Begin”, or “End”, “Start” or “Stop”, etc.

(2) Physical Hardware Linked to Software Displays – If physical hardware is linked to and/or represented by software displayed data or controls (i.e. LCD), the labels for the physical hardware and the software representation are required to match.

(3) Circuit Breakers

(a) If the physical device in any way operates as a circuit breaker, the abbreviation “cb” is required to be used in the label. For example: “Power cb”.

(b) Circuit breaker positions are recommended to be labeled Open and “Close”, not “On” and “Off” or “Push” and “Pull”.

(4) Switches – Switches are required to be named according to their function (e.g. “Main Power”, “Battery”, etc...). In cases where there is more than one switch with the same function it is acceptable to name them by function and numerical sequence (e.g. “Power1”, “Power2”, etc...).

(5) Push Buttons – Push buttons are recommended to be named according to their function. If necessary, use the word “Press” (not “Mash”, “Push” or “Depress”) to instruct the crew how to operate it.

E. Units of measure are recommended to be in Standard International (SI) units, unless otherwise required to match the hardware.

O.3.4.5 EQUIPMENT LABELING

O.3.4.5.1 EQUIPMENT IDENTIFICATION

A. All items on a piece of hardware that have a crew interface are required to be identified, including, but not limited to: displays, controls, switches, connectors, LEDs, containers, vents, etc., such that these items can be clearly referenced in crew procedures. The size for these labels are required to be smaller than the main label naming the payload.

B. Multi–quantity items

(1) Multi–quantity items that are permanently installed into hardware (not loose) that require individual distinction but are not serialized are recommended be individually numbered. Controls level items are recommended to be logically numbered/lettered left to right or top to bottom in descending order (e.g. “Drive A”, “Drive B”, “Drive C”).

(2) Serial Numbers – Multi–quantity items that are serialized are to display the serial number as part of the identification.

C. Logos – If organizational or commercial logo(s) are used, they cannot be distracting to the crew while operating the payload. For front panels, the size of the logo is recommended to be smaller than the main name label and be located away from the identification label if possible.

O.3.4.5.2 EQUIPMENT CODING

O.3.4.5.2.1 CABLE AND HOSE LABELING

A. Crew Interface Cables and Hoses Definition – Electrical cables and hoses *which are interfaced with by the crew* for nominal operations (e.g. experiment operations), planned maintenance (e.g. ORU replacement), or are designed to have a crew interface in the event of a contingency situation, are considered “Crew Interface Cables and Hoses”, and are subject to the format requirements below.

B. Crew Interface Cables and Hoses are required to have hardware ID labels, cable end labels, and any safety labels as deemed necessary. If one end of a cable or hose is permanently attached to a piece of hardware, that end does not require a cable end label, and it does not require an IMS barcode. The loose end that the crew interfaces with is required to have a cable end label to tell the crew where it mates. If the cable or hose diameter is such that it can accept a sleeve/band style label, that is preferred. Flag style labels can be used if necessary. IPLAT can help the PD choose the appropriate style and size of the labels.

(1) Electrical Cable End Plugs and Corresponding Electrical Connector Ports

(a) The cable end plug is required to be designated with a “P” (e.g. P1), regardless of gender. Note: “P” is recommended to be used even for cable to cable connections.

(b) Connector Port Names: The connector port name is required to begin with a descriptor that describes its purpose (e.g. Data or Power), followed by a ”J” (regardless of gender) and a 3 or less character number. Examples: Data J510, Power J1.

(c) The plug number and receptacle number for a mating pair are required to be identical (e.g. P1 mates with J1), except when not possible because a cable is generic.

(2) Cable and Hose Label General Characteristics

(a) Size - The size of the text on these labels is recommended to be at least 0.12 in preferred, or 0.10 in minimum.

(3) Cable and Hose Identifying Labels - Cables and hoses are required to have a main identifying label with the information below. This label is required to be placed at the mid-length position of the cable/hose, *unless the cable or hose is 6 meters or greater, which would then require an identification label placed every 2 meters.* See Figure O.3.4.5.2.1-1 for examples.

- The OpNom of the cable/hose.
- For hoses: The flow direction is required to be indicated with an arrow below the OpNom if the hose ends are not interchangeable.
- The Part Number of the cable or hose (optional)
- The Serial Number of the cable or hose (optional)

(4) Cable and Hose IMS Barcodes – A cable/hose is required to have an IMS barcode. It is required to be placed to the right of the hardware ID label (if not using a standard hardware ID label with the IMS barcode included), at the mid-length position, as shown in Figure O.3.4.5.2.1-1.

(5) Cable and Hose End Labels - Labels at the terminal ends of cables/hoses are required to contain the information below in vertical order, center justified. See Figure O.3.4.5.2.1–1 for cable/hose label examples.

First Line: The identification of this end of the cable/hose.

– For cables, use “P” followed by a plug number.

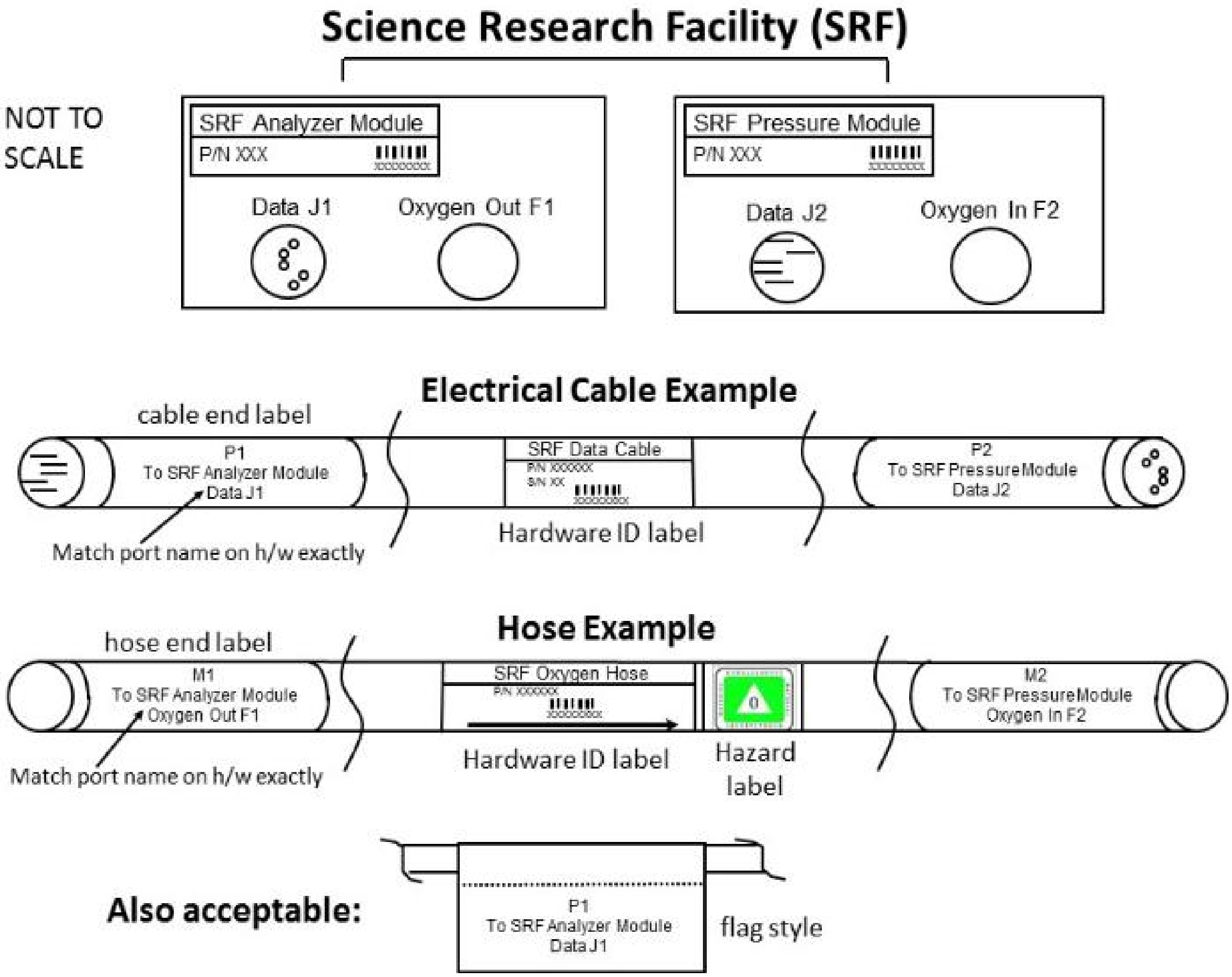
– For a hose, use “M” for male, or “F” for female, followed by a number.

Second Line: The word “To” followed by the OpNom of the piece of equipment to which this end of the cable/hose mates with. If this end can interface to multiple connector ports (e.g. generic cables), this line may be left off.

Third Line: The exact name of the receptacle on the hardware that this end of the cable/hose mates with (e.g. Data J1 or Oxygen Out). If this end can interface to multiple connector ports (i.e. generic cables), this line may be left off. If the receptacle is on a piece of hardware not provided by the PD (e.g. GFE laptop), and the receptacle is not labeled, appropriate descriptive words are required to be used (e.g. Serial Port).

Note: Having only the first line (the “P number) is allowed for the following cases: 1) If cables are clustered together and cannot display the 3 lines of information on cable end labels without causing physical interference and visual clutter, having only the first line (the “P” number) is allowed. 2) If a cable end has generic or multiple connection locations instead of connecting to one specific location.

(6) Hose Hazard Labels – Hoses are required to have standard hazard class decals indicating the appropriate hazard level for the substance transported through the hose. This label is recommended to be placed to the right of the identifying label.



Notes:

Electrical cables/ports: "P" designates cable end plugs and "J" designates receptacles on hardware regardless of gender (pins/sockets).

Hose Identifying Labels: Flow direction to be shown if the hose ends are not interchangeable.

FIGURE O.3.4.5.2.1-1 CABLE AND HOSE LABELING

O.3.4.5.2.2 COLOR CODING

Color coding is only to be used to enhance the ability of the ISS crew to perform tasks.

A. Red, yellow, and orange can only be used to mark emergency use, caution, warning, and hazard labels. See Section O.3.4.9 for Caution & Warning labeling requirements.

B. Identification/Connectivity – Color coding used for component identification or to denote connectivity relationships are required to combine color with text such that when those components are referred to within procedures, it is clear which components the procedures are referring to.

C. Color Difference

   (1) The colors chosen are required to be easily distinguished from one another within the same system or integrated rack.

   (2) Each color is required to always be associated with a single meaning within the same system or integrated rack.

D. Number of Colors – No more than nine colors, including white and black, are recommended to be used in a coding system.

E. Markings/Background Color – Markings and background colors on labels are required to have sufficient contrast such that the labels are readable in ambient ISS lighting conditions. Labels are to adhere to the accepted combinations of markings and background color listed below. Labels that do not fall into these marking/background categories will be approved on a case-by-case basis.

Marking	Background
Black	White
Black	Yellow
Black	Silver (metalphoto labels)
White	Black
White	Red
White	Grey
Yellow	Blue
Red	White
Blue	Yellow

O.3.4.6 OPERATING INSTRUCTION LABELS

Operating instruction labels are labels (affixed to hardware) that contain multiple procedural steps, as opposed to singular instructions such as "This Side Up". The procedural text is to conform to ODF standards as documented in ODF Standards, SSP 50253 and be approved by the appropriate IP ODF component board. For US payloads, submit ECR to USPODFCB for review and approval.

O.3.4.7 STOWAGE CONTAINER LABELING

This section applies to stowage containers or kits provided by the payload, located within the payload's stowage allocation, not in general ISS stowage. See the examples in Figure O.3.3.1-2 for labeling of individual items and Figure O.3.4.7-1 for Ziploc bag labeling.

A. The PD has choices how the hardware will be delivered to the NASA Packing Organization facilities. The following is an explanation of the options available to the PD for stowing their hardware:

- Stand-alone: A single hardware item in a box or in a pink-poly non-flight bag. In this case packaging provisions will be provided by NASA Packing Organization.
- Kit – A container with a Kit OpNom name that contains two or more unique items that have different Part Numbers, but is required to be manifested as the Kit OpNom name, a single entity. Kitting is required to be done by the PD. The NASA Packing Organization will not kit items.
- Pre-packed: For non-kit hardware all pre-packed items inside are manifested individually.

The PD is required to decide if the stowage provision (e.g. ziploc bag, connector cap, cardstock, etc.) needs to be tracked on-orbit (kept) or trashed by the crew. Figure O.3.4.7-1 shows examples of labeling where the provision is tracked on-orbit vs. trashed by the crew.

(1) Bags or other stowage provisions that are recommended to be tracked on-orbit (kept) are required to have a barcode.

(2) Bags or other stowage provisions that are recommended to be trashed on-orbit cannot have a barcode.

Notes:
(1) Payloads are required to utilize Launch, Return, On-Orbit Data Set (LRODS) to indicate delivery of hardware in flight approved materials. If not indicated in LRODS, NASA Packing Organization assumes packing material is not flight approved. If the hardware is labeled per the instructions below, NASA Packing Organization assumes the provision is flight approved.
(2) Stowage provisions are available from the NASA Packing Organization via their Request For Service (RFS) process. See memo CMC2-00025, for available stowage provisions.
(3) When pre-packing items, ensure they cannot damage each other.

B. Containers, ziploc bags, bubble-wrap bags, or kits used to contain single or multiple items are required to be labeled as specified below:

(1) Content labels are required to follow size, format, and content as defined in SDG32108582, IMS Stowage Kit Contents Label (for a manifested container), or SDG32112200, Stowage Contents Labels, drawing (for a non-manifested container), or as approved by IPLAT.

(2) Each stowage container cargo bag is required to display a contents label on the dominant face that is visible to the crew.

(3) The name of the container or kit and all contents is required to be identified using the approved OpNom. In the case of a bag that is not manifested, OpNom for the bag itself (e.g. ziploc bag) is not required, but the bag is required to be labeled with the contents of the items inside.

(4) If the hardware itself will not accept a standard size, adhesive-backed label due to form, fit, or function, the hardware is required to be placed into a container (e.g., ziploc, bubble-wrap, mylar, antistatic film, etc) that is labeled with the OpNom, part number, and serial number of the hardware. Form, fit or function issues may apply if surface area of hardware is too small to accept standard size label, or if surface area of hardware is curved and will not accept an adhesive-backed label.

(5) If textured surfaces or other characteristics of a stowage provision (e.g., cold stowage bag, desiccant bag, etc.) make it difficult or impossible to apply a standard adhesive-backed label, the OpNom, and/or part number, and serial number, (if applicable) are recommended to be clearly and legibly handwritten on the stowage provision using a Sharpie marker or other permanent ink marker, or mechanically printed directly on the surface of the stowage provision (e.g. Inkjet).

(6) Items allocated to a specific crewmember are required to be identified on the contents label with the user’s title, name, or other coding technique.

(7) Containers with designated locations for placement of hardware set (e.g., socket wrenches in a tool kit) are to have each location identified with the OpNom of the item stowed.

(8) When operations require that a bag be temporarily stowed to hold and manage their contents, bags are to have hook Velcro on the back (non-dominant face) or provide other means to temporarily stow the bag, except for Cold Stowage bags which cannot accept Velcro because they cannot withstand the thermal environment.

(9) Opaque stowage provisions containing items with a hazard response rating (0,1,2,3,4), are required to label the outside, lower left corner surface of the stowage provision with a hazard response label showing the highest hazard response level of the items inside. Note: Hazard response labeling is only required on opaque stowage provisions where any hazard response labels on interior contents are not clearly visible.

(10) Special Handling Requirements:

(a) ESD-sensitive hardware is required to be labeled as such on hardware itself and on the outside of the stowage provision that contains the hardware, in the lower left corner of the crew facing surface.

(b) Pressure vessels are required to be labeled as such on the hardware itself and on the outside of the stowage provision that contains it, in the lower left corner of the crew facing surface, with the standard “WARNING PRESSURIZED VESSEL” label in the Decal Catalog JSC 27260 (drawing SDG32105066).

C. Foam Container Labeling – The NASA Packing Organization provides foam packaging, and most PDs use this service. However, for cases when the PD chooses to engineer their own foam, the following requirements apply. See Figure O.3.4.7-2 for examples.

(1) Foam containing hardware items is required to be labeled with the OpNom, part number, serial number, and quantity (if greater than one) of each of the contents within the foam. Labeling with a Sharpie marker or other permanent ink marker is an option when adhesive labels will not work.

(2) Foam containers with designated locations for placement of hardware (e.g., socket wrenches in a tool kit) are to have each location identified with the OpNom of the item stowed.

(3) Foam is recommended to be labeled to indicate usage and disposal status to the crew for on-orbit use,on a non-dominant face, according to the following categories. The dominant face is reserved for on-orbit labeling to identify the hardware contained in the foam. Note that usage and disposal status for foam can be clearly and legibly labeled with a Sharpie marker or other permanent ink marker.

(a) “Trash”: For foam that is known that it is recommended to be discarded at any time

(b) “Keep”: For foam that is known that it is recommended to be kept

(c) “Trash after installation”: For foam that is known that it is recommended to be discarded after the hardware is installed

(d) Leave Blank: for foam that it is unknown if it can be trashed or kept (better to say nothing than to say the wrong thing)

(e) “Custom”: Denoting an above status with additional notes

(4) When only a portion of the launch foam is required to transfer with the hardware, the piece is recommended to be labeled with yellow highlighted text to indicate transfer status (such as: “Transfer foam cap with <specify OpNom >”)

(5) Items allocated to a specific crewmember are required to be identified on the contents label with the user’s title, name, or other coding technique.

(6) Foam to be tracked on-orbit - Engineered foam used to protect hardware is required to be labeled with the OpNom, part number, and serial number (if applicable) of the foam in an inconspicuous location on the foam (not on the front

face). The dominant face is reserved for on-orbit labeling to identify the hardware contained in the foam.

(7) Foam to be tracked on-orbit - Foam containing multiple items is required to be labeled with a contents label with the OpNom, part number, and serial number of the container, and the OpNom and quantity of the contents within the foam.

(8) Keep-out zones are required to be labeled (e.g. “Caution: Hardware has Keep out Zones”) on the outside of the foam in the lower left corner of the crew facing cushion surface.

(9) Single/Multiple foam pieces: Foam is recommended to be labeled with the part number of the foam itself, and multiple foam pieces are recommended to be labeled with the piece count (e.g. 1 of 3 pieces) on a non-crew facing surface.

(10) Foam reassembly on-orbit: When multiple pieces of foam are used to create a “box” around hardware, and the crew is required to reassemble the foam box on orbit after use, then arrows, color or other means of coding are recommended to be used to simplify re-assembly.

(11) Filler foam: For bags containing multiple pieces of filler foam, Velcro is recommended to be applied to the foam to assist the crew with restraining the foam during packing and unpacking.

D. Table O.3.4.7-1 is a checklist from the NASA Packing Organization intended to assist PDs to ensure their pre-packaged hardware is ready for delivery.

TABLE O.3.4.7-1 HARDWARE READINESS FOR DELIVERY CHECKLIST (2 PAGES)

	Question		Comment
1	Does the manifest correctly reflect what will be delivered?	Yes ☐	Proceed to Question #2.
		No ☐	Resolve manifest issue, then proceed to Question #2.
2	Is the stowage provision planned to be tracked on-orbit? (Provisions include bags, bubble wrap, end caps, card stock, and foam.)	Yes ☐	• Provision is required to be manifested • Barcode is required to be applied to provision • Provision listed on shipping documentation and parts tag created Proceed to Question #3.
		No ☐	Proceed to Question #3.
3	Does LRODS indicate hardware is delivered in stowage provision?	Yes ☐	Proceed to Question #4.
		No ☐	The NASA Packing Organization will pack the hardware in needed stowage provisions. Skip to Question #5.
4	Is the stowage provision labeled per the labeling guidelines in SSP 57000, Appendix O?	Yes ☐	Proceed to Question #5.
		No ☐	Correct issue(s), re-submit to IPLAT for approval, and then proceed to Question #5.
5	Is the hardware labeled per SSP 57000, Appendix O[1]	Yes ☐	Proceed to Question #6.
		No ☐	Correct issue(s), re-submit to IPLAT for approval, and then proceed to Question #6.
6	Do payload operations require temp stowage by the crew? If yes, is hook Velcro on the back of the bag (or other temp-stow solution)? Note: Cold stowage cannot accept Velcro.	Yes ☐	Proceed to Question #7.
		No ☐	Add hook Velcro to back of bag, or provide other means to temp stow bag. Proceed to Question #7.
7	Is the stowage provision sized appropriate for the enclosed hardware? Note: oversized bags add unnecessary mass.	Yes ☐	Proceed to Question #8.
		No ☐	Provide appropriate sized stowage provision (e.g. use a different bag, cut to size, or fold and tape down, etc.), then proceed to Question #8.
8	Is the stowage provision flight approved?	Yes ☐	Proceed to Question #9.
		No ☐	Submit an RFS to the NASA Packing Organization for flight approved materials. Proceed to Question #9.
9	Are all hardware support items (e.g. connector caps) contained in the stowage provisions flight approved?	Yes ☐	Proceed to Question #10.
		No ☐	Remove non-flight approved hardware support items. Proceed to Question #10.

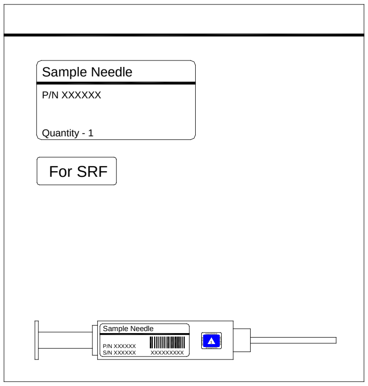
TABLE O.3.4.7-1 HARDWARE READINESS FOR DELIVERY CHECKLIST (2 PAGES)

	Question		Comment
10	Does shipping paperwork, parts tag, hardware labels and manifest match?	Yes ☐	Deliver hardware to the NASA Packing Organization for final packing prior to flight.
		No ☐	Correct issues before delivering hardware to the NASA Packing Organization.

Note 1: Label hardware per SSP 50007, Space Station Inventory Management System Bar Code Label Requirements and Specification and SSP 57000.

- IPLAT inform OC on the JSC Form 2994 if hardware does not meet requirements due to exemptions. The NASA Packing Organization needs that info for HVR (hardware verification review)
  - No OpNom label due to form/fit/function
  - Any requirement in Appendix O.
- When labels of parts within packed bags cannot be read, has hardware OpNom, part number/serial number, and barcode data been provided to NASA Packing Organization, via Part 2 kit contents spreadsheet? OC will provide standard template.

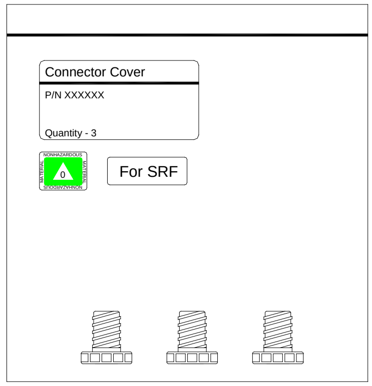
Ziplock Example (Ziplock not tracked)



Note: This is an example of a hardware item that does need to be tracked on orbit, but the ziplock bag does not need to be tracked. The hardware can be labeled with an IMS barcode. If the item(s) will not be returned to the ziplock bag then only a hardware identification label is used.

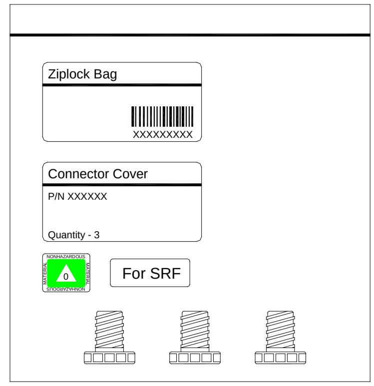
* Since the hazard response label on the hardware (sample needle) is clearly visible, a separate hazard response label on the ziplock bag is not required.

Ziplock Example (Ziplock not tracked)



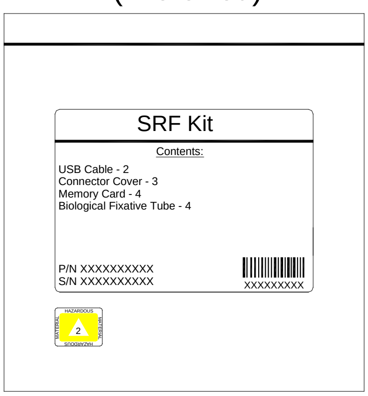
Note: This is an example of a small hardware items (s) that does not need to be tracked on orbit. JF1345 Form (IMS Exemption) has been approved because the hardware can not be labeled with an IMS barcode. If the item(s) will not be returned to the ziplock bag then only a hardware identification label is used.

Ziplock Example (Ziplock tracked)



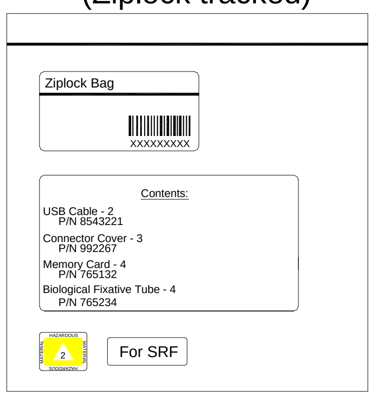
Note: This is an example of a small hardware item(s) that does need to be tracked on orbit because the hardware needs to be returned to the ziplock bag (ziplock is not thrown away). JF1345 Form (IMS Exemption) has been approved because the hardware can not be labeled with an IMS barcode. The ziplock bag should have a barcode on it. The part number for the ziplock itself is not necessary.

Kit Example (Preferred)



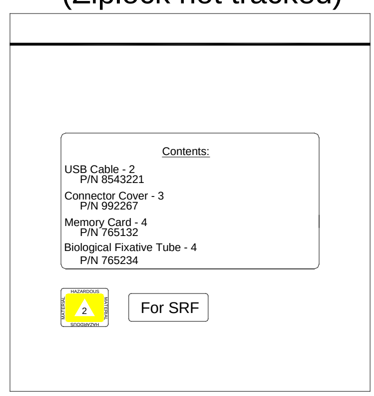
Note: This is an example of stowage items that have been organized into a manifested kit.

Multiple Individually Manifested Items Example (Ziplock tracked)



Note: This is an example of a stowage items that have not been organized in a manifested kit. These stowage items need to be tracked on orbit because the hardware needs to be returned to the ziplock bag. The ziplock bag should have a barcode onit, but the part number for the ziplock itself is not necessary because it's the hardware inside that is relevant.

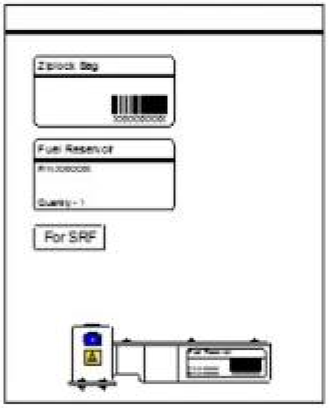
Multiple Individually Manifested Items Example (Ziplock not tracked)



Note: This is an example of stowage items that have not been organized into a manifested kit. These stowage items will not be returned to the ziplock bag.

FIGURE O.3.4.7-1 ZIPLOCK BAG LABEL EXAMPLES (PAGE 1 OF 2)

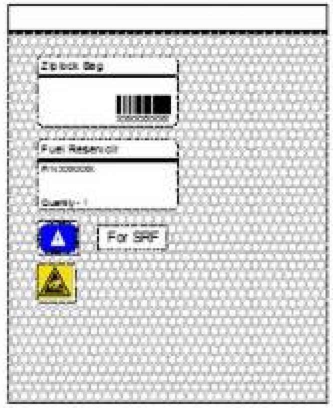
Additional
Ziplock Example
(Ziplock tracked)



Note: This is an example of a hardware item that does need to be tracked on orbit because the hardware needs to be returned to the ziplock bag (ziplock is not thrown away).
The ziplock bag should have a barcode on it.
The part number for the ziplock itself is not necessary.

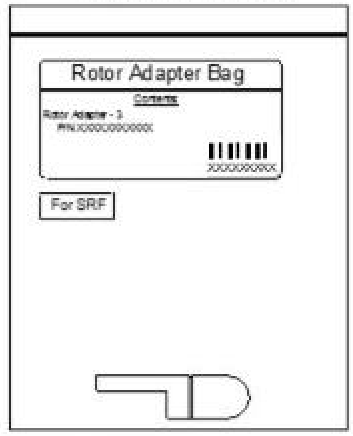
* Since the hazard response label and ESD label on the hardware (fuel reservoir) are clearly visible, a separate hazard response label and ESD label on the ziplock bag is not required.

Additional
Ziplock Bubblewrap Example
(Ziplock tracked)



Note: This is an example of a hardware item that does need to be tracked on orbit because the hardware needs to be returned to the ziplock bag (ziplock is not thrown away).
The ziplock bag should have a barcode on it.
The part number for the ziplock itself is not necessary.

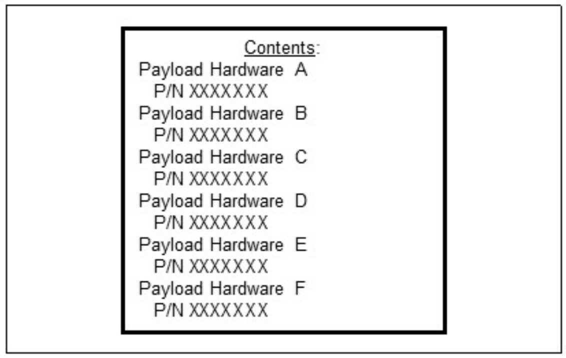
Non-kit
Ziplock Example
(Ziplock tracked)



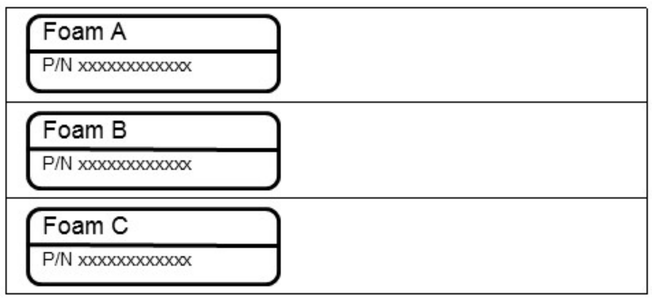
Note: This is an example of a hardware item(s) that does need to be tracked on orbit because the hardware needs to be returned to the ziplock bag (ziplock is not thrown away).
The ziplock bag should have a barcode on it.
The part number for the ziplock itself is not necessary. JF1345 Form (IMS Exemption) has been approved because the hardware can not be labeled with an IMS barcode.

* The example above is for the Rotor Adapter. The ziplock name is "Rotor Adapter Bag" which references the only item that is in the ziplock. There is no official OpNom for the ziplock or a part number (which is not necessary). The "Rotor Adapter Bag" name (which could also be a pouch or other container with a variation in the OpNom) is the drawing name that is shipped to the NASA Packing Organization.

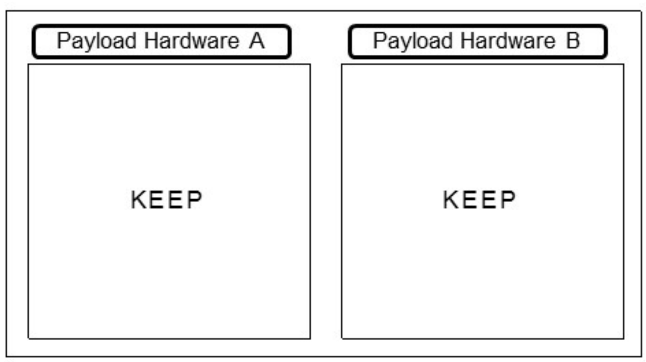
FIGURE O.3.4.7-1 ZIPLOCK BAG LABEL EXAMPLES (PAGE 2 OF 2)



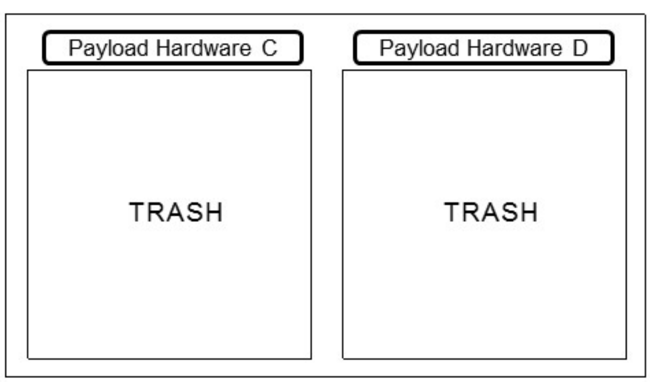
Top of Foam A



Side of Individual Foam Pieces



Inside of Individual Foam Piece A (Top View) - items removed



Inside of Individual Foam Piece B (Top View) - items removed

FIGURE O.3.4.7-2 FOAM LABEL EXAMPLES

O.3.4.8 GROUPED EQUIPMENT ITEMS

A. Functional groups of three or more equipment items (i.e. displays, controls, switch positions, connectors, LEDS, etc.) are recommended to be identified as a group (e.g., by common color, by boundary lines). Functional groups of equipment items are all associated or connected with a common system or purpose. (e.g., CABIN AIR, FURNACE A, EXPERIMENT “M”, PANEL LIGHTING). Two functionally related items are recommended to be grouped when such grouping provides clarification of purpose and/or distinguishes them from surrounding items. See Figure O.3.4.8-1 for grouping label examples.

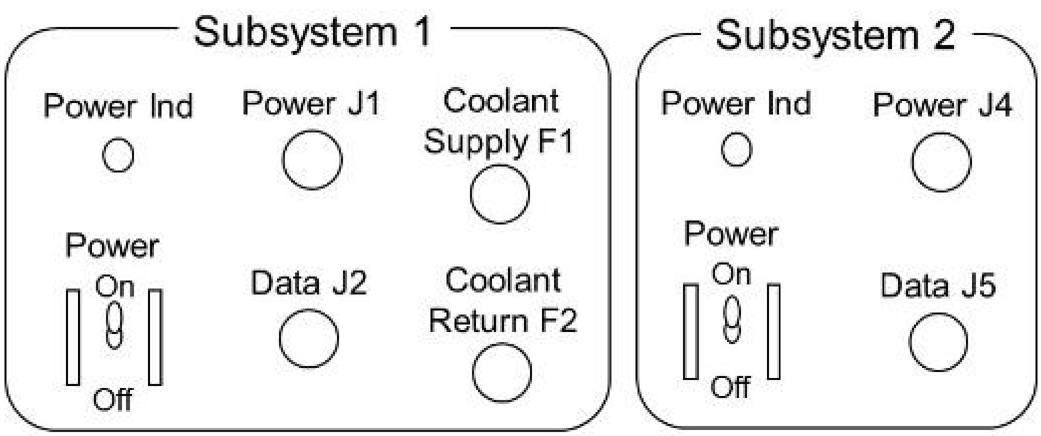


FIGURE O.3.4.8-1 GROUPING LABEL EXAMPLES

B. Labels are required to be located above the functional groups they identify.

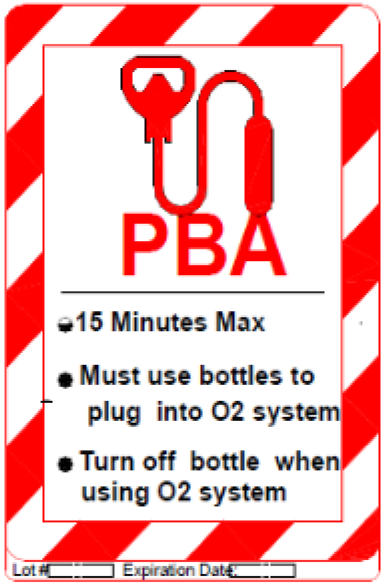
C. When a line is used to enclose a functional group and define its boundaries, the labels are recommended to be centered at the top of the group, in a break in the line. When it is not possible to center the text at the top, the text may be placed elsewhere along the perimeter of the boundary line, but local vertical orientation or the text is recommended to be maintained.

(1) The width of the line cannot be greater than the stroke width of the letters.

(2) The line is to form an enclosed rectangle, or box, with rounded corners. Deviations from the rectangular shape are allowed when dimensional restrictions preclude a perfect rectangle.

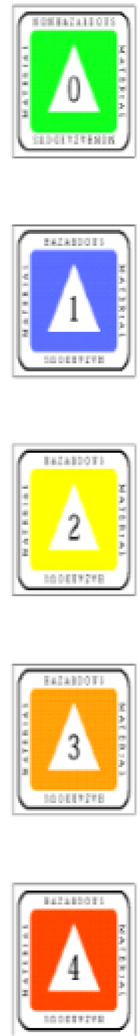
O.3.4.9 CAUTION AND WARNING LABELS

Caution and warning labels are required for indicating potentially undesirable conditions. See Figure O.3.4.9-1 for examples. The ISRP or an OB safety representative is required to approve non-standard Caution and Warning label wording.



Emergency Use Label Example

Caution/Warning Label Example



Toxic Hazard Label Examples

FIGURE O.3.4.9-1 CAUTION AND WARNING LABELS EXAMPLES

A. Caution and warning labels are recommended to be standardized between and within systems.

B. Caution and warning labels are recommended to be distinct from one another.

C. Caution and warning labels are required to identify the type of hazard and the action that would prevent its occurrence.

D. The caution and warning markings are required to be located in a visible area.

E. Emergency-Use Labels are required to have the following characteristics:

(1) Labels on emergency-use items (e.g., repair kits, emergency lighting, fire extinguisher, etc.) are required to be surrounded by diagonal red and white stripes either on the item or adjacent to it, and on its container.

(2) The emergency-use stripes are required to alternate red and white.

(3) The red and white stripes are recommended be of equal width.

(4) There are recommended to be no fewer than four red stripes and three white stripes.

(5) The striping is recommended to be applied at a 45 degree angle rotated clockwise from the vertical.

(6) The striping is recommended to begin and end with a red stripe.

(7) The text is required to be white letters on the red background or red letters on a white background.

F. Caution And Warning Labels are required to have the following characteristics:

(1) Labels on Caution and Warning items are required to be either on the item or adjacent to it, and on its container. Caution/warning labels are required to be surrounded by diagonal yellow and black stripes.

(2) The caution/warning type stripes are required to alternate yellow and black.

(3) The yellow and black stripes are recommended to be of equal width.

(4) There are recommended to be no fewer than four yellow stripes and three black stripes.

(5) The striping is recommended to be applied at a 45 degree angle rotated clockwise from the vertical.

(6) The striping is recommended to begin and end with a yellow stripe.

(7) The text is required to be black letters on the yellow background.

(8) For Caution and Warning items located within a storage container, the Caution and Warning label is required to be applied to the outside of the container, and the titles of the Caution and Warning items are recommended to be included on the marking.

G. Switches and Buttons

(1) The striping around a switch or button is recommended to not be wider than 25mm (1 in.) or narrower than 3 mm (0.125 in.).

(2) If one side of a switch or button has less than 3 mm (0.125 in.) space, no striping is required to be applied to that side.

H. Hazard Labels

(1) Chemicals – The standard hazard class decals are required to be used to identify the proper hazard class of payload chemicals (i.e. chemicals in solid, liquid, or gaseous states), as deemed by the payload's toxicology representative. The developer may obtain these decals from JSC 27260 or produce identical labels.

(2) Other hazards - When biological, radiation, sharps, battery, or other hazards are identified by safety personnel, the appropriate standard label (if available) is

required to be applied in a prominent location. The developer may obtain these decals from JSC 27260 or produce identical labels.

I. Space within 1 inch (above preferred) of a fire port is required to be reserved for at least the minimum size fire port location code label as shown in Figure O.3.4.9-2. Where possible, space for a larger label is recommended to be reserved. The following lists the order of preference for the labels depending on space constraints.

- A label that accommodates the words: “EMERGENCY USE”, “FIRE PORT”, and location code (e.g. LAB1P2_D2)
- A label that accommodates the words: “FIRE PORT”, and location code (e.g. LAB1P2_D2).
- A label that accommodates the location code (e.g. LAB1P2_D2).

Note: IPLAT will install the label during the final HFIT-IPLAT evaluation, or other forum. The PD has the option of installing the label themselves if they so choose.

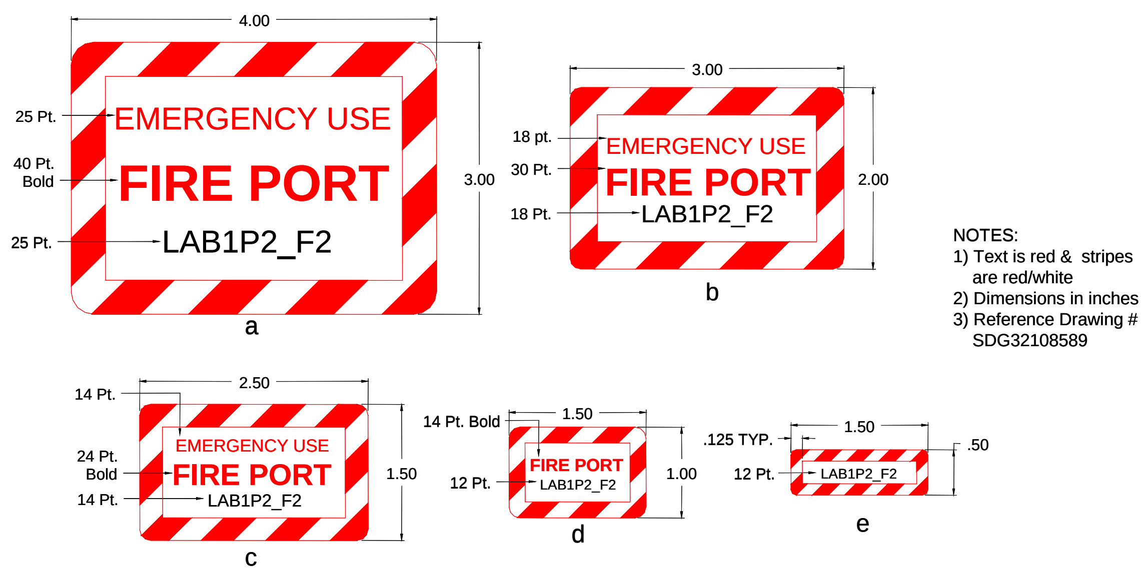


FIGURE O.3.4.9-2 FIRE PORT LOCATION CODE LABELS

O.3.4.10 ALPHANUMERIC

O.3.4.10.1 FONT STYLE

A. The font style used on decals, placards, engravings, and labels is recommended to be Helvetica or Arial. If these are not available, a similar sans serif font is acceptable.

B. Stenciled Characters – Stencil–type characters are not to be used on display/control panels or other equipment.

O.3.4.10.2 PUNCTUATION

Punctuation is not to be used on labels except as a part of the approved OpNom or as otherwise noted in this appendix.

O.3.4.10.3 SPECIAL CHARACTER

A. Subscript and Superscript Size – Subscripts and superscripts are recommended to be 0.6 to 0.7 times the height of associated characters.

B. Subscripts – Numeric subscripts and upper case letter subscripts are recommended to be centered on the baseline of associated characters.

C. Lower Case Letter Subscripts –The base of lower case letters and the ovals of g, p, q, etc., are recommended to be at the same level as the base of adjacent capital letters.

D. Degree Symbol – The degree symbol is recommended to be centered on an imaginary line extended from the top of the F or C symbols.

E. Pound or Number Symbol (#) – The pound or number symbol is recommended to be centered on an imaginary line extended from the top of the associated numerals and placed two stroke widths away from them.

O.3.4.10.4 LINE SPACING

A. The spacing between lines of related text is recommended to be 0.5 of upper case letter height.

B. Spacing between headings and text is recommended to be 0.6 to 1.0 of upper case letter height.

O.3.5 LABELING INSTRUCTIONS APPLICABILITY MATRIX

Table O.3.5-1 is intended to help payload developers understand which Appendix O labeling instructions are applicable to their type of hardware. The categories below are self-explanatory, except “Non-Rack Unpwred”, which basically applies to any unpowered equipment such as supplies, scientific samples, tools, etc. When it says “If app”, that means if the situation is applicable.

TABLE O.3.5-1 LABELING INSTRUCTIONS APPLICABILITY MATRIX (7 PAGES)

Section	**Title**	**Rack**	**Subrack**	**Non-Rack Powered**	**Non-Rack Unpwred**	**Cables & Hoses**	**COTS**
O.3.1	OpNom – labels required to match OpNom	X	X	X	X	X	X
O.3.2	Barcodes – required to have barcodes	X	X	X	X	X	X
O.3.3.1.A	Placement per drawings	X	X	X	X	X	
O.3.3.1.B	Payloads Operated from Rack Front Panels – per Fig O.3.3.1-1	X	X				

TABLE O.3.5-1 LABELING INSTRUCTIONS APPLICABILITY MATRIX (7 PAGES)

Section	Title	Rack	Subrack	Non-Rack Powered	Non-Rack Unpwred	Cables & Hoses	COTS
O.3.3.1.B.1	Payloads Operated from Rack Front Panels - Rack IMS Combination Name Label	X					
O.3.3.1.B.2	Payloads Operated from Rack Front Panels - Subrack IMS Combination Name Label		X				
O.3.3.1.B.3	Payloads Operated from Rack Front Panels - Rack UIP	X					
O.3.3.1.C	Non-rack self-contained payloads, ORUs – ID label in upper left corner of dominant face			X			
O.3.3.1.D.1	Loose Equipment - ID label in upper left corner of dominant face				X		
O.3.3.1.D.2	Loose Equipment – OpNom takes precedence when space limitations				X		X
O.3.3.1.E	Control Panel Labels – Positions – above item		X	X			
O.3.3.1.F.1	Part Numbers and Serial Numbers – placed together	X	X	X	X	X	
O.3.3.1.F.2	Part Numbers and Serial Numbers – Use P/N and S/N	X	X	X	X	X	
O.3.3.1.G	Orientation – labels oriented with respect to local worksite plane	X	X	X	X	X	
O.3.3.1.H	Visibility – labels visible when equipment used or accessed	X	X	X	X	X	X
O.3.3.1.I	Association Errors	X	X	X	X	X	X
O.3.3.1.J.1	Subrack Location Codes – Rack level	X					
O.3.3.1.J.2	Subrack Location Codes – Control Panels controlling multiple subracks		X				
O.3.3.1.K	Access Panels – assist in locating the panel	X					
O.3.3.1.K.1	Access Panels – ID label upper left corner	X					
O.3.3.1.K.2	Access Panels – ID labels, what to include	X					

TABLE O.3.5-1 LABELING INSTRUCTIONS APPLICABILITY MATRIX (7 PAGES)

Section	Title	Rack	Subrack	Non-Rack Powered	Non-Rack Unpwred	Cables & Hoses	COTS
O.3.3.1.L.1	Alignment Marks/Interface ID– Alignment Marks when specific orientation required	X	X	X	X	X	
O.3.3.1.L.2	Alignment Marks/Interface ID– Alignment Marks visible during attachment	X	X	X	X	X	
O.3.3.2.A	Orientation – rack vertical orientation	X	X				
O.3.3.2.B	Orientation – rotated rack ops orientation	X					
O.3.4.1	Ground Assembly and Handling labels not interfere with flight labels	X	X	X	X	X	
O.3.4.2	Function Considerations – label per purpose or function of hardware	X	X	X	X	X	
O.3.4.3.A	Labeling Standardization – Standard decals per JSC 27260 or identical to them	X	X	X	X	X	
O.3.4.3.B	Labeling Standardization – Standardized between and within systems	X	X	X	X	X	
O.3.4.3.C.1	IMS Combination Name Label – horizontal line	X	X	X	X	X	X
O.3.4.3.C.2	IMS Combination Name Label – OpNom above line	X	X	X	X	X	X
O.3.4.3.C.3	IMS Combination Name Label – acronym (if applic) below line	X	X	X	X	X	X
O.3.4.3.C.4	IMS Combination Name Label – P/N and S/N below line	X	X	X	X	X	X
O.3.4.3.C.5	IMS Combination Name Label – barcode in lower right corner	X	X	X	X	X	X
O.3.4.3.C.6	IMS Combination Name Label – Control panel names		X	X			X
O.3.4.3.C.7	IMS Combination Name Label – no other text allowed except mentioned	X	X	X	X	X	X
O.3.4.3.D	Casing – mixed case	X	X	X	X	X	
O.3.4.3.E.1	Size – Sizes per Table O.3.4.3-1	X	X	X	X	X	
O.3.4.3.E.2	Size – Sizes Categories	X	X	X	X		
O.3.4.3.E.2	Size – Size of Decals – minimize white space	X	X	X	X	X	

TABLE O.3.5-1 LABELING INSTRUCTIONS APPLICABILITY MATRIX (7 PAGES)

Section	Title	Rack	Subrack	Non-Rack Powered	Non-Rack Unpwred	Cables & Hoses	COTS
O.3.4.4.A	Readability – labels concise and direct	X	X	X	X	X	
O.3.4.4.B.1	Readability – Language - English	X	X	X	X	X	X
O.3.4.4.B.2	Readability – Language – If dual Language, English first and 25% larger	X	X	X	X	X	
O.3.4.4.C	Readability – Minimize visual clutter	X	X	X	X	X	
O.3.4.4.D.1	Readability – Displays & Controls – verbs use present tense	X	X	X			
O.3.4.4.D.2	Readability – Displays & Controls – h/w linked to s/w displays, labels match	X	X	X			If app
O.3.4.4.D.3.a	Readability – Displays & Controls – circuit breakers use “cb”	X	X	X			
O.3.4.4.D.3.b	Readability – Displays & Controls – circuit breakers use “Open” & “Close”	X	X	X			
O.3.4.4.D.4	Readability – Displays & Controls – Switches named according to function	X	X	X			X
O.3.4.4.D.5	Readability – Displays & Controls – Push buttons named according to function	X	X	X			
O.3.4.4.E	Readability – Displays & Controls – Units of measure in SI units	X	X	X			
O.3.4.5.1.A	Equipment ID – all items on h/w identified	X	X	X	X	X	X
O.3.4.5.1.B.1	Equipment ID – multi-qty items individually numbered		X	X	X		
O.3.4.5.1.B.2	Equipment ID – multi-qty items that are serialized display S/N as part of ID				X	X	
O.3.4.5.1.C	Equipment ID – Logos not distracting	X	X	X	X	X	X
O.3.4.5.2.1.A	Cable & Hose Labeling – Crew Interface Cables and Hoses definition					X	
O.3.4.5.2.1.B	Cable & Hose Labeling – Are required to have ID labels, end labels, any safety labels, etc.					X	

TABLE O.3.5-1 LABELING INSTRUCTIONS APPLICABILITY MATRIX (7 PAGES)

Section	**Title**	**Rack**	**Subrack**	**Non-Rack Powered**	**Non-Rack Unpwred**	**Cables & Hoses**	**COTS**
O.3.4.5.2.1.B.1.a	Cable & Hose Labeling – Elec cable plugs & corresponding ports – cable end plug use “P” (e.g. P1)					X	
O.3.4.5.2.1.B.1.b	Cable & Hose Labeling – Elec cable plugs & corresponding ports - Connector Port names have descripter and then J number (e.g. Power J1)	X	X	X		X	
O.3.4.5.2.1.B.1.c	Cable & Hose Labeling – Elec cable plugs & corresponding ports – plug number and receptacle number match (e.g. P1, J1)	X	X	X		X	
O.3.4.5.2.1.B.2.a	Cable & Hose Labeling – text size 0.12 in preferred, 0.10 in min					X	
O.3.4.5.2.1.B.3	Cable & Hose Labeling – Cable/Hose ID Labels in middle of cable/hose (or every 2m) and include OpNom, flow direction (hoses), P/N and S/N					X	
O.3.4.5.2.1.B.4	Cable & Hose Labeling – Cables/Hoses have IMS barcode					X	
O.3.4.5.2.1.B.5	Cable & Hose Labeling – Cable/Hose End Label format specifics					X	
O.3.4.5.2.1.B.6	Cable & Hose Labeling – Hose Hazard labels					X	
O.3.4.5.2.2.A	Color Coding – red, yellow, orange only for C&W conditions	X	X	X	X	X	X
O.3.4.5.2.2.B	Color Coding – Identification/Connectivity – combine color with text	X	X	X	X	X	
O.3.4.5.2.2.C.1	Color Coding – Color Difference – colors easily distinguished	X	X	X	X	X	
O.3.4.5.2.2.C.2	Color Coding – Each color has single meaning	X	X	X	X	X	
O.3.4.5.2.2.D	Color Coding – Each color has single meaning	X	X	X	X	X	

TABLE O.3.5-1 LABELING INSTRUCTIONS APPLICABILITY MATRIX (7 PAGES)

Section	Title	Rack	Subrack	Non-Rack Powered	Non-Rack Unpwred	Cables & Hoses	COTS
O.3.4.5.2.2.E	Color Coding – Acceptable markings/background color combinations	X	X	X	X	X	
O.3.4.6	Operating Instruction Labels	If app	If app	If app	If app	If app	
O.3.4.7.A.1	Stowage Container Labeling – Bags to be tracked have barcode				X		
O.3.4.7.A.2	Stowage Container Labeling – Bags to be trashed can't have barcode				X		
O.3.4.7.B	Stowage Container Labeling – Bags, specific label instructions				X		
O.3.4.7.C	Stowage Container Labeling – Foam Containers, specific label instructions				X		
O.3.4.8.A	Grouped Equipment Items – 3 or more related items grouped	X	X	X			
O.3.4.8.B	Grouped Equipment Items – Labels above the group	X	X	X			
O.3.4.8.C	Grouped Equipment Items – Grouping box format	X	X	X			
O.3.4.9.A	Caution and Warning Labels – standardized between/within systems	If app	If app	If app	If app	If app	If app
O.3.4.9.B	Caution and Warning Labels – C&W labels distinct from one another	If app	If app	If app	If app	If app	If app
O.3.4.9.C	Caution and Warning Labels – Identify hazard and action to prevent it	If app	If app	If app	If app	If app	If app
O.3.4.9.D	Caution and Warning Labels – C&W labels in visible area	If app	If app	If app	If app	If app	If app
O.3.4.9.E	Caution and Warning Labels – Emergency Use label format specifics	If app	If app	If app			
O.3.4.9.F	Caution and Warning Labels – C&W label format specifics	If app	If app	If app	If app	If app	If app
O.3.4.9.G	Caution and Warning Labels – Switches & buttons	If app	If app	If app			

TABLE O.3.5-1 LABELING INSTRUCTIONS APPLICABILITY MATRIX (7 PAGES)

Section	Title	Rack	Subrack	Non-Rack Powered	Non-Rack Unpwred	Cables & Hoses	COTS
O.3.4.9.H.1	Caution and Warning Labels – Hazard Labels - Chemicals		If app	If app	If app	If app	If app
O.3.4.9.H.2	Caution and Warning Labels – Hazard Labels – Other hazards	If app	If app	If app	If app	If app	If app
O.3.4.9.I	Caution and Warning Labels – Fire Port Location Code labels	If app	If app				
O.3.4.10.1.A	Font Style – Helvetica or Arial (sams serif)	X	X	X	X	X	
O.3.4.10.1.B	Font Style – No stencil-type characters	X	X	X	X	X	
O.3.4.10.2	Punctuation – don’t use	X	X	X	X	X	
O.3.4.10.3.A	Special Character – Subscript/Superscript size	If app	If app	If app	If app	If app	
O.3.4.10.3.B	Special Character – Subscripts centered	If app	If app	If app	If app	If app	
O.3.4.10.3.C	Special Character – Lower Case Letter Subscripts	If app	If app	If app	If app	If app	
O.3.4.10.3.D	Special Character – Degree Symbol	If app	If app	If app	If app	If app	
O.3.4.10.3.E	Special Character – Pound or Number Symbol	If app	If app	If app	If app	If app	
O.3.4.10.4.a	Line Spacing – between related text	X	X	X	X	X	
O.3.4.10.4.b	Line Spacing – between headings and text	X	X	X	X	X	

APPENDIX P

COTS PAYLOADS PROCESS AND REQUIREMENTS

APPENDIX P - COTS PAYLOADS PROCESS AND REQUIREMENTS

P.1.0 INTRODUCTION

P.1.1 PURPOSE

Appendix P provides a streamlined certification process for commercially available payload hardware or software procured directly from a vendor or authorized distributor. Payload items that meet this definition will henceforward be described as COTS and can be certified following the guidelines in this appendix. This appendix is derived from SSP 50986.

P.1.2 SCOPE

This appendix is intended to address unmodified COTS hardware. It is acceptable (sometimes even required) to add labels but still consider the COTS hardware as unmodified.

P.1.3 USE

This process and requirement set will be used by NASA and NASA-sponsored COTS payloads. It is possible that IPs will use this process and document it in their respective requirements documents.

P.1.4 EXCEPTIONS

COTS payloads must comply with all interface requirements determined to be applicable by the process defined in Appendix P.

Any exception to requirements defined in Appendix P must be approved by the ISS Program.

P.2.0 COTS OVERVIEW

P.2.1 COTS DEFINITIONS

COTS payload items must be unmodified other than labels. In addition, the following general definitions must be met in order to use the minimum requirements set. If these definitions are not met, the COTS process may still be used but additional requirements may apply.

1. The COTS item has no safety-critical structures and is not hard mounted for launch or on-orbit. (This allows structures requirements to be omitted. Protrusion requirements may still apply depending on planned operation.)
2. The COTS item is unpowered or only powered by batteries. (This allows most EPS requirements to be omitted.)
3. The COTS item has no ISS C&DH interfaces. (This allows C&DH requirements to be omitted.)
4. The COTS item has no potable water interfaces. (This allows potable water requirements to be omitted.)
5. The COTS item is not placed in cold stowage. (Cold stowage COTS will have additional requirements.)

6. The COTS item is “user friendly” and a commercially viable product. (This allows human factors requirements to be omitted.).

If these definitions are met, and the COTS payload is shown to not impact Crew or ISS Safety, the COTS payload will, at a minimum, verify to the requirements documented in the following section.

P.2.2 COTS REQUIREMENTS

Assuming the definitions in P.2.1 are met, the COTS payload will be allowed to verify to at least the minimum set of interface requirements listed in Table P.2.2-1, Minimum COTS Payloads Requirements, Guidelines and Data Deliverables.

TABLE P.2.2-1 MINIMUM COTS PAYLOADS REQUIREMENTS, GUIDELINES AND DATA DELIVERABLES (2 PAGES)

SSP 57000 Requirement Number	Requirement Paragraph	Comments
3.1.4.2	PROTRUSION DATA REQUIREMENTS	
3.1.5	DESCRIPTION OF PAYLOAD	
D.3.2.1 / D.4.3.2.1	ELECTROMAGNETIC INTERFERENCE FOR TRANSPORT VEHICLES	
3.2.2.1.3 / 4.3.2.2.1.3	RE02 LIMITS	
D.3.2.2	DC MAGNETIC FIELDS FOR RUSSIAN TRANSPORT VEHICLES	This data deliverable only applies to payloads that intentionally generate magnetic fields (electromagnets and permanent magnets)
3.2.2.9 / 4.3.2.2.9	INTENTIONAL RADIATING AND RECEIVING	
3.2.2.10	INTENTIONAL RADIATING AND RECEIVING CERTIFICATION	
3.2.2.11	INTENTIONAL RADIO FREQUENCY EMISSION/OPERATION AUTHORITY	
3.5.2 / 4.3.5.2	CABIN AIR HEAT LOAD LIMITS	
3.9.2 / 4.3.9.2	WATER-SOLUBLE VOLATILE ORGANIC COMPOUND RELEASES	
3.11.1 / 4.3.11.1	MATERIALS AND PROCESSES USE AND SELECTION	Offgassing evaluation required only for items with 5 pounds mass or greater; exclusions include uncured adhesives, lubricants, cleaning wipes, marker pens, and other items containing liquids or gels.
3.11.3 / 4.3.11.3	CLEANLINESS	Payload COTS item may verify to generally clean.
G.3.12.1 / G.4.3.12.1	CONTINUOUS NOISE LIMITS	

TABLE P.2.2-1 MINIMUM COTS PAYLOADS REQUIREMENTS, GUIDELINES AND DATA DELIVERABLES (2 PAGES)

SSP 57000 Requirement Number	Requirement Paragraph	Comments
3.12.3.2 / 4.3.12.3.2	INTERMITTENT NOISE LIMITS	*Test correlated analytical model or some other method approved and documented in the Acoustic Noise Control Plan.
3.12.7 / 4.3.12.7	IDENTIFICATION LABELING	IPLAT accepts most existing COTS labeling. At a minimum, an IMS Combination Name Label will be added.

Note: In addition to verifying the requirements in Table P.2.2-1, COTS Payloads must also complete the Safety Review Process.

Table P.2.2-1 uses a subset of the requirements from the SSP 57000 general requirements as well as Appendices D and G. The table utilizes the same numbers and titles for each COTS requirement-related section and subsection as in the SSP 57000 general section and appendices.

Additional requirements may be added to the matrix in the payload unique ICD, if necessary, to cover additional interfaces.

APPENDIX Q

SERIES / RE-FLIGHT HARDWARE REQUIREMENT REDUCTION PROCESS

APPENDIX Q - SERIES / RE-FLIGHT HARDWARE REQUIREMENT REDUCTION PROCESS

Q.1.0 INTRODUCTION

Q.1.1 PURPOSE

Appendix Q provides a streamlined certification process for series and re-flight payload hardware. Payload hardware items that meet the definition for series and/or re-flight hardware and meet the criteria described below can be certified following the guidelines in this appendix.

Q.1.2 SCOPE

This appendix is intended to address any pressurized volume series and re-flight hardware that meets the definitions below. The hardware may be a component of an integrated rack, a subrack, or a (pressurized) non-rack payload. It is acceptable (sometimes even required) for labels to change on the series or re-flight hardware.

Q.1.3 USE

This process can be used by any NASA and NASA-sponsored payload hardware. It is possible that IPs will use this process and document it in their respective requirements documents.

Q.1.4 EXCEPTIONS

Series and re-flight hardware must comply with all interface requirements determined to be applicable by the process defined in this appendix.

Any exception to requirements defined in this appendix must be approved by the ISS Program.

Q.1.5 DEFINITIONS

Q.1.5.1 SERIES HARDWARE

Series hardware is defined (by SE&I) as payloads or elements made up of hardware items, including ORUs, that are of the same design as previously flown hardware. Series hardware items must be built to the same drawings, have the same part number, and use the same processes as the initial piece of hardware.

Q.1.5.2 RE-FLIGHT HARDWARE

Re-flight hardware is defined as payloads or elements made up of hardware items, including ORUs, that have previously flown (using the same part number and serial number) on a transportation vehicle or ISS and are unmodified (except for nominal refurbishment which does not impact any interfaces), and are being manifested for re-flight.

Q.1.5.3 EXPERIMENT DEPENDENT CHANGES

Re-flight and/or series payloads may have changes to the experiment operations that affect the hardware interfaces. These instances may include the same hardware configuration but changes in the experiment parameters that affect requirements. If a payload has experiment dependent changes that affect interfaces, additional verification may be required.

Q.2.0 SERIES / RE-FLIGHT HARDWARE REQUIREMENT REDUCTION CRITERIA

Payloads or payload hardware items must meet the following criteria in order to be considered series or re-flight hardware.

1. The payload or payload hardware item is planned for use in the pressurized volume only. Unpressurized hardware is not allowed to use the series/re-flight hardware requirement reduction process.
2. The payload or payload hardware item is being transported on the same vehicle as previously verified, or has been verified to the same set of enveloping requirements. (i.e., Common Launch requirements from SSP 50835).

   Note: Powered MLEs must re-verify mass and CG requirements for each flight.
3. The payload or payload hardware item is unmodified except for labels. If an item's part number has changed solely due to a different label being applied, then the item may still be considered series or re-flight if it can be shown that the hardware part number, without the new label, is the same as previously flown.

   Note: Modifications and experiment dependent changes must be reviewed and assessed for impacts to previously closed interface verification.

Payloads or payload hardware items that meet all the criteria above will be allowed to verify as few as one re-flight requirement. The required data submittal will be a data certification from the PD that certifies that the payload hardware meets the criteria above. The ISS Program reserves the right to levy additional requirements as deemed necessary. For example, payloads that change out a fan must, at a minimum, re-verify acoustics requirements. Hard mounted MLEs must re-verify mass and CG requirements for each flight. Exceptions that were flight specific must be generated/approved for the new flight.

Q.3.0 SERIES / RE-FLIGHT HARDWARE REQUIREMENT

The owner of the payload or payload hardware item must provide a data cert to SE&I for series / re-flight items. The data cert must identify the payload part number(s) and flight for which verification was completed and certify that the payload meets the criteria in Section Q.2.0. It may be necessary for the hardware owner to submit additional data and/or re-verify certain interface requirements. SE&I will determine this on a case-by-case basis. The list of additional requirements must be documented in the payload's unique hardware ICD.

APPENDIX R

INSTRUCTIONS FOR HUMAN FACTORS IMPLEMENTATION TEAM (HFIT) VERIFICATION

APPENDIX R - INSTRUCTIONS FOR HUMAN FACTORS IMPLEMENTATION TEAM (HFIT) VERIFICATION

R.1.0 INTRODUCTION

The ISS HFIT provides an optional service to verify human factors requirements for all payload equipment that the crew will interface with during nominal operations, planned maintenance, and contingency operations.

Appendix R provides the instructions for the verification of payload human factors requirements. The verification of human factors requirements will be a joint process requiring the cooperative efforts of the HFIT and the PD.

R.2.0 ISS PAYLOAD HUMAN FACTORS REQUIREMENTS APPROVAL PROCESS

This document provides the instructions for the approval of payload human factors requirements in order to comply with SSP 57000 section 3.12 specifications. The development of this set of instructions is to provide assistance to the Payload Developer (PD) with the verification of human factors requirements listed in Form 881, “Human Factors Requirements Applicability & Compliance Form” and SSP 57000 section 3.12. The HFIT evaluation will be a joint effort requiring an Astronaut Crew Representative, NASA Human Factors and Boeing Human Factors representatives.

R.2.1 RESPONSIBILITIES

The PD is responsible for complying with all requirements listed in SSP 57000 section 3.12. If the PD chooses to use the HFIT service, HFIT will certify payload compliance by means of inspection of PD drawings and/or photos, measurements, demonstration, and/or any other required information needed to complete evaluation of program human factors requirements. The PD will coordinate with the HFIT before submitting data for approval. HFIT is responsible for reviewing all data for payload human factors criteria for the SSP 57000 section 3.12 requirements listed in Form 881. HFIT is also responsible for performing the on site human engineering verification of the hardware and ensuring that the hardware is usable from a human engineering perspective, including commonality, standardization, and operations.

Upon receiving Form 881 from HFIT, the PD and HFIT will assess/verify through vendor or on site inspection, the hardware indicated on Form 881. This data will be collected byHFIT with the help of the PD. The PD will aid HFIT by providing any data collected as a result of design or hardware modeling.

The VCB is responsible for resolving issues and disagreements between the PD and HFIT.

R.2.2 HFIT APPROVAL INSTRUCTIONS

The process for human factors approval, by HFIT, is illustrated in Figure R.2.2-1. HFIT will use the following instructions in reviewing and providing the approval of payload human factors requirements on Form 881. Form 881 includes the list of the SSP 57000 section 3.12 requirements and their applicability to the particular payload, and is used by HFIT to record requirements compliance.

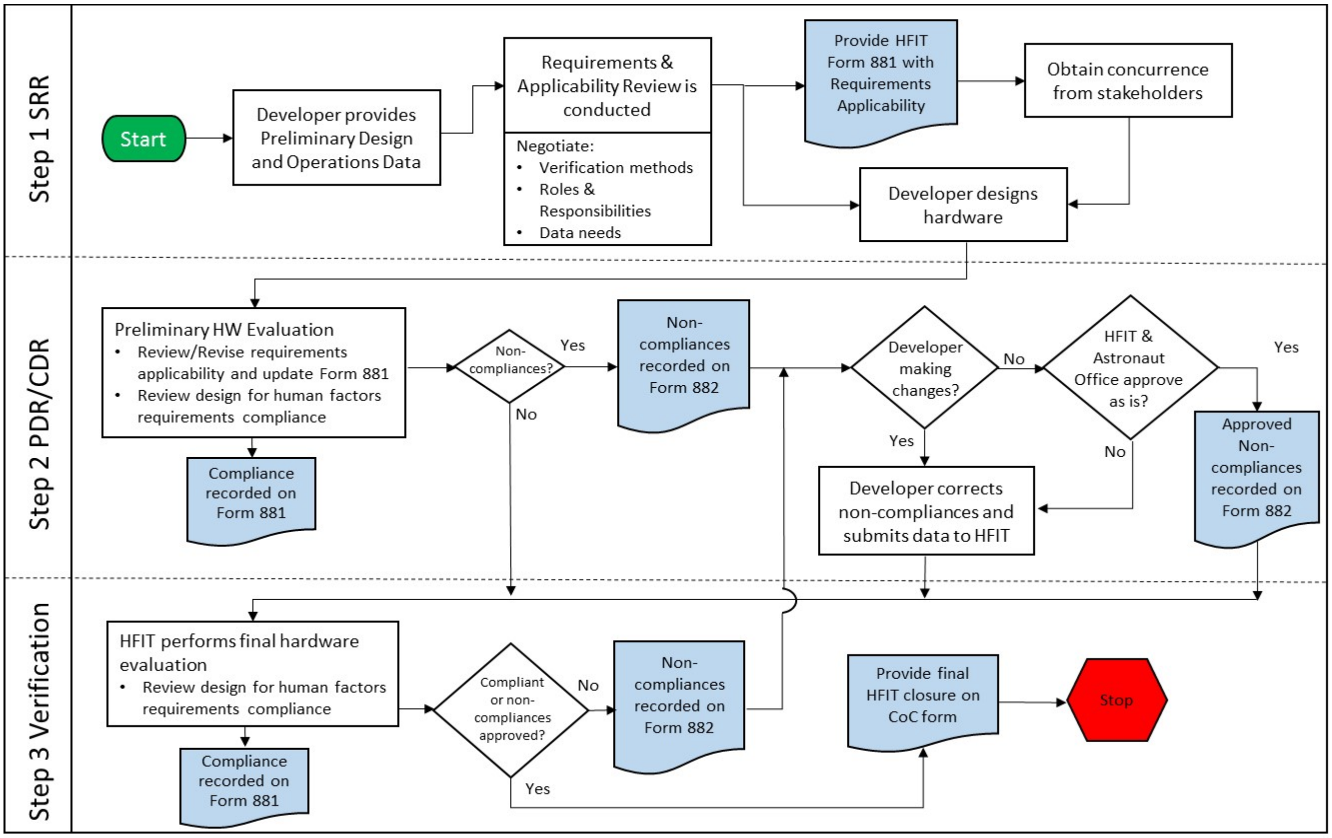


FIGURE R.2.2-1 HFIT PAYLOAD HUMAN FACTORS APPROVAL PROCESS

Prior to initiation of the HFIT process, the PD decides whether to use HFIT or not. If the PD decides not to use HFIT, the PD will use the existing SSP 57000 process flow for requirements verification and exceptions. If the PD decides to use HFIT, the following steps apply:

Step 1. Requirements and Applicability Review. This ideally happens at the System Requirements Review (SRR) phase. Based on information provided from the PD, HFIT determines which SSP 57000 section 3.12 requirements are applicable to the payload, and records this in Form 881, “Human Factors Requirements Applicability & Compliance Form”. This set of applicable requirements is agreed to by both the PD and HFIT,

Step 2. Preliminary Hardware Evaluation. This happens at Preliminary Design Review (PDR), Critical Design Review (CDR), or at a time negotiated by the PIM and HFIT. During this process the hardware is evaluated against the applicable section 3.12 human factors requirements. Compliance with each applicable requirement is noted on Form 881. Additional feedback based on human factors best practices or on-orbit crew operational experience is also recorded at the end of Form 881. This feedback is meant to help the payload be successful, but is not required to be implemented for approval.

Any non-compliances with any requirements are recorded on Form 882 “Human Factors Requirements Non-Compliance Acceptability Form”. For non-safety related minor exceptions to the SSP57000 section 3.12 requirements, HFIT can accept the design if it is found to be operable by the crew.

Step 3. Final Hardware Evaluation. A closed Form 882 and HFIT Certification of Compliance (CoC) complete this step. HFIT will only issue a CoC when all hardware issues are resolved with the exception of sections 3.12.3.2 Intermittent Noise Limits and 3.12.7 Identification Labeling. These requirements will be completed through the formal process described in SSP 57000. HFIT, in the CoC, lists all part numbers applicable to the certified hardware and all SSP 57000 section 3.12 requirements that could not be met by this process. Acknowledgement of the waived condition is noted by HFIT on Form 882. All members listed below must sign Form 882. Once all requirements listed in Form 881 are met and all Form 882 discrepancies are closed, the CoC will be issued for the Certification of Flight Readiness (CoFR).

MEMBERS AND FUNCTION

1) **Astronaut Office Representative:** This is any member of the Astronaut Office who has signature status granted by the Astronaut Office (CB).

2) **Human Factors Representative:** This is any member of the NASA or Boeing Human Factors Group who has signature authority.

3) **Payload Developer (or Payload Integrator):** This is the PD point of contact assigned to work with HFIT.

4) **NASA HFIT Lead**

R.2.3 OPTIONS FOR REMOTE HFIT VERIFICATION

This section addresses verification process updates that reduce the cost of HFIT travel to PD sites under certain circumstances as described below.

Verification options in lieu of HFIT travel to the PD site:

- Remote verification using photos, video, or video conferencing, with PD support.
- Deputizing of on-site personnel to perform the hands-on aspects of human factors verification (e.g. ESA astronauts located in Europe could perform HFIT verification at PD location with HFIT remote support). HFIT retains approval authority.
- If the PD brings the hardware to one of the NASA centers, HFIT personnel can perform hands-on verification.

The following is a list of categories of payloads as they relate to potential for remote verification, including definitions and examples. Table R.2.3-1 discusses whether each one of these categories is suitable for remote HFIT verification. Generally speaking, the less complex the hardware is, the more likely that remote verification is appropriate. Similarly, remote verification is more likely to be appropriate for modified re-flight hardware.

<u>New simple payload hardware</u>: A passive, non-powered payload with no crew interfaces, except for handling, or battery-powered with few crew interfaces.

<u>Unmodified re-flight payload</u>: A payload that frequently flies to and from the ISS.

<u>Modified re-flight payload</u>: A payload that changes part number or whose design changes.

<u>Complex hardware</u>: A powered payload with multiple crew interfaces.

TABLE R.2.3-1 SUITABILITY FOR REMOTE HFIT VERIFICATION

Payload Category	Remote HFIT Verification Appropriate?
New simple payload hardware	It depends, but typically remote verification applies. A full hands-on HFIT review may still be required and will be assessed on a case-by-case basis. If needed, the HFIT review would be scheduled at the PD site, or performed by personnel approved by HFIT.
Unmodified re-flight payload	If truly unmodified, then existing verification is still valid, except for cleanliness and burrs.
Modified re-flight payload	It depends. A review of the design changes that affect human factors will be assessed by HFIT and the crew. If changes warrant a hands-on HFIT evaluation, one will be scheduled. If the changes have a limited effect on human factors, then the payload can be verified remotely by HFIT, typically via photos.
Complex hardware	No. A full hands-on HFIT review is required, and will be scheduled at the PD site.

HFIT will make a determination as to the suitability of performing remote verification. This determination will be based on hardware complexity, repetitiveness, and the PDs history with working with HFIT in the past (e.g. delivering hardware with few human factors issues), in order for remote verification to be considered. Certain situations may necessitate a hands-on verification regardless of type of payload. Also, a more complicated payload may be able to be verified remotely under certain circumstances.

APPENDIX S

GUIDELINES FOR PAYLOAD LEAK TESTING DURING QUALIFICATION AND ACCEPTANCE ENVIRONMENTAL TESTING

APPENDIX S - GUIDELINES FOR PAYLOAD LEAK TESTING DURING QUALIFICATION AND ACCEPTANCE ENVIRONMENTAL TESTING

S.1.0 INTRODUCTION

S.1.1 PURPOSE

This appendix is intended to provide PDs with the test methods and acceptance criteria that will allow for the assurance that each payload will not leak under the maximum use condition.

S.1.2 SCOPE

Payload developers that have their payloads equipped with the gas or fluid systems or vacuum lines that have to be verified for pressure integrity via leak testing are recommended to use this appendix.

S.1.3 USE

This appendix is not intended to replace existing qualification and acceptance test procedures but rather to provide guidance for the development of such procedures that will help PDs to produce the leak tight payloads.

S.2.0 PERSONNEL

Personnel performing Nondestructive Evaluation processes has to be trained and certified. Therefore, it is strongly recommended that formal certification of personnel knowledge and skills for conducting the test specified herein are maintained.

S.3.0 TEST DESCRIPTION AND ALTERNATIVES

S.3.1 TEST ARTICLES

Leak testing needs to be performed on sealed and pressurized with working fluid (gas or liquid) payloads for both qualification and acceptance to verify compliance with the leakage rate specifications.

S.3.2 TEST SEQUENCE/SENSITIVITY

Payload developers need to plan to perform multiple leak tests during the course of their development process. At a minimum, the payloads need to go through leak tests before and after each of the following applicable qualification and acceptance tests:

1) Thermal vacuum and/or thermal cycle
2) Random, sinusoidal, or acoustic vibration
3) Pyrotechnic shock
4) Humidity
5) Proof pressure test

The test method employed must have sensitivity and accuracy consistent with the specified maximum allowable leakage rate. Recommended maximum allowable leakage rates and leak test methods to be employed to verify pressure integrity are shown in Table S.3.2-1.

Conversion between different leakage rate units for Air needs to be done in accordance with Table S.3.2-2.

Conversion between test gas leakage rate to a corresponding leakage rate of a working fluid needs to be done in accordance with Table S.3.2-3.

Maximum allowable leakage rate range that could be reliably verified is shown in Table S.3.2-4.

The leak test method employed needs to have a sensitivity to detect leakage rate of at least half of the specified pass/fail leakage rate allowable e.g., if the allowable leakage rate is less than 10^{-4} scc/sec, the method ("end-to-end" test set-up) used needs to demonstrate it is capable of detecting at least 5.0×10^{-5} scc/sec by using a standard leak source. For definitions used, refer to Section S.8.0. This sensitivity verification needs to be performed prior to every leak test. Also, local leak detection methods e.g., Detector Probe, are not recommended to be used to verify requirements for total leakage rate for a payload. Payload leakage rate specifications will be determined based on the standard methods derived for the seal design.

TABLE S.3.2-1 RECOMMENDED MAXIMUM ALLOWABLE LEAKAGE RATES AND LEAK TEST METHODS TO BE USED TO VERIFY PRESSURE INTEGRITY AND PINPOINT LOCAL LEAKS

Toxicity Hazard Level (THL) or Other Limitations	Recommended Maximum Allowable Leakage Rate (MALR) to Be Verified: Test Methods
Catastrophic	Although no greater than 10^{-9} scc/sec is a prevalent value, the specific MALR calculated in accordance with NOTE 5 has to take precedence: • Method I (to verify pressure integrity); • Method IV may be used to verify pressure integrity only if MALR for the payload filled with liquid is more than $5x10^{-5}$ scc/sec; • Methods XI, XV (to pinpoint local leaks)
Critical	Although no greater than 10^{-7} scc/sec is a prevalent value, the specific MALR calculated in accordance with NOTE 5 has to take precedence: • Methods I and II (to verify pressure integrity); • Method IV may be used to verify pressure integrity only if MALR for the payload filled with liquid is more than $5x10^{-5}$ scc/sec; • Methods XI, XV (to pinpoint local leaks)
Fluid (gas or liquid) leak is not allowed or desired	No greater than 10^{-4} scc/sec: • Methods I, II, III, IV, and Va (to verify pressure integrity); • Methods IX, X, XI, XII, XIII, XIV, XV (to pinpoint local leaks)
Not safety, just general concerns about leaks	No greater than 10^{-3} scc/sec: • Methods I through XV (selected to verify pressure integrity and/or pinpoint local leaks depending on a flow direction through leaks (out of or into payload)

NOTES:

1. In all cases, leak testing has to be conducted after the payload proof pressure test (ref. paragraph S.3.0).
2. For the definitions used, refer to Section S.8.0.
3. Sources of data for leakage rates: There was no single source used for developing these Guidelines. The leakage rates are the results of an analysis of available sources/practices. Namely, NASA practice, e.g., Leakage Testing Handbook, 1969; Aerospace Industry practice - Boeing leak test capabilities; ASNT recommendations, e.g., NDT Handbook, vol. 1 Leak Testing; Other Industries practice, Leak detector capabilities, e.g., SAE-J1267 LEAKAGE TESTING; ASTM Standards, e.g., E 479-91 Standard Guide for Preparation of a Leak Testing Specification, etc.
4. Units for a leakage rate as scc/sec [standard (pressure differential of 760 torr at 0 degrees centigrade) cubic centimeters per second] are most commonly used units in the ISS Program documentation (see, for example, paragraph N.3.7.4 NITROGEN LEAKAGE), but certainly they may be different in the specific payload specifications and/or test procedures, e.g., Pa ● m^3/s, L●μHg/sec or μl/s for payload pressurized with working fluid (gas or liquid) leaks, or **Torr L/s** for sealed payload leaks.
5. MALR has to be verified to ensure that the maximum amount of substance that could leak over the mission duration [calculated as MALR x mission duration x safety factor (assigned by PD and concurred by Safety) would lead to the allowable Toxicity Hazard Level (THL)], or less than the allowed SMAC value (whichever is more conservative).

TABLE S.3.2-2 CONVERSION CHART FOR DIFFERENT LEAKAGE RATE UNITS

From \ To for Air leakage rate	Pa◦m³/s	mbar L/s	Torr L/s	scc/sec	µL/s	scc/m	Mol/s@0°C	kg/yr at 0°C
Pa◦m³/s	1	10	7.5	9.87	$7.5x10^{3}$	592	$4.41x10^{-4}$	400
mbar L/s	0.1	1	0.75	0.987	750	59.2	$4.41x10^{-4}$	40
Torr L/s	0.133	1.33	1	1.32	1000	78.9	$5.85x10^{-4}$	53.2
scc/sec	0.101	1.01	0.76	1	760	59.8	$4.45x10^{-5}$	40.4
µL/s	$1.33x10^{-4}$	$1.33x10^{-3}$	10^{-3}	$1.32x10^{3}$	1	$7.89x10^{-2}$	$5.86x10^{-8}$	$5.32x10^{-2}$
scc/m	$1.69x10^{-3}$	$1.69x10^{-2}$	$1.27x10^{-2}$	$1.67x10^{-2}$	12.7	1	$7.45x10^{-7}$	0.676
Mol/s@0°C	$2.27x10^{3}$	$2.27x10^{4}$	$1.7x10^{4}$	$2.24x10^{4}$	$1.7x10^{7}$	$1.34x10^{3}$	1	$9.08x10^{5}$
Air at 0°C kg/yr	$2.5x10^{-3}$	$2.5x10^{-2}$	$1.88x10^{-2}$	$2.48x10^{-2}$	18.8	1.48	$1.1x10^{-6}$	1

TABLE S.3.2-3 CONVERSION CHART FOR HELIUM AND OTHER GASES LEAKAGE RATES

To Convert Leakage Rate (Q) Measured with Helium as a Tracer Gas	If Leak Is Determined to Have a Viscous Flow Through It, Multiply Helium Leakage Rate by	If Leak Is Determined to Have a Molecular Flow Through It, Multiply Helium Leakage Rate by
Q of argon	0.883	0.316
Q of neon	0.626	0.447
Q of hydrogen	2.23	1.41
Q of nitrogen	1.12	0.374
Q of air	1.08	0.374
Q of water vapor	2.09	0.469

NOTES:

1. Before converting leakage rates for different fluids/gases, the type of flow through leaks must first be identified or, if not possible, be determined based on a best guess estimate.
2. With viscous flow through leak, the leakage rate Q is proportional to the difference in the squares of the pressures acting across the leak (most probable with leakage rates higher than 10^{-5} scc/sec).
3. With molecular flow through leak, the leakage rate Q is proportional to the difference in pressures applied across the leak (most probable with leakage rates below 10^{-5} scc/sec).

TABLE S.3.2-4 LEAK TEST METHODS TO BE EMPLOYED TO VERIFY PRESSURE INTEGRITY AND PINPOINT THE LOCAL LEAKS

Method No.	Leak Test Method	Leakage Rate That Could Be Reliably Verified (scc/sec)
	Methods for Total Internal-to-External Leakage Rate Verification	
I	Vacuum Chamber	10^{-9}
II	Accumulation	10^{-7}
III	Bombing	10^{-5}
IV	Mass Loss After Vacuum Exposure	$5x10^{-5}$
Va	Pressure Change [Pressure Decay technique]	10^{-4}
	Methods for Total External-to-Internal Leakage Rate Verification	
Vb	Pressure Change [Pressure Rise technique]	10^{-5}
VI	Hood	$5x10^{-10}$
	Methods for Total Internal-to-Internal Leakage Rate Verification	
VII	Volumetric Displacement	10^{-3}
VIII	Leak Detector Direct Connection	10^{-8}
	Methods for Local Internal-to-External Leakage Rate Verification	
IX	Immersion	10^{-4}
X	Chemical Indicator	$5x10^{-6}$
XI	Detector Probe	10^{-5}
XII	Local Bell Jar	$5x10^{-10}$
XIII	Foam/Liquid Application	10^{-4}
XIV	Hydrostatic/Visual Inspection	10^{-3}
	Methods for Local External-to-Internal Leakage Rate Verification	
XV	Tracer Probe	$5x10^{-8}$

NOTES:

1. Choice criteria are such that the selection of a method to be chosen other than Internal-to-External Leakage Rate Verification or External-to-Internal Leakage Rate Verification requires a special justification presented, for example, in a payload verification plan, and approved by the responsible safety organization such as ISRP.
2. The leak test method employed has to demonstrate to have a sensitivity to detect leakage rate of at least half of the specified pass/fail leakage rate allowable (ref. paragraph S.3.0).
3. For the definitions used, refer to Section S.8.0.
4. Sources of data for leakage rates: There was no single source used for developing these Guidelines. The leakage rates are the results of an analysis of available sources/practices. Namely, NASA practice, e.g., Leakage Testing Handbook, 1969; Aerospace Industry practice - Boeing leak test capabilities; ASNT recommendations, e.g., NDT Handbook, vol. 1 Leak Testing; Other Industries practice, Leak detector capabilities, e.g., SAE-J1267 LEAKAGE TESTING; ASTM Standards (see Section S.9.0).

S.3.3 TEST DURATION

Leak testing may be performed prior to payload proof pressure testing only if approved by the responsible safety organization. In all cases, leak testing has to be conducted after the payload proof pressure test. The leak tests have to be performed with the payload pressurized at the MDP and then at the minimum design pressure if the seals are dependent upon pressure for proper sealing. Regardless of the method used, the test duration has to be sufficient to detect any out-of-specification leakage rate. Payload leak tests are considered adjunctive to the payload qualification environmental tests in that their results are part of the success criteria for these tests.

S.3.4 REDUNDANT SEALS

If the payload has redundant seals, pressure integrity of each seal has to be verified independently, at least during the payload Qualification testing phase. Depending on the seal material and the payload design configuration, the procedural details of leak testing are recommended to be as follows.

S.3.4.1 CONFIGURATION WITH LEAK CHECK PORT BUILT IN BETWEEN SEALS

If the payload configuration includes the leak check port built in between seals, then pressure integrity of each seal could be verified using one of the leak test methods described in Section S.5.0, or sometimes using a combination of two methods from Table S.5.0-1. The important step in the leak test procedure has to be the final leak test of the cap installed on the leak check port with the seal sometimes called “blind gland” using, for example, METHOD XII (Local Bell Jar) described in Table S.5.0-1.

S.3.4.2 CONFIGURATION WITH NO LEAK CHECK PORT BUILT IN BETWEEN SEALS

If the payload configuration does not include the leak check port built in between seals, then pressure integrity of each seal has to be verified independently during the payload Qualification testing phase when only primary and/or secondary seal has to be installed and leak tested against the specified requirement for a leakage. If both seals passed, the final leak testing of both seals has to be done as well.

For the payload Acceptance testing phase, the decision on whether each seal pressure integrity verification is required has to be made by PD/PI in conjunction with the ISRP and associated safety reviews. However, if such verification is warranted for the non-metallic seals, it is recommended to combine one of the total leak test methods with a tracer gas, for example, described in Section S.5.1 with the so called “through leakage” test when the MALR has to be less than 1.0×10^{-7} scc/sec over predetermined time that depends on the seal size and its material properties. This approach would help finding problems associated with either seal damage or foreign debris accidentally thrown on a sealing surface earlier in a test flow.

S.3.5 TEMPERATURE EFFECT

When temperature potentially affects the sealing materials or surfaces, an evaluation of the hardware design and operational characteristics has to be performed and, if technically warranted, the leak test has to be conducted at the minimum and maximum qualification temperature limits (determination of worst case test temperature must take consideration of contained fluids or vapor that undergo a phase change). If it is determined from the evaluation that a leak test at temperature limits is warranted on a payload of a given level-of-assembly due solely to one or more lower tier payloads comprising the assembly, and it can be shown that all of those lower tier payloads receive an appropriate leak test at temperature limits as part of a lower level qualification test, then the higher level-of-assembly does not require leak testing at temperature limits.

S.4.0 TEST SAFETY STANDARDS AND LEAK TEST METHOD APPLICATION

Applicable safety standards have to be followed in conducting all tests. Any fluids used for leak testing have to be compatible with operational media. Helium or other leak detectors may be used for detecting leakage rates starting from 10^{-9} scc/sec and higher. Leak tests have to be conducted only after satisfactory proof pressure tests have been completed. Leak detection and measurement procedures may require vacuum chambers, bagging of the entire payload, or other special techniques to achieve the required accuracy.

One of the following methods as defined in Section S.5.0, or another suitable leak test method, (see definition in Section S.8.0) has to be used. The selected method has to be coordinated with the ISS Program and ISRP.

The following test methods are recommended for payloads pressurized with working fluid (gas or liquid): Methods I, II, Va (Pressure Decay), VII, VIII, IX, X, XI, XII, XIII, or XIV as appropriate.

The following test methods are recommended for sealed payloads:

Methods III, IV, Vb (Pressure Rise technique), VI, or XV as appropriate.

Test methods other than those identified herein have to be presented in enough detail to allow the ISRP to review and come to the same conclusion as the PD. That is, the test method possesses the necessary sensitivity, calibration, appropriate time duration, test set-up and qualified test personnel to ascertain the leakage rates defined can be verified. This will be examined on a case-by-case basis by the ISRP. As for instance in the case where a payload contains a highly caustic, hazardous material, the PD has stated the intent is to submerge the payload in water and measure the pH of the water over an extended period of time for any change. The sensitivity of the measuring device is capable of detecting very minute changes in the water pH. This method was deemed acceptable by the ISRP after calculations were made that confirmed that the required maximum allowable leakage rate could be verified using a test methodology proposed by the PD.

S.5.0 TEST METHODS

There are fairly standard methods developed for typical leak testing used by industry. Fifteen of these methods are defined in SSP 41172, Qualification and Acceptance Environmental Test Requirements. The methods chosen need to correspond to the following paragraphs of SSP 41172, either from Qualification or Acceptance testing sections although there are no significant technical differences between both sections.

TABLE S.5.0-1 LEAK TEST METHODS DEFINED IN SSP 41172

Method No.	Paragraph for Qualification Testing	Paragraph for Acceptance Testing
METHOD I (Vacuum Chamber)	4.2.11.2B	5.1.7.2B
METHOD II (Accumulation)	4.2.11.2H	5.1.7.2H
METHOD III (Bombing)	4.2.11.2O	5.1.7.2O
METHOD IV (Vacuum Exposure/Mass Loss)	4.2.11.2N	5.1.7.2N
METHOD V (Pressure Change)	4.2.11.2C	5.1.7.2C
METHOD VI (Hood)	4.2.11.2F	5.1.7.2F
METHOD VII (Volumetric Displacement)	4.2.11.2I	5.1.7.2I
METHOD VIII (Leak Detector Direct Connection)	4.2.11.2J	5.1.7.2J
METHOD IX (Immersion)	4.2.11.2A	5.1.7.2A
METHOD X (Chemical Indicator)	4.2.11.2D	5.1.7.2D
METHOD XI (Detector Probe)	4.2.11.2E	5.1.7.2E
METHOD XII (Local Bell Jar)	4.2.11.2K	5.1.7.2K
METHOD XIII (Foam/Liquid Application)	4.2.11.2L	5.1.7.2L
METHOD XIV (Hydrostatic/ Visual Inspection)	4.2.11.2M	5.1.7.2M
METHOD XV (Tracer Probe)	4.2.11.2G	5.1.7.2G

S.6.0 TEST LEVELS AND DURATION

The leak tests need to be performed with the payload pressurized at the MDP and then at the minimum design pressure if the seals are dependent upon pressure for proper sealing. Regardless of the method used, the test duration needs to be sufficient to detect any out-of-specification leakage.

S.7.0 SUPPLEMENTARY INFORMATION/RATIONALE

Payload leak tests are considered adjunctive to the payload qualification and acceptance environmental tests in that their results are part of the success criteria for these tests.

The rationale used in determination of the leakage rates specified in these guidelines is as follows:

The greatest number of leak tests is for Non Safety containment leak testing that have to allow the simple, less expensive, and most commonly used leak test methods such as Pressure Change (for total Internal-to-External leakage rate verification), Foam/Liquid Application and Immersion (for local Internal-to-External leakage rate verification or pinpointing local leaks). The generally accepted leak test sensitivity without any special care given (no smaller leakage rate can be indicated by these methods) is in the range of 10^{-3} - 10^{-4} scc/sec. If no gas leak is indicated with these methods, there won't be any immediate, obviously noticeable, indications of a liquid leak. With more intensity, such as longer duration, best lighting, higher pressure, the sensitivity of these methods can be improved. The payloads organizations are to be encouraged to use these simple, less expensive, leak test methods where possible because the methods are less likely to give erroneous "no-leak" indications than the more sensitive leak test methods.

Leaks resulting in Critical and Catastrophic hazards, as indicated by toxicity, biological assessment, flammability, interference with Environmental Control Life Support System, loss of required service, and Design for Minimum Risk (fracture critical) failure requires better leak test sensitivity than can be provided by the simple, inexpensive, methods used for non-safety leak testing. Helium Mass Spectrometer leak test equipment is the most commonly used more sensitive leak test equipment. By specifying a maximum allowable leakage rate of 10^{-7} scc/sec a Helium Mass Spectrometer or leak test equipment with comparable sensitivity will be required for a leak testing for leaks that can cause a Critical hazard. Because of the many erroneous "no-leak" indications can be obtained, more rigorous attention must be given to equipment calibration and operator certification for Helium Mass Spectrometer leak testing.

Leaks that can cause a Catastrophic hazards require the most sensitive, demanding, Helium Mass Spectrometer leak testing using a Vacuum Chamber (Bell Jar) to satisfy the leak test requirement of 10^{-9} scc/sec. This required leak test sensitivity has to be limited to only where essential to verify the flawless containment integrity and leak quantification.

S.8.0 DEFINITIONS

CALIBRATION

Where quantification of the leakage rate is applicable, a suitable leak test method needs to be defined as one that establishes a calibration of the leak test setup such that the calibration method is commensurate with the allowable leakage rate to be detected. For leak test standard tools such as graduated flasks, columns, and pipettes purchased at standard scientific suppliers, the calibration of the graduations are to be accepted. Tracer gas leak standards need to bear a calibration certification sticker from metrology or the vendor and need to be within the prescribed dates and, if equipped with a pressure gage, within the appropriate pressure range.

CHARACTERIZATION

A suitable leak test method need to demonstrate the appropriate time duration to establish confidence in the ability to detect leakage rates above background and establish a stable time period to allow for permeation, multiple leak paths, etc. The time duration established to calibrate the leak test setup to demonstrate the ability to detect leakage will be accepted as the (one) time constant. To demonstrate leakage rate stability during the performance of the actual leak test, the leak test setup is required continuous monitoring until the measured leakage rate result exhibits less than 10 percent variation for a duration of three time constants.

DETECTOR PROBE

In leak testing, a device used to collect tracer gas from an area of the test payload and feed it to the leak detector at the reduced pressure required. Also called a sniffing probe.

DOCUMENTATION

Appropriate documentation needs to include as a minimum: the operator, the inspector, the method of calibration (where applicable) and sensitivity of the leak test setup, a detailed sketch/description of the leak test setup, number of test data points measured, and the respective time intervals of the measurements. The test report and procedures need to include also information on any training and/or certification of the inspectors and technicians.

DRIFT

In leak testing, the relatively slow change in the background output level of the leak detector due to the electronics rather than a change in the level of the tracer gas.

EXTERNAL-TO-INTERNAL TOTAL LEAKAGE

The combined leakage rate of a tracer gas through all the existing leaks from outside to inside of a payload being tested.

INTERNAL-TO-EXTERNAL TOTAL LEAKAGE

The combined leakage rate of a tracer gas through all the existing leaks from inside of a payload being tested to outside.

INTERNAL-TO-INTERNAL TOTAL LEAKAGE

The combined leakage rate of a tracer gas through all the existing leaks in a payload internal barrier.

LEAK

A hole, crack, or void in the wall of an enclosure capable of passing liquid or gas from one side of the wall to the other under action of pressure or concentration differential existing across the wall, independent of the quantity of fluid flowing.

LEAKAGE

The act or an instance of leaking of gas or liquid through the leaks [see **LEAK**] or due to permeation [see **PERMEATION**].

LEAKAGE RATE

The flow rate of a gas or fluid through a leak at a given temperature as a result of a specified pressure difference across the leak. Standard conditions for gases are 77 degrees F (25 degrees C) and 100 kPa. Leakage rates are expressed in various units such as pascal cubic meters per second or standard cubic centimeters per second.

LEAK DETECTOR

A device for detecting, locating, and/or measuring leakage.

LOCAL LEAK

See **LEAK**.

MAXIMUM DESIGN PRESSURE

The MDP for a payload pressurized with working fluid (gas or liquid) is the highest pressure defined by the maximum relief pressure, maximum regulator pressure, maximum temperature, and transient pressure excursions. NOTE: Where pressure regulators, relief devices, and/or a thermal control system (e.g., heaters) are used to control pressure, collectively they must be two-fault tolerant from causing the pressure to exceed the MDP of the system.

PAYLOAD PRESSURIZED WITH WORKING FLUID (GAS OR LIQUID)

A payload designed to retain its leak tightness at both standard atmospheric and positive differential internal pressure.

PERMEATION

The passage of a gas or fluid into, through, and out of a solid barrier having no holes large enough to permit more than a small fraction of molecules to pass through any one leak [see **LEAK**].

PRESSURE INTEGRITY

Ability of a payload to retain its leak tightness at both standard atmospheric and positive or negative differential pressure.

PROOF PRESSURE

The pressure to which payloads pressurized with working fluid (gas or liquid) are subjected to fulfill the acceptance requirements to give evidence of satisfactory workmanship and materials quality. Proof pressure is the product of the MDP and the appropriate proof factor of safety required for screening maximum allowable flaws based on fracture mechanics analysis.

SEALED PAYLOAD

A payload designed to retain its leak tightness at both standard atmospheric and negative differential internal pressure.

SENSITIVITY OF LEAK TEST

The smallest leakage rate that an instrument, method, or system is capable of detecting under specified conditions.

STANDARD LEAK

A device that permits a tracer gas to be introduced into a leak detector or leak test setup at a known rate to facilitate calibration of the leak detector.

SUITABLE LEAK TEST METHOD

A suitable leak test method needs to exhibit, as a minimum, the following:

- Calibration
- Characterization
- Documentation

TOTAL LEAKAGE RATE

See **INTERNAL-TO-EXTERNAL TOTAL LEAKAGE**

Note: Other definitions relevant to leak testing may be found in ASTM E1316, Standard Terminology for Nondestructive Examinations.

S.9.0 ASTM STANDARDS

For the list of ASTM standards that could be used as an extra guidance for the payload leak testing, see Table S.9.0-1.

TABLE S.9.0-1 ASTM STANDARDS (2 PAGES)

Document No.	Document Title
D 3078-02	Standard Test Method for Determination of Leaks in Flexible Packaging by Bubble Emission
E 165-02	Standard Test Method for Liquid Penetrant Examination
E 427-95 (Reapproved 2000)	Standard Practice for Testing for Leaks Using the Halogen Leak Detector (Alkali-Ion Diode)
E 432-91 (Reapproved 1997)	Standard Guide for Selection of a Leak Testing Method
E 433 – 71 (Reapproved 2003)	Standard Reference Photographs for Liquid Penetrant Inspection
E 479-91 (Reapproved 2000)	Standard Guide for Preparation of a Leak Testing Specification
E 493-97	Standard Test Methods for Leaks Using the Mass Spectrometer Leak Detector in the Inside-Out Testing Mode
E 498-95 (Reapproved 2000)	Standard Test Methods for Leaks Using the Mass Spectrometer Leak Detector or Gas Analyzer in the Tracer Probe Mode
E 499-95 (Reapproved 2000)	Standard Test Methods for Leaks Using the Mass Spectrometer Leak Detector or Gas Analyzer in the Detector Probe Mode
E 515-95 (Reapproved 2000)	Standard Test Method for Leaks Using the Bubble Emission Techniques
E 543 – 02	Standard Practice for Agencies Performing Nondestructive Testing
E 650 – 97 (Reapproved 2002)	Standard Guide for Mounting Piezoelectric Acoustic Emission Sensors
E 750 – 98	Standard Practice for Characterizing Acoustic Emission Instrumentation
E 908-98	Standard Practice for Calibrating Gaseous Reference Leaks
E 976 – 00	Standard Guide for Determining the Reproducibility of Acoustic Emission Sensor Response
E 1002-96	Standard Test Method for Leaks Using Ultrasonics
E 1003-95 (Reapproved 2000)	Standard Test Method for Hydrostatic Leak Testing
E 1066-95 (Reapproved 2000)	Standard Test Method for Ammonia Colorimetric Leak Testing
E 1208-99	Standard Test Method for Fluorescent Liquid Penetrant Examination Using the Lipophilic Post-Emulsification Process
E 1209-99	Standard Test Method for Fluorescent Liquid Penetrant Examination Using the Water-Washable Process
E 1210-99	Standard Test Method for Fluorescent Liquid Penetrant Examination Using the Hydrophilic post-Emulsification Process
E 1211-02	Standard Practice for Leak Detection and Location Using Surface-Mounted Acoustic Emission Sensors
E 1219-99	Standard Test Method for Fluorescent Liquid Penetrant Examination Using the Solvent-Removable Process
E 1220-99	Standard Test Method for Visible Penetrant Examination Using the Solvent-Removable Process
E 1417 – 99	Standard Practice for Liquid Penetrant Examination
E 1418-99	Standard Test Method for Visible Penetrant Examination Using the Water-Washable Process
E 1419 – 02b	Standard Test Method for Examination of Seamless, Gas-Filled, Pressure Vessels Using Acoustic Emission
E 1603-99	Standard Test Methods for Leakage Measurement Using the Mass Spectrometer Leak Detector or Residual Gas Analyzer in the Hood Mode

TABLE S.9.0-1 ASTM STANDARDS (2 PAGES)

Document No.	Document Title
E 2024-99	Standard Test Methods for Atmospheric Leaks Using a Thermal Conductivity Leak Detector
F 78-97 (Reapproved 2002)	Standard Test Method for Calibration of Helium Leak Detectors by Use of Secondary Standards
F 1929-98	Standard Test Method for Detecting Seal Leaks in Porous Medical Packaging by Dye Penetration
F 2095-01	Standard Test Methods for Pressure Decay Leak test for Nonporous Flexible Packages With and Without Restraining Plates
F 2096-02	Standard Test Method for Detecting Gross Leaks in Medical Packaging by Internal Pressurization (Bubble Test)