NSTS-21000-IDD-MDK
Rev B

Space Flight Operations Contract

Middeck Interface Definition Document

NSTS-21000-IDD-MDK

Prepared by Boeing North American, Inc.
Reusable Space Systems

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Contract NAS9-20000

United Space Alliance

STS
INTERFACE CONTROL DOCUMENT

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Document Change Log

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1	05-Aug-97	A03584	17	(Section 9)
2	13-Nov-97	A03665	18	(Section 8)
3	10-Jan-00	A03931	19	(Section 6)
3	10-Jan-00	A03959	20	(Sections 3 & 6)
3	10-Jan-00	A03960	21	(Section 6)
4	26-Oct-00	A04314	22	(Section 6)
5	07-May-01	A04290	23	(Sections 2, 7, & 8)
6	07-May-01	A04518	24	(Section 1)
7	24-Sep-01	A04589	25	(Section 6)
8	20-Dec-01	A04605	26	(Sections 2 & 10)
9	09-Jan-02	A04384	27	(Sections 2 & 3)
10	12-Feb-02	A04669	28	(Section 10)
11	07-Mar-02	A04512	29	(Section 4)
12	02-Jul-02	A04396	30	(Section 2 & 3)
13	17-Jul-02	A04695	31	(Section 6)
14	09-Sep-02	A04672	32	(Section 4)
15	10-Oct-02	A04760	33	(Section 3)
16	07-Feb-03	A04799	34	(Section 3)
17	27-May-03	A04852	35	(Sections 7 & 8)
18	18-Nov-03	A04286	36	(Sections 7 & 9)

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5	15-Aug-96	Basic
6	17-Jul-02	IRN 31
7	18-Nov-03	IRN 36
8	27-May-03	IRN 35
9	18-Nov-03	IRN 36
10	12-Feb-02	IRN 28

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1.0 SCOPE

1.1 Purpose

This Interface Definition Document (IDD) defines and controls the design of interfaces between the Shuttle Orbiter and payloads that use Orbiter middeck payload accommodations. This IDD and Payload unique Interface Control Document (ICD), which is developed from this IDD are defined below.

1.1.1 Definition of IDD

a. Defines the interfaces which shall be provided by the baseline Shuttle Orbiter for payloads that employ Orbiter Middeck payload accommodations.

b. Defines and controls constraints which shall be observed by members of the Shuttle Orbiter and the payload community in using the interfaces so defined.

c. Establishes commonality with respect to approaches, analytical models, technical data and definitions for integrated analysis by interfacing parties.

1.1.2 Definition of Payload Unique ICD

a. Defines and controls the design of interfaces between the Shuttle Orbiter and the payload. The purpose of the payload unique ICD is the selection of the IDD interfaces, definition of selectable parameters, and unique interfaces between the Orbiter and the specific payload.

b. Defines and controls the constraints which shall be observed by both the Shuttle Orbiter and the payload in using the interfaces so defined.

c. Established commonality with respect to analytical approaches, analytical models, technical data and definitions for integrated analysis by both interfacing parties.

1.2 Standard Middeck Payload Accommodations

Middeck payload mounting provisions shall consist of SSP provided locker accommodations or mounting panels, which are defined as Payload Mounting Panels, Vented Payload Mounting Panels, Single Panels, Single Panels, Single Adapter Plates, or Double Adapter Plates. The SSP shall provide the mounting panels that interface directly to the avionics bay wire trays. Payloads shall not be designed to interface directly with the avionics bay wire trays.

A standard Middeck payload is defined as not exceeding 54 pounds when stowed in a standard middeck modular locker. Payloads with requirements exceeding standard Middeck allocations may result in a reduction in manifesting possibilities. The maximum payload weight includes only the payload and not

the weight of the locker shell, locker trays, or protective provisions, such as dividers, bungees, vibration isolating foam. Refer to Paragraph 3.4.1.

For payloads not stowed in standard middeck modular lockers, the payload maximum weight is based upon the payload's center-of-gravity as defined in paragraph 4.8.2, and Figures 4.8.2-1 and 4.8.2-2.

A standard middeck payload does not require late installation or access nor early removal of payload after mission completion.

A standard middeck payload requires either passive, non-ducted, or ducted air cooling. Non-ducted and ducted air cooling shall be accomplished by a payload supplied and integrally installed air circulation fan. Refer to paragraph 6.2.1.

1.2.1 Location Assignments

On any flight, the SSP reserves the right to assign locations to payloads mounted on an adapter plate (s), a payload mounting panel (s), a vented payload mounting panel (s), and payload stored within standard lockers. For those payloads requiring ducted cooling, there will be dedicated locations providing the Orbiter active cooling capability. Specific location requests and payload requirements may result in a reduction in manifesting opportunities.

For those flights with planned on-orbit transfers there may be restriction on launch and landing manifesting due to Orbiter restrictions on payload attachment interfaces, weight, C.G., flow requirements, and power requirements.

1.3 Effectivity

Unless otherwise specified, the interfaces defined and controlled herein are applicable to the operational configuration of the SSP.

1.4 Change Policy

All changes to this document shall be controlled in accordance with the procedures prescribed herein and by NSTS 07700, Vol. IV, Book 1. Dispositioned changes shall reflect program decisions and will record new, changed, and/or deleted requirements.

1.5 Waivers; Deviations; and Exceedances

Unique ICD's are derivatives of this IDD and do not require Orbiter Project or Space Station Project approval if they remain within the interface design parameters defined by this document. Limits of this ICD are established in a conservative manner to minimize individual payload and mixed cargo analyses. Any exceedance or deviation from the capabilities or services defined in this IDD shall be documented in a unique Section 20 paragraph of the derived ICD. This unique paragraph shall document the specific requirement violated, a description of the existing condition, and a rationale for acceptance.

Definitions:

Exceedance: A condition that does not comply with stated requirements but does not add risk to intended usage or configuration and can be shown acceptable without special analysis or controls.

Deviation: A condition that does not comply with stated requirements but does not add risk to intended usage or configuration and can be shown acceptable through additional analysis or controls.

Waiver: A condition that does not comply with stated requirements and could add risk to safety of crew and orbiter. Requires additional analysis and could require special controls, such as flight rules changes, to assure adequate flight margins.

2.0 DOCUMENTATION

2.1 Applicable Documents

The following documents of the exact issue shown shall form a part of this document to the extent specified herein. In the event of conflict between the documents referenced and the contents of this document the contents of this document shall be considered a superseding requirement.

Military

MIL-C-5541 April 14, 1981	Chemical Conversion Coatings on Aluminum Rev. C and Aluminum Alloys * Ref. Para. 8.4.1
MIL-DTL-18240 Rev. F June 2, 1997	Detail Specification Fastener Element, Self-Locking Threaded Fastener, 250°F Maximum * Ref. Para. 3.4.2.5.2

NASA (National Aeronautics and Space Administration)

SN-C-0005	Specification, Contamination Control Current Issue, Requirements for the Space Shuttle Program * Ref. Para. 5.1
40M39569 Rev. E May 30, 1983	(MSFC) Connectors, Electrical Miniature Circular Environment Resisting 200 ^{0}C, Specification * Ref. Para. 9.1.2
NSTS 1700.7B January 1989	Safety Policy and Requirements for Payloads using the Space Transportation System * Ref. Para. 4.6 and 5.2
NHB-8060.1C Apr. 1991	Flammability, Odor and Off Gassing and Compatibility Requirements * Ref. Para. 5.2
NSTS 07700 Current Issue	Mission Integration Control Board Vol. IV, Book 1 Configuration Management Procedures * Ref. Para. 1.4

NSTS-08080-1 NASA STD 145A Current Issue	Acoustic Noise Criteria * Ref. Para. 4.7.2, 4.7.3-1
NSTS-08242 Jan. 4, 1988	Limitations for Non-flight Materials and Equipment Used in and Around Space Shuttle Orbiter Vehicle * Ref. Para. 5.1
NHB 8071.1 Sept. 1, 1988	Fracture Control Requirements for Payloads National Space Transportation System (NSTS) * Ref. Para. 4.6 and 5.2
40M39569 December 15, 1973	Connectors, Electrical Miniature Circular, Environment Resisting 200 ^{0} C, Specification for * Ref Para 9.1.2
NSTS 21000-IDD-760XD July, 1999	Payload and General Support Computer (PGSC) * Ref. Para. 10.1, 10.2.1, 10.2.2, 10.3.1.2, 10.3.2
NSTS 07700 Vol. XIV Appendix 9 Current Issue	Design Data - Intravehicular Activities * Ref. Para. 3.7
NSTS 18798 Rev. A April 1, 1989	Interpretations of NSTS Payload Safety Requirements Ref. Para. 7.2.1.4
NSTS 21000-IDD-ISS June 7, 1995	International Space Station Interface Definition Document Ref. Para. 7.1.1
ICD-2-19001 Rev. K	Shuttle Orbiter/Cargo Standard Interfaces * Ref. Para. 7.1.1
NSTS 37330 Dec. 2, 1999	Bonding, Electrical, and Lightning Specifications Document * Ref. Para. 8.4.1, 8.4.1.1, 8.4.1.2.2, and 8.4.1.2.3.1

Industry

ANSI Y14.5 1982	Dimensioning and Tolerancing *Ref. Fig. 3.4.2.4-1

* All asterisk (*) reference paragraphs listed refer to this IDD

2.2 Boeing Drawings and Specifications

All part numbers listed in this ICD beginning with the following prefix: V602-, V646-, V070- or V733- and all specification numbers beginning with the following letters: MA, MC, MD or ME are Boeing documents pertaining to drawings peculiar to the specific Middeck payloads.

2.3 International Latex Corporation ILC Drawings

All part numbers listed in this ICD beginning with the number (s) 10108-XXXXX are ILC drawings.

3.0 PHYSICAL INTERFACES

3.1 Geometric Relationships

3.1.1 Orbiter Crew Module (CM) Coordinate System

The Orbiter Crew Module coordinate system is as shown in Figure 3.1.1-1 as follows:

Origin:	In the Orbiter crew module plane of symmetry, 200 inches below the crew module reference plane and at crew module X station=0.
Orientation:	The X_{cm} axis is in the crew module plane of symmetry, parallel to and 200 inches below the crew module reference plane. Positive is from the nose of the vehicle toward the tail. The Z_{cm} axis is in the crew module plane of symmetry, perpendicular to the X_{cm} axis positive upward in landing attitude. The Y_{cm} axis completes a right hand system.
Characteristics	Rotating right-handed cartesian. The standard subscript is CM (E.G. X_{cm}).

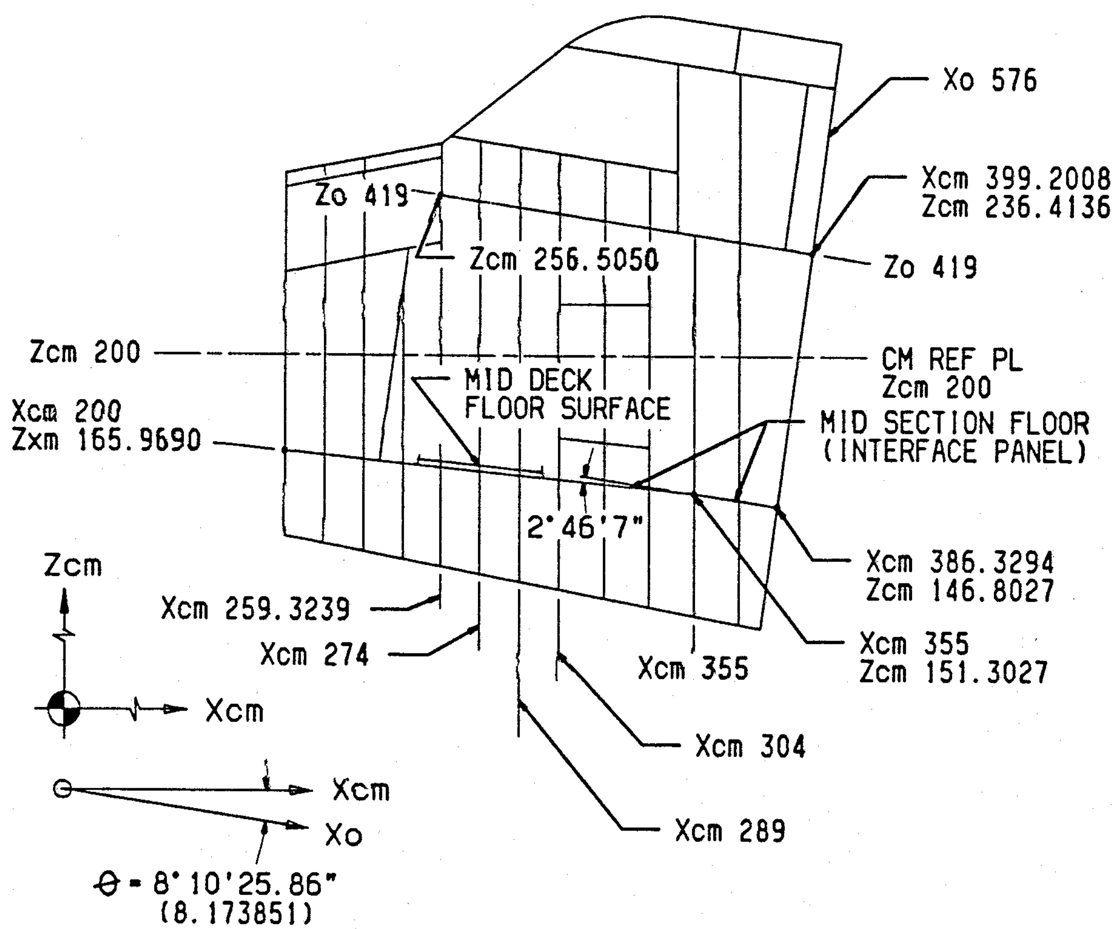
3.2 Dimensions and Tolerances

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: $\pm 0^0 \cdot 30'$



<u>Xo & Zo KNOWN, THEN</u>

$$X_{cm} = \cos\theta * X_o + \sin\theta * Z_o - 230.5199739$$

$$Z_{cm} = -\sin\theta * X_o + \cos\theta * Z_o - 96.4358496$$

<u>Xcm & Zcm KNOWN, THEN</u>

$$X_o = \cos\theta * X_{cm} - \sin\theta * Z_{cm} + 214.4671943$$

$$Z_o = \sin\theta * X_{cm} + \cos\theta * Z_{cm} + 128.2308622$$

FIGURE 3.1.1-1
ORBITER CREW MODULE COORDINATE SYSTEM

3.3 Structural Interfaces

Payloads may be located in the Middeck in the following areas as illustrated in Figure 3.3-1.

a. Aft surface of wire trays of Avionics Bays 1 and 2

b. Forward surfaces of wire trays of Avionics Bay 3A

3.3.1 Avionics Bay Locations

Payloads shall use the provisions in Section 3.4 to mount in Avionics Bays 1, 2, and 3A. Availability of specific locations for payload use is pursuant to amount of ducted and non-ducted air cooling, and power required by the individual middeck payloads, mission profile and its length, the size of Orbiter crew, and amount of crew equipment to be stowed in Standard Stowage Lockers at these locations. Ducted air cooled payloads shall utilize the active air cooling Orbiter outlet ducts provided in the locations shown in Figure 3.3-1 for avionics Bays 1, 2, and 3A. The available ducted locations shall be dependent upon standard available mission air flow configuration options as defined in Section 6. A single outlet duct may support either a single or double size payload. Double size payload location accommodations shall be dependent upon avionics bay wire tray weight carrying capability at a given location (Reference Section 4.0).

3.4 Middeck Payload Provisions

Middeck payload mounting provisions shall consist of SSP provided locker accommodations or mounting panels, which are defined as Payload Mounting Panels, Vented Payload Mounting Panels, Single Panels, Single Adapter Plates, or Double Adapter Plates. The SSP shall provide the mounting panels that interface directly to the avionics bay wire trays. Payloads shall not be designed to interface directly with the avionics bay wire trays. Standard modular stowage locker accommodations consist of stowing the payload hardware in vibration isolating foam inside a standard middeck stowage tray, which is installed inside a standard Modular Stowage Locker. The Payload stowage configuration within the tray and locker is controlled by the (SSP).

3.4.1 Standard Modular Stowage Locker

A standard Modular Stowage Locker provides approximately 2 cubic feet of stowage volume as shown in Figure 3.4.1-1. The standard Modular Stowage Locker has provisions for either one large stowage tray or two small stowage trays. Payloads that cannot be stowed inside trays shall be stowed directly in a locker with isolation material between the locker and the payload. The isolation material (Pyrell or similar material) shall have a minimum thickness of 0.5 inch and be compressed 25%. The payload will have a zero “g” retention to prevent equipment from floating out of the tray/locker during on-orbit activities.

3.4.1.1 Standard Stowage Trays

Two sizes of standard stowage trays are available to payloads. Large stowage trays provide 0.85 cubic feet of volume as shown in Figure 3.4.1.1-1. A large tray weight is approximately 3.4 pounds and a small tray weight is approximately 2.45 pounds.

In addition to payload equipment being packaged in trays using foam inserts as described in Section 3.4, the standard stowage tray may have non-structural plastic tray dividers dividing the trays into halves, quarters, eighths or sixteenths. SSP provided elastic restraints may be used with or without dividers to prevent equipment from floating out when lockers are opened on-orbit.

3.4.1.2 Modified Locker Access Door

Payloads which are stowed inside a standard stowage locker and require access for power or cooling shall use a modified locker door. A modified locker door has three removable panels as defined in Figure 3.4.1.2-1. All unique panels shall be payload supplied.

3.4.2 Mounting Panels

Payloads heavier or of a larger size than those that can be accommodated by a standard stowage locker can be mounted via single Adapter Plates, Double Adapter Plates, Payload Mounting Panels, and Vented Payload Mounting Panels. Payload base plate thickness shall be 0.25 inch.

3.4.2.1 Single Adapter Plate

Payloads may be attached directly to a single adapter plate using universal hole pattern for attachment. Maximum payload envelope and attaching hole pattern are defined in Figure 3.4.2.1-1. Payloads shall not protrude more than 20.312 inches along the X_{cm} axis from the face of the adapter plate. Single adapter plate weight is 6.2 pounds and its thickness is 0.750 inches.

3.4.2.2 Double Adapter Plate

The payloads heavier or of a larager size than those that can be accommodate inside a standard stowage locker or attached to a single adapter plate or a payload mounting panel shall be attached to a double adapter plate. The double adapter late has a universal hold pattern for payload attachment. Maximum payload envelope and attaching hole pattern are defined in Figure 3.4.2.2-1. Double adapter plate weight is 15 pounds, and its thickness is 0.875 inches.

Double adapter plates attach to two single adapter plates or to two payload mounting panels installed one above the other to the avionics bay structure interface as shown in Figure 3.4.2.2-2. If the double adapter plate is mounted to two single adapter plates, the payload shall not protrude more than 19.437 inches along the Xcm axis from the face of the double adapter plate. If the double adapter plate is mounted to two payload mounting panels, the payload shall not protrude more than 19.687 inches along the Xcm axis from the face of the double adapter plate.

3.4.2.3 Payload Mounting Panel

Payloads may be attached directly to a payload mounting panel or directly to two payload mounting panels, thus eliminating the need for a double adapter plate. The hole patterns and mounting methods are defined in Figure 3.4.2.3-1. Payloads shall not protrude more than 20.562 inches along the Xcm axis from the face of the mounting panel. A single payload mounted panel weight is 3.5 pounds with a thickness of 0.500 inches.

3.4.2.4 Vented Payload Mounting Panel

The VPMP is designed to accommodate payloads with heat dissipation and/or temperature control requirements that exceed the Shuttle middeck cabin air allowables specified in section 6.0 Thermal Interface. Payloads may be mounted directly to either one or two VPMP's, depending on the payload footprint , weight requirements and/or air circulation configuration. Section 6.0 Thermal Interface defines the orbiter's provisions & requirements for payload rear air cooling. Shuttle makes three configurations available for supply and return air port locations for the double sized payloads, reference Paragraph 3.8.2.

The VPMP physical interface is defined in figures 3.4.2.4-1. Payload weight and center of gravity allowables are defined in Section 4.8 Interface Loads. A single VPMP weighs 4.0 pounds and is considered part of the allowable payload weight. The hole mounting pattern differs from that provided in the single or double adapter plates. Payload fastener details/requirements are found in paragraph 3.4.2.5.

The payload maximum static envelope in the Xcm axis is 20.562 inches from the face of the VPMP.

The payload sealing surface must extend beyond the nominal seal width by 0.050 inches on both sides of the seal to accommodate fastener float as shown in Figure 3.4.2.4-1.

The VPMP features payload alignment pin hole locations which may be used for mounting assistance.

3.4.2.5 Adapter Plate Interface/Attachment Hardware

Attachment hardware for attaching to the avionics bay structure is integral to the locker, adapter plates, payload mounting panels, and vented payload mounting panels. Attachment hardware required for payload installation to the adapter plates or mounting panels shall be dependent upon whether or not payloads have planned on-orbit transfers as defined in the following paragraphs.

3.4.2.5.1 Attachment Hardware - Payloads Without Planned On-Orbit Transfers

For payloads without planned on-orbit transfers, the attachment points on the payload for securing to an adapter plate, payload mounting panel, or vented payload mounting panel shall be designed per Figure 3.4.2.5.1-1. This requirement will allow the use of SSP-supplied corrosion resistant bolts (NAS-1954C) for flight installation. The mounting Bolt holes of the payload must be $\pm$ .0312 inch diameter to provide bolt installation clearance.

3.4.2.5.2 Attachment Hardware - Payloads with Planned On-Orbit Transfers

For payloads with planned on-orbit transfers, the attachment points on the payload for securing to an adapter plate, payload mounting panel, or vented payload mounting panel shall be payload supplied and shall be designed per the following requirements:
The payload mounting bolts shall be:

- Required for flight installation,
- Payload supplied,
- Compatible with Shuttle provided inserts, part number NAS1394CA4 for PMPs. VPMP's have floating inserts, part number ME 115-0070-1004 and fixed inserts, part number NAS1394CA4 as shown in Figure 3.4.2.4-1.
- Captive,
- Retractable (spring loaded away from the mounting plane) and flush or recessed behind the mounting plate when not engaged.
- Installed to an installation torque of 50 to 75 inch pounds.

The payload mounting bolts shall have the following:

- Silver plating and self-locking feature per MIL-DTL-18240
- A maximum penetration into the adapter plate, PMP or VPMP equal to 0.480 inches,
- A minimum diametric float capability of 0.040 inches for single payloads, 0.060 inches for double payloads, and
- A 3/16 inch internal hex Allen head screw tool interface.

3.4.2.6 Mounting Access

When payloads are attached to single adapter plates, double adapter plates, payload mounting panels, or vented payload mounting panels, clearances shall be provided for the tool to engage the payload mounting bolts from the cabin. Minimum clearance required shall be bolt head diameter plus 0.12 inches radius minimum clearance.

3.4.2.7 On-Orbit Separation Interface Requirements

For those payloads with planned on-orbit transfers, the on-orbit separation interface shall be between the payload and the adapter plates, payload mounting panel, or vented payload mounting panel. Payloads shall be designed to be installed or removed within 30 minutes. Payloads shall not require the use of special tools for payload removal unless the tool is supplied by the payload.

3.4.2.8 Closeout Cover Access

Standard closeout cover is SSP provided. The purpose of the closeout cover is to limit mixing between cabin and avionics bay air during ground and on-orbit installation/removal. Standard closeout cover accommodates payloads designed to be completely removed from the ventd payload mounting panel. Unique closeout cover may be required for payloads only partially installed/removed from vented payload mounting panel.

3.5 Payload/GSE Hard Points

GSE quick release pin T and U handles are available as GFE, and payloads using this service shall provide hardware receptacles in accordance with Figure 3.5-1. Non-standard accommodations to install and remove payload provided equipment in the Middeck area shall be provided by the payload as required.

3.6 Fire Protection

Each payload display/control panel and/or electronics box shall have adequate provisions for fire protection. Each payload shall have in an accessible location a "fire hole", 0.500 inch in diameter, located so as to allow a fire extinguisher to be inserted for suppressing fire behind the panel. The hold shall be covered by a 0.75 inch diameter GFE decal placed over the fire hole.

3.7 Payload Envelope Protrusions

The payload static envelope dimensions for lockers cannot exceed the dimensions as shown in Figures 3.4.2.1-1, 3.4.2.2-1 and 3.4.2.3-1. Payload protrusions in the X-direction exceeding those as defined in paragraphs 3.4.2.1, 3.4.2.2, 3.4.2.3 and 3.4.2.4 shall require prior approval by SSP.

Payload items accessible to crew member contact must be designed to preclude sharp edges and protrusions per System Description and Design Data-Intravehicular Activities, NSTS 07700, Volume XIV, Appendix 9.

3.8 Orbiter Inlet/Outlet Locations for Ducted Air Cooled Payloads

A single outlet duct shall be allocated for either a single or double size payload. Ducted cooling configurations shall be limited to four allowable configurations, one for single and three for double, as identified in the following paragraphs.

Payloads shall located outlets on either side of the vented payload mounting panel cross member or shall provide fan performance that would overcome the obstruction if outlets are located directly over the cross member. Payloads shall locate their inlets and outlets on opposite halves of the payload.

3.8.1 Orbiter Inlet/Outlet Locations for Single Payload Accommodations

The Orbiter Inlet is the Payload air inlet (cold avionics bay air) and the Orbiter Outlet is the Payload air outlet (hot payload air). The Orbiter inlet and outlet locations for single payload accommodations shall be as shown in Figure 3.8.1-1.

3.8.2 Orbiter Inlet/Outlet Locations for Double Payload Accommodations

The Orbiter inlet and outlet locations for double payload accommodations shall be as shown in Figure 3.8.2-1. Specific Orbiter configurations of inlet and outlets shall be based upon double payload flow rate needs as defined in Paragraph 6.2.1.5.5.2.

For double size payloads with their air inlets and outlets on the top half of the payload, the air cooling interface shall be as shown in Figure 3.8.2-1 (Sheet 1 of 3). This configuration does not require a payload provided minimum gap.

For double size payloads with inlet on bottom half and outlet on top half of payload, the air cooling interface shall be as shown in Figure 3.8.2-1 (Sheet 2 of 3).

Sheet 2 of 3 configuration can be used if there is a minimum of 0.75 inch gap between the vented payload mounting panel and the payload to allow air recirculation from the plenum to air inlet. This gap may be part of payload design.

Sheet 3 of 3 shall be used if there is no payload provided minimum 0.75 inch gap.

3.9 Inter-Vehicular Activity (IVA) Transfer Pathway

Middeck payloads to be transferred to/from International Space Station (ISS) shall be limited to 18.125 (width) by 21.88 (depth) by 21.062 (length) dimensions due to IVA transfer pathway limitations. Payloads requiring handholds for transfer operation shall require a unique clearance assessment if they violate the maximum allowable dimensions.

3.10 Crew Restraints

Crew Restraints in the form of foot loops are provided by the Space Shuttle Program (SSP) for middeck payloads. The location is documented in the Crew Compartment Configuration Drawing (CCCD).

3.11 Overhead Window Interface Requirements

Payloads which require use of the starboard overhead window interface shall comply with the maximum payload envelope requirements defined in Figure 3.11-1. An interface frame shall be provided by the payload customer and shall meet the design requirements defined in Figure 3.11-1. The overhead window interface is designed for on-orbit use only, therefore, payload hardware (including the interface frame) shall be stowed during launch and landing and when not in use.

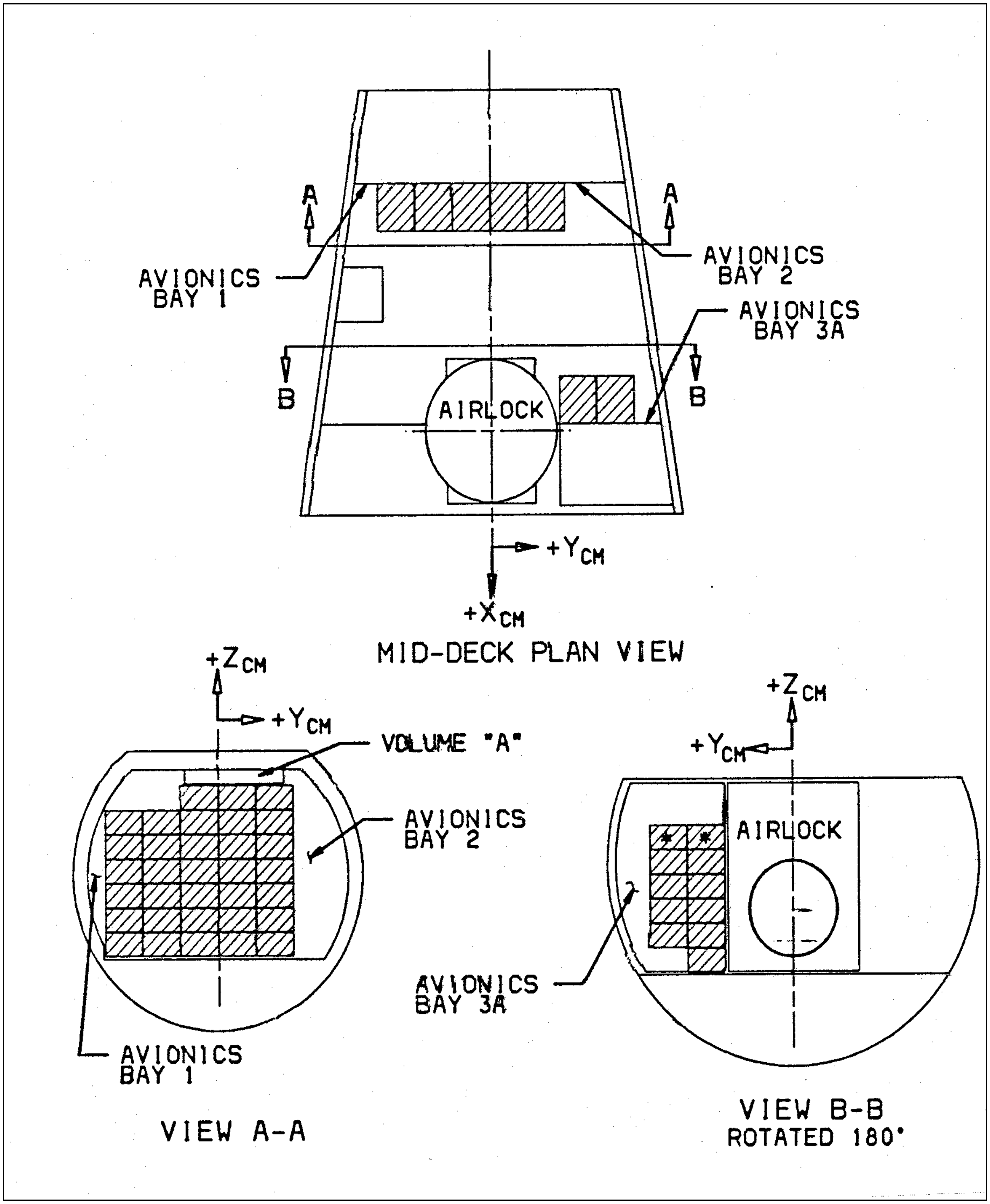


FIGURE 3.3-1 MIDDECK MODULAR LOCKER LAYOUT
(SHEET 1 OF 2)

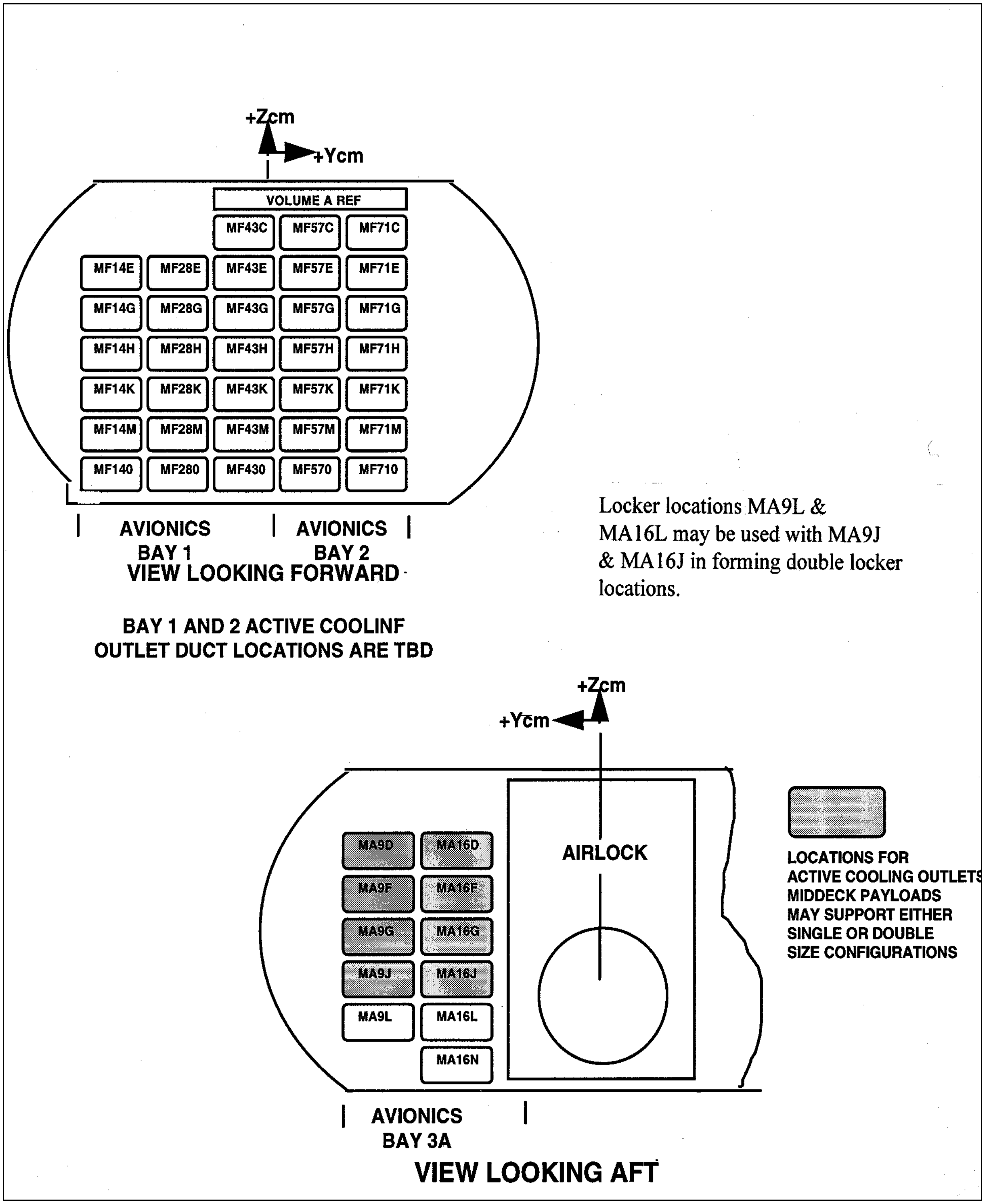
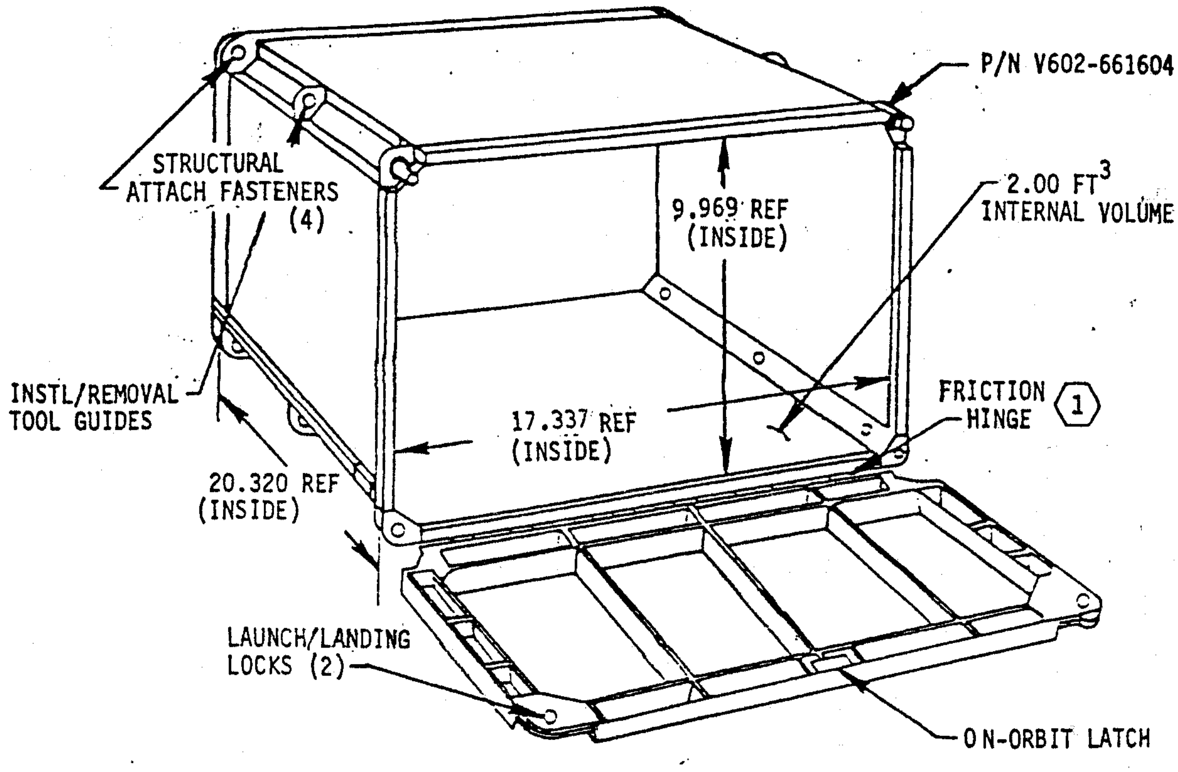


FIGURE 3.3-1 MIDDECK MODULAR LOCKER LAYOUT
(SHEET 2 OF 2)



NOTES:

1. MODULAR LOCKER HAS A MAXIMUM DESIGN DENSITY OF 30 LBS/FT^3, AND A MINIMUM OF 10 LBS/FT^3.

2. BASELINE LOCKERS ARE DESIGNED TO THE FOLLOWING CRITERIA:

   - THE LOCKER IS FULLY PACKED
   - THERE MUST BE ISOLATOR MATERIAL BETWEEN THE LOCKER WALLS AND THE CONTENTS

3. DOOR IS FLUSH WITH BOTTOM OF LOCKER WHEN OPENED 90° AND CAN OPEN 180° (STRAIGHT DOWN)

4. DOOR HAS FRICTION HINGE FOR ZERO-G OPERATION AND A MAGNETIC LATCH FOR TEMPORARY CLOSURE OF DOOR

FIGURE 3.4.1-1 STANDARD MIDDECK MODULAR LOCKER

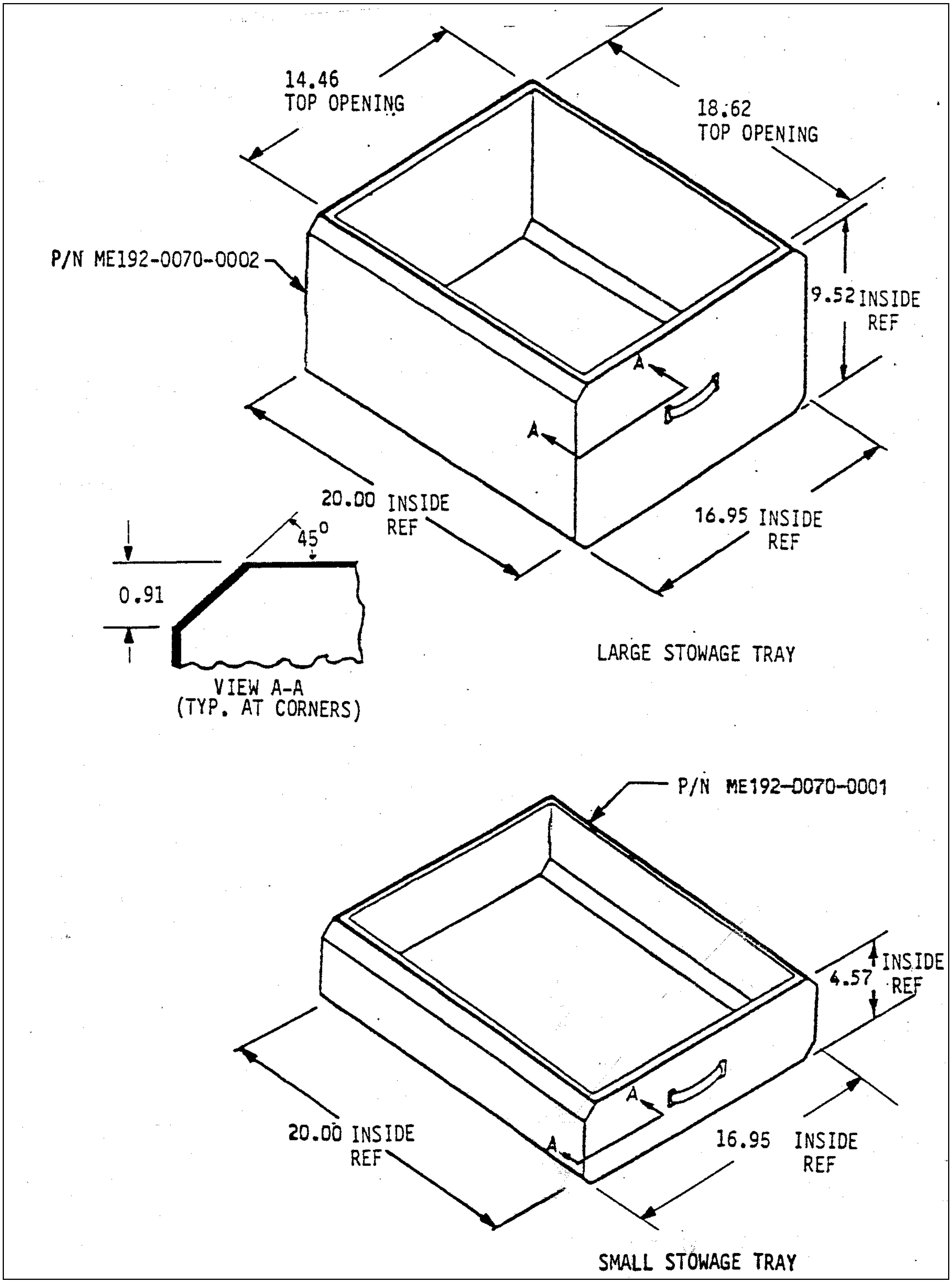


FIGURE 3.4.1.1-1 STANDARD STOWAGE TRAYS

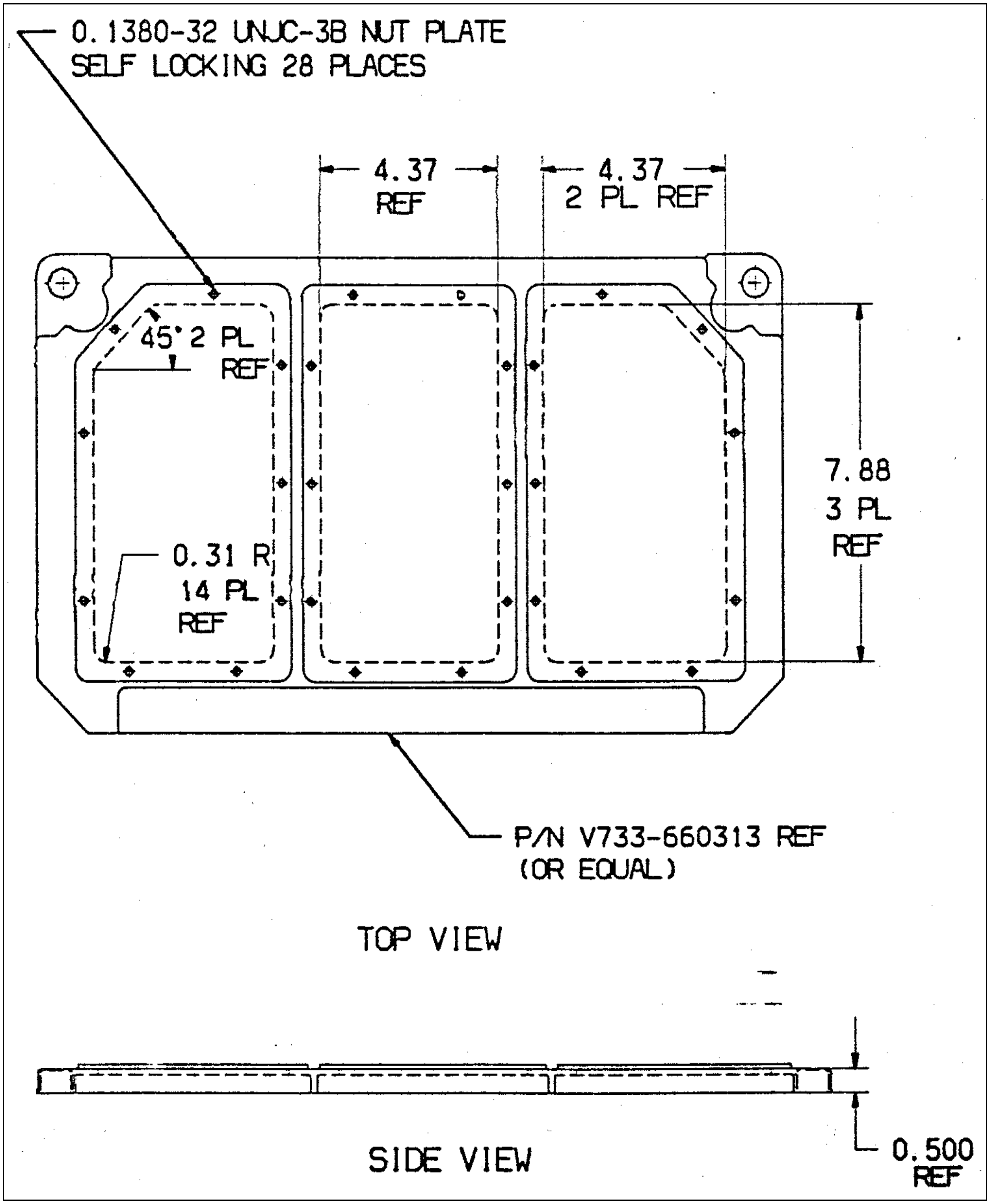


FIGURE 3.4.1.2-1 MODIFIED LOCKER ACCESS DOOR

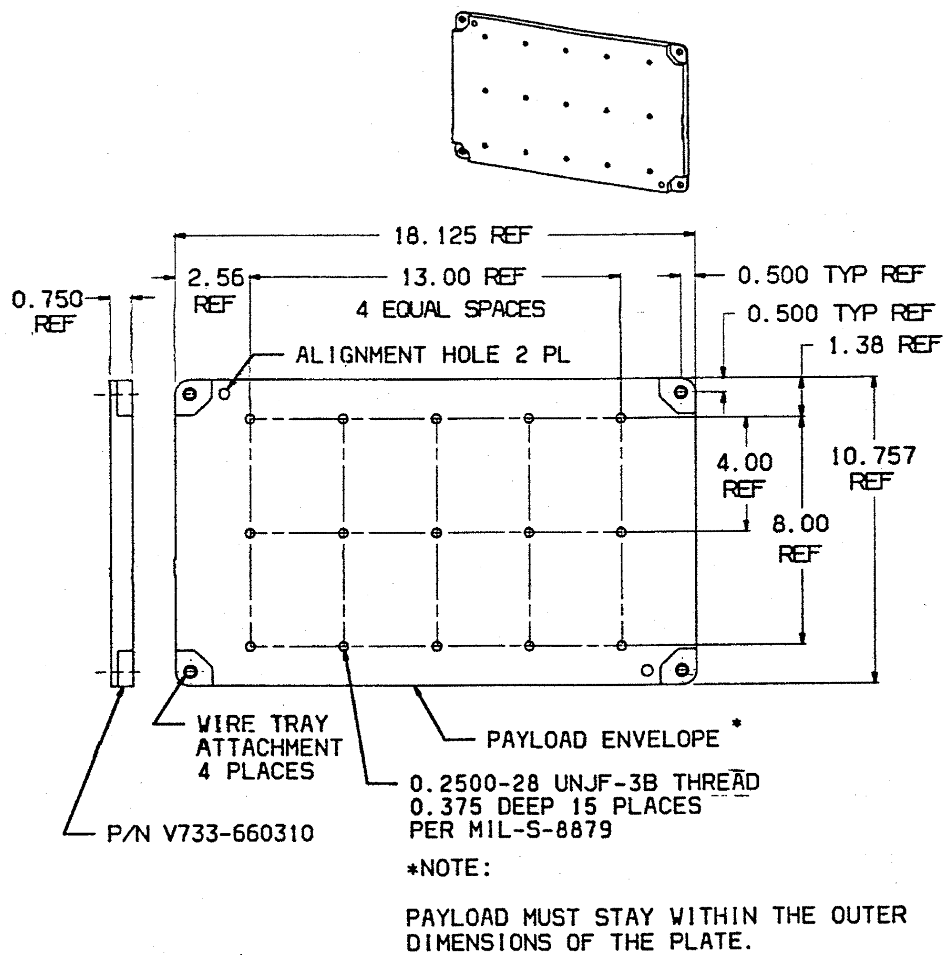


FIGURE 3.4.2.1-1 SINGLE ADAPTER PLATE

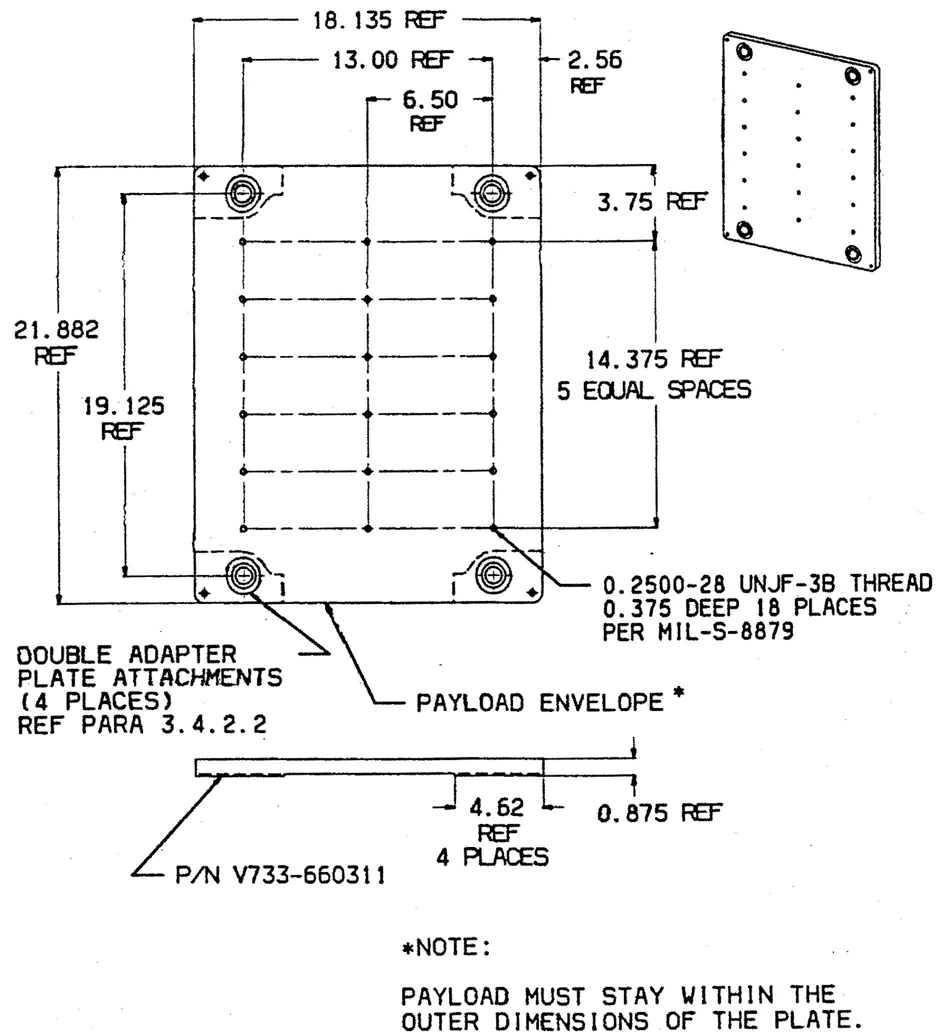


FIGURE 3.4.2.2-1 DOUBLE ADAPTER PLATE

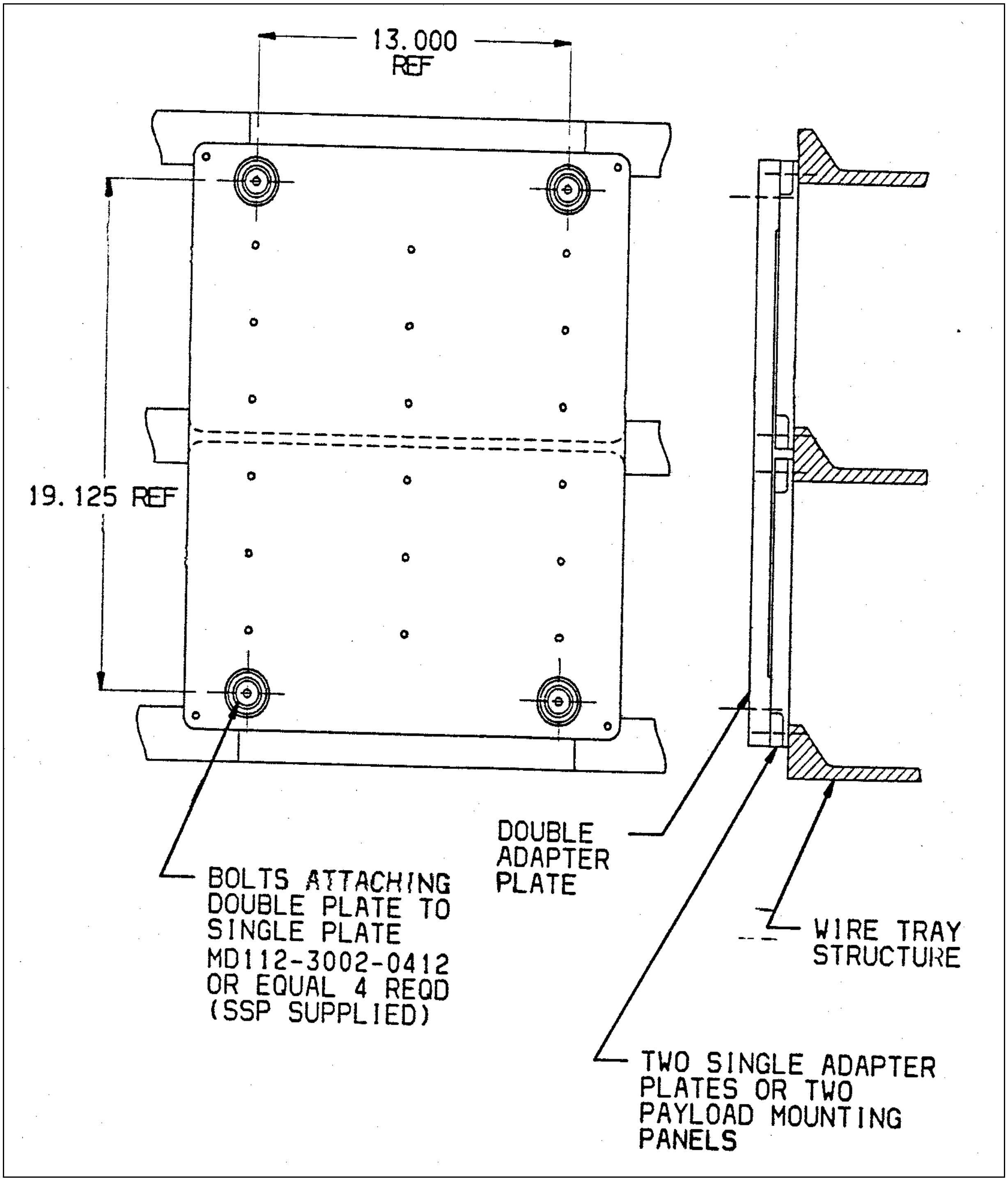


FIGURE 3.4.2.2-2 DOUBLE ADAPTER PLATE ATTACHMENT TO WIRE TRAYS

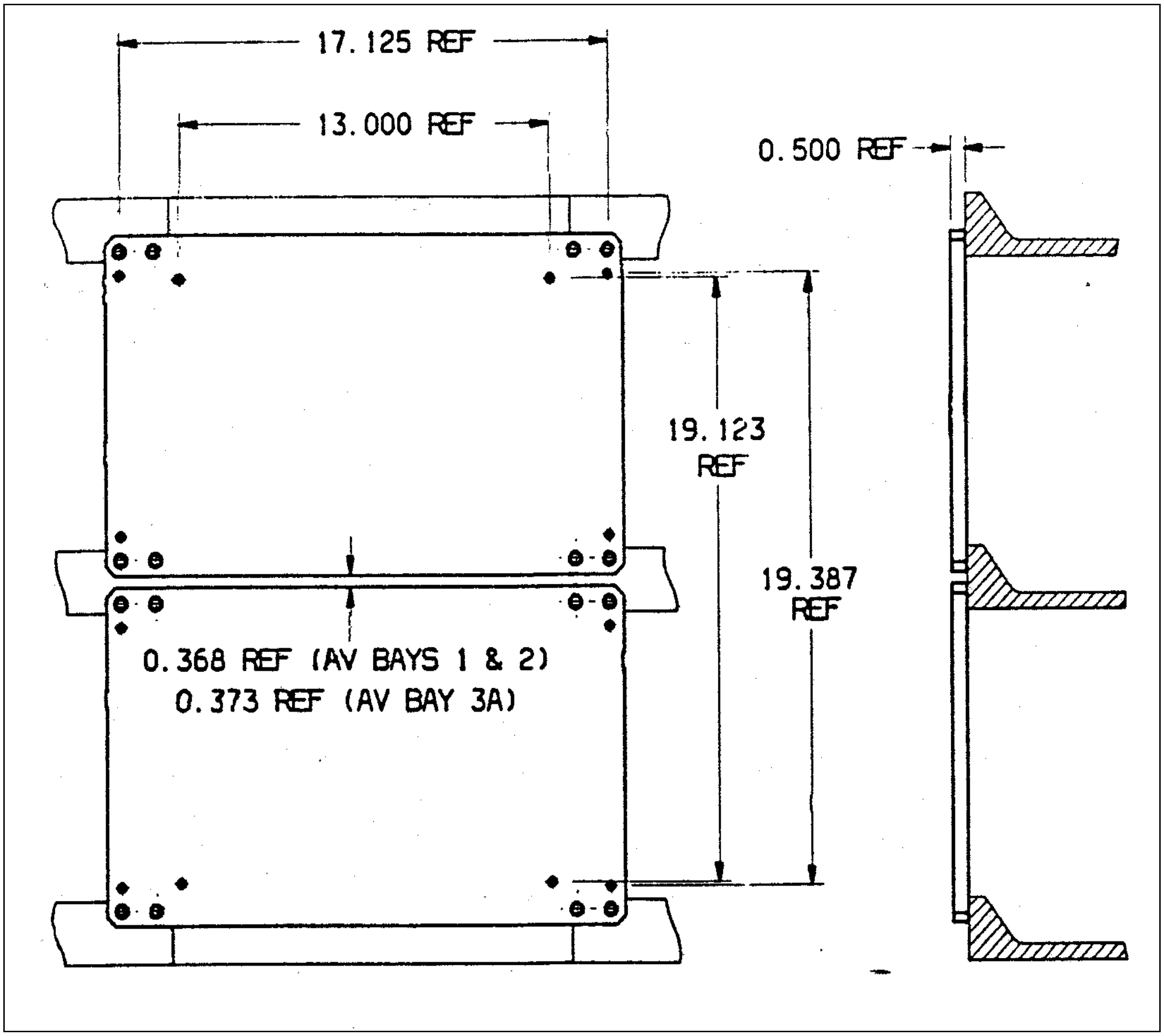


FIGURE 3.4.2.3-1 PAYLOAD MOUNTING PANEL
(SHEET 1 OF 2)

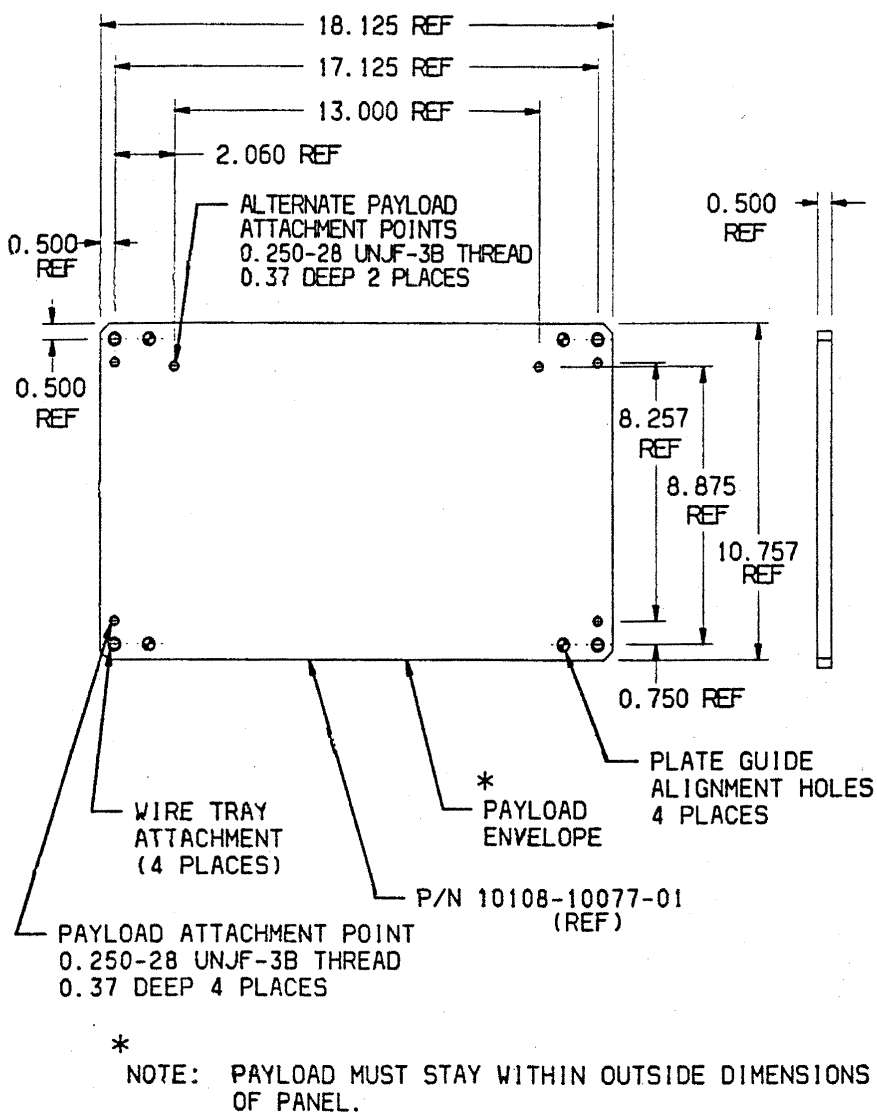
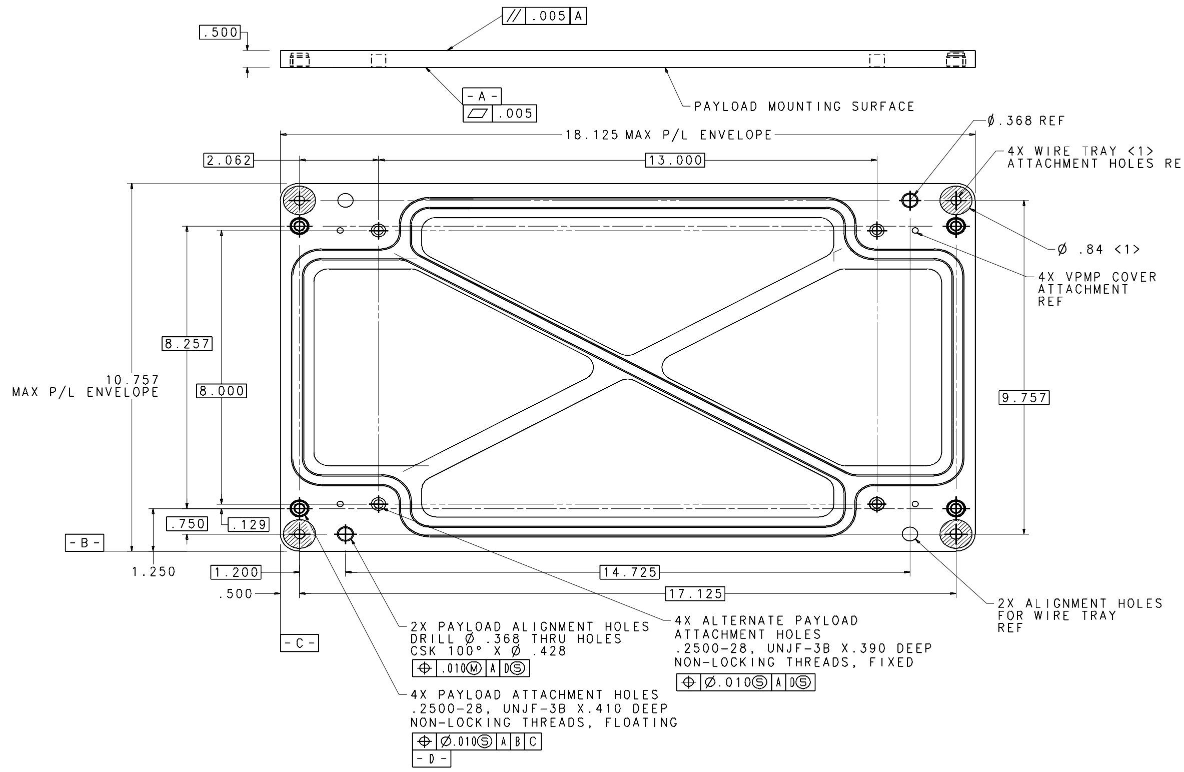


FIGURE 3.4.2.3-1 PAYLOAD MOUNTING PANEL
(SHEET 2 OF 2)



NOTES:
- PAYLOAD MUST STAY WITHIN OUTSIDE DIMENSIONS OF PANEL.
- <1> SHADED AREA IS FOR REFERENCE ONLY AND DEFINES THE AREA WHERE THE MILSON FASTENERS ARE LOCATED FOR ALL VPMP CONFIGURATIONS (STANDARD AND UNIQUE).
- REFERENCED HOLES ARE NOT PAYLOAD ACCESSIBLE
- DIMENSIONING & TOLERANCING PER ANSI Y14.5-1982

FIGURE 3.4.2.4-1 VENTED PAYLOAD MOUNTING PANEL
(SHEET 1 OF 3)

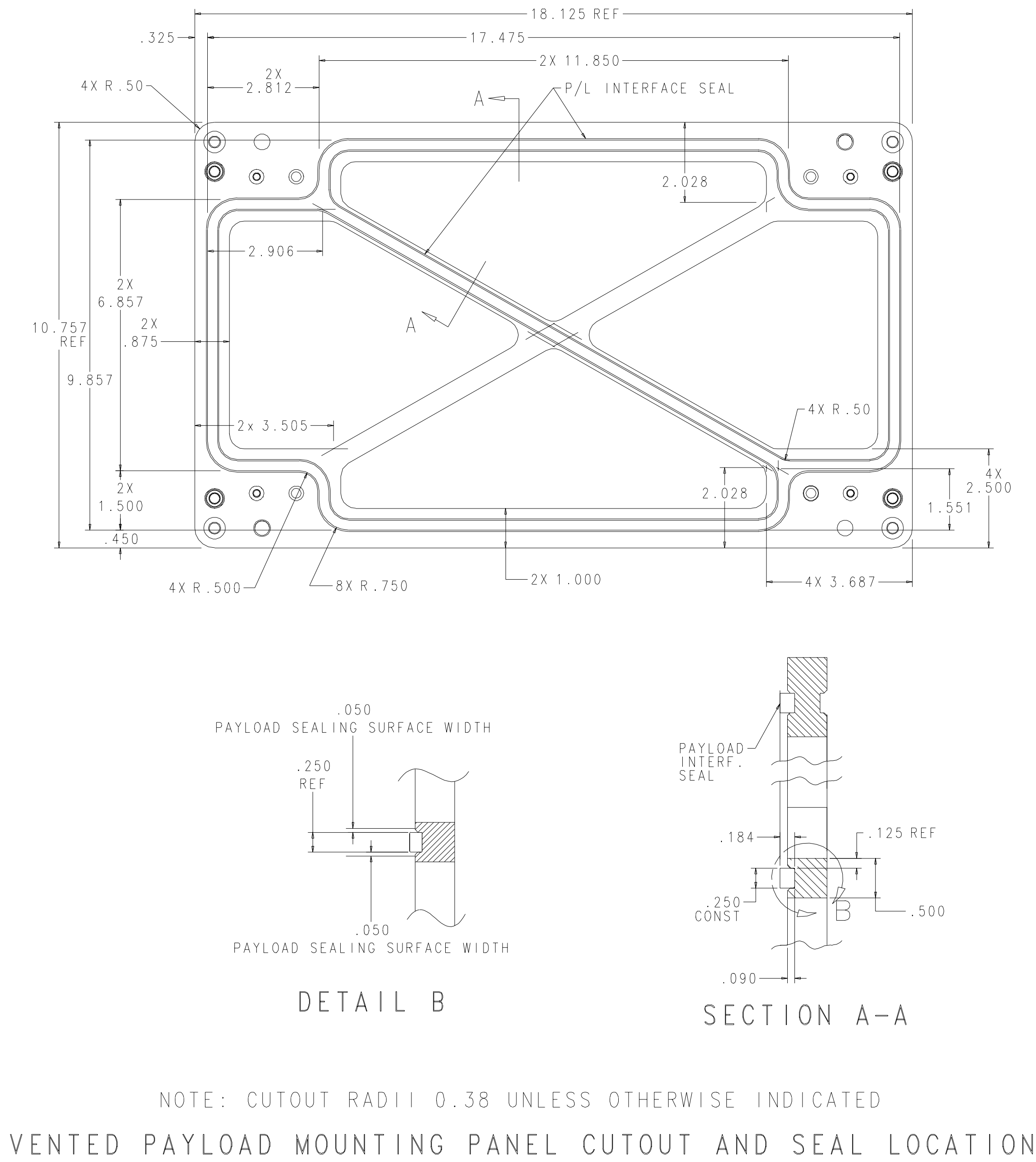
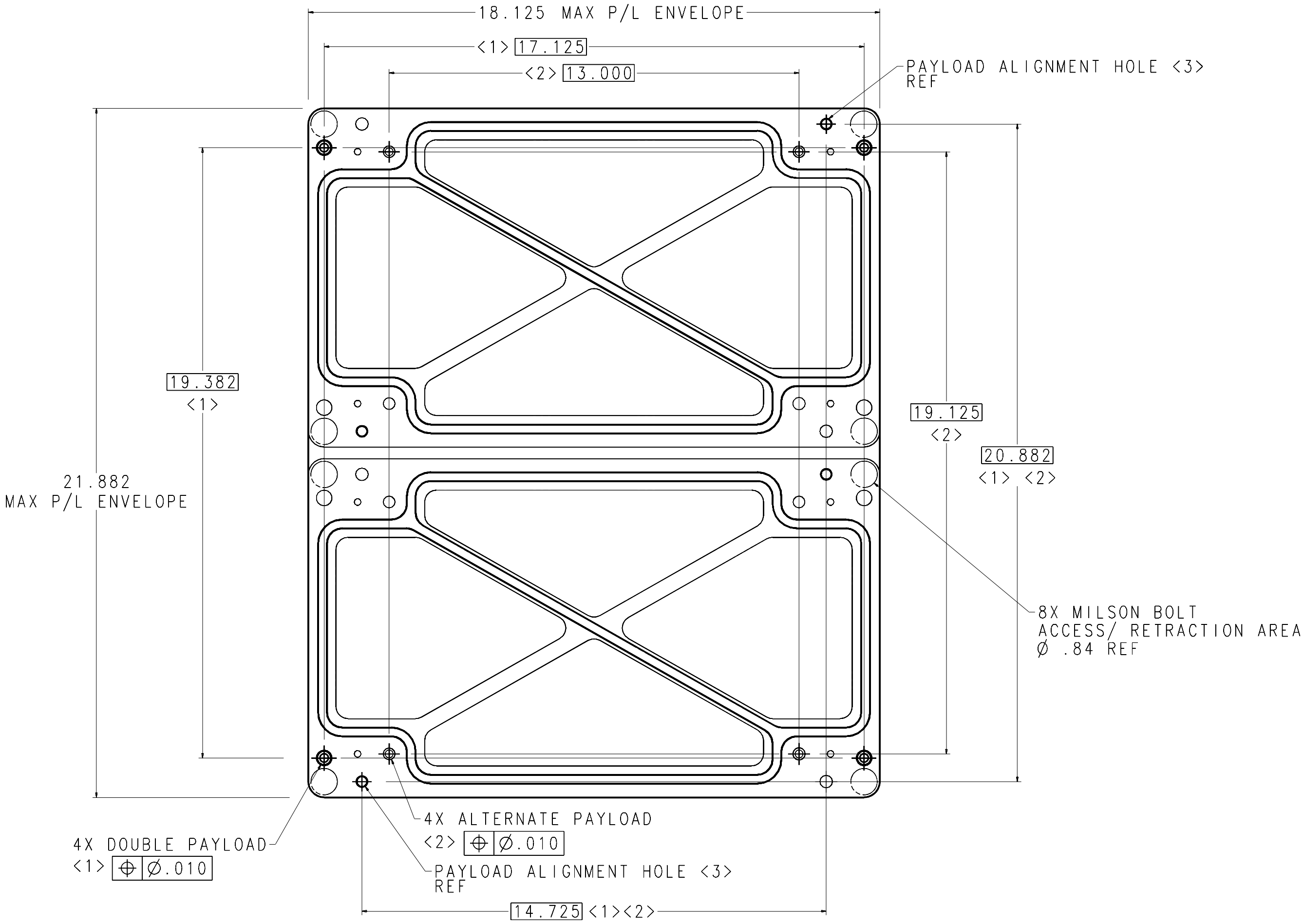


FIGURE 3.4.2.4-1 VENTED PAYLOAD MOUNTING PANEL
(SHEET 2 OF 3)



NOTES:
- <1> DIMENSION FOR ATTACH HOLE PATTERN ON DOUBLE PAYLOAD
- <2> DIMENSION FOR ATTACH HOLE PATTERN ON ALTERNATE PAYLOAD
- FOR CUTOUT, SEAL, GUIDE PIN HOLES, COVER ATTACHMENTS, PAYLOAD MOUNTING HOLES, MILSON ACCESS AREA, SEE SINGLE PAYLOAD VPMP.
- <3> GUIDE PIN ON DOUBLE P/L NOT TO EXCEED .250 DIA
- DIMENSIONING & TOLERANCING PER ANSI Y14.5-1982

DOUBLE PAYLOAD INTERFACE

FIGURE 3.4.2.4-1 VENTED PAYLOAD MOUNTING PANEL
(SHEET 3 OF 3)

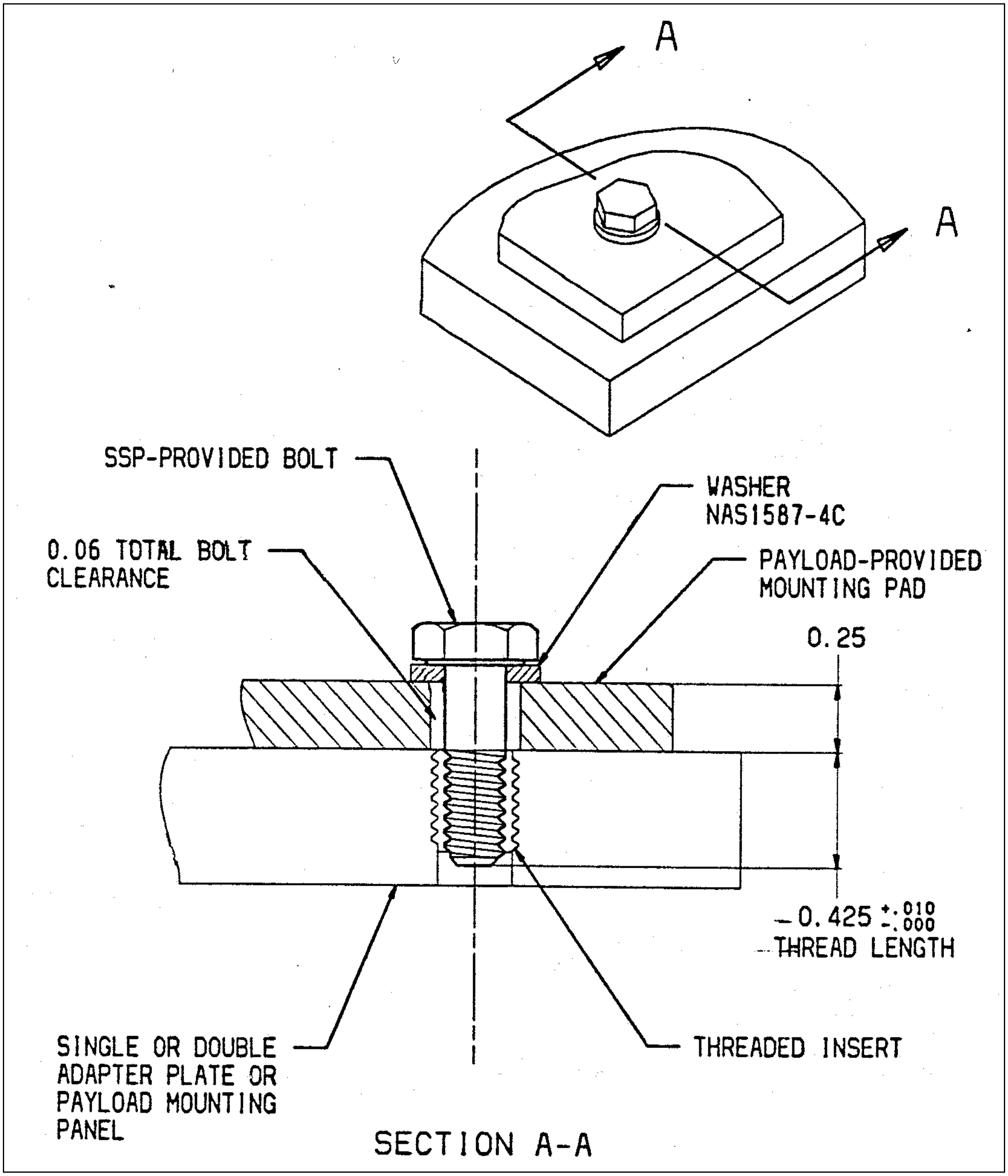


FIGURE 3.4.2.5.1-1 PAYLOAD/STS ATTACHMENT POINT DETAILS FOR NO PLANNED ON-ORBIT TRANSFER

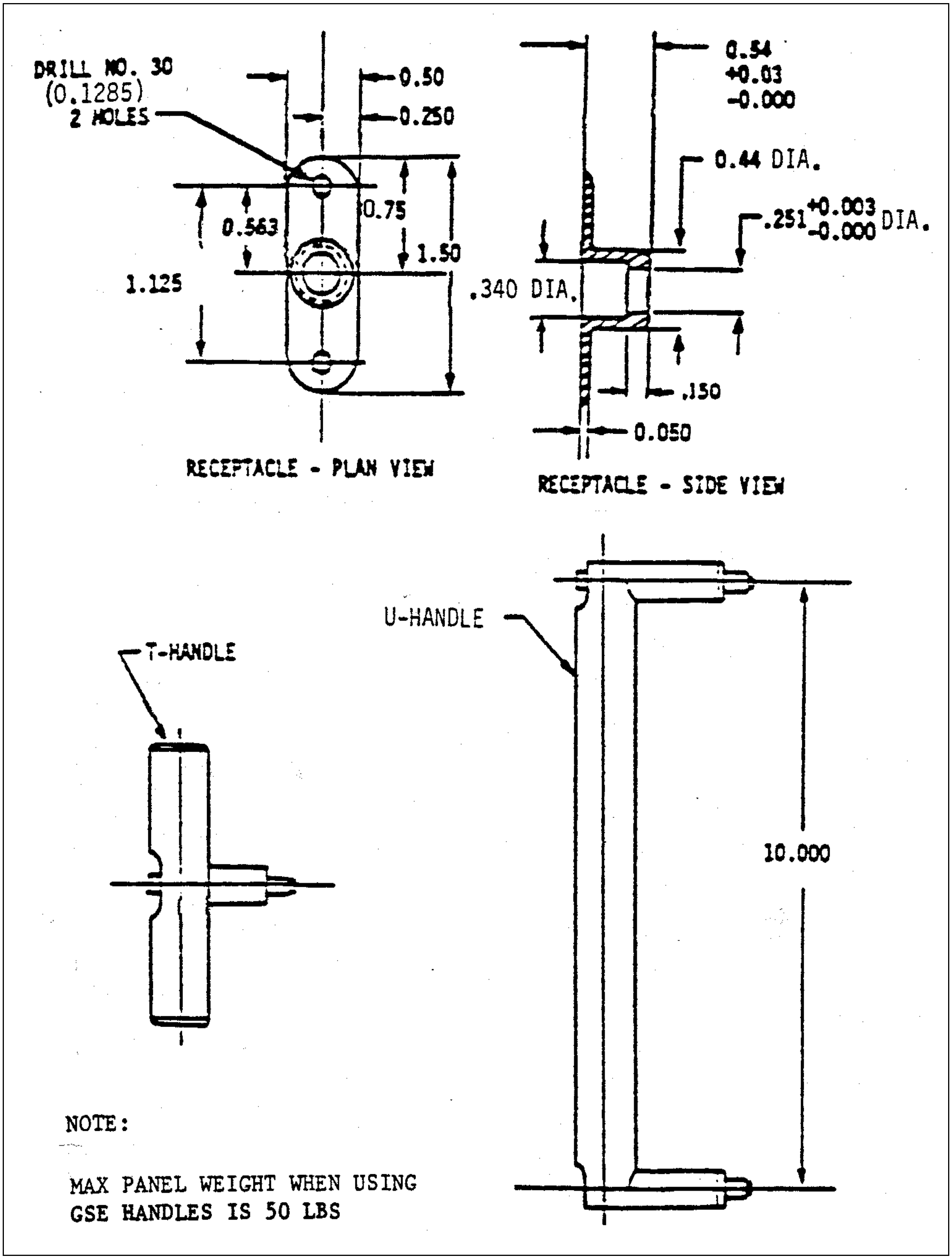


FIGURE 3.5-1 PAYLOAD/GSE HARD POINTS

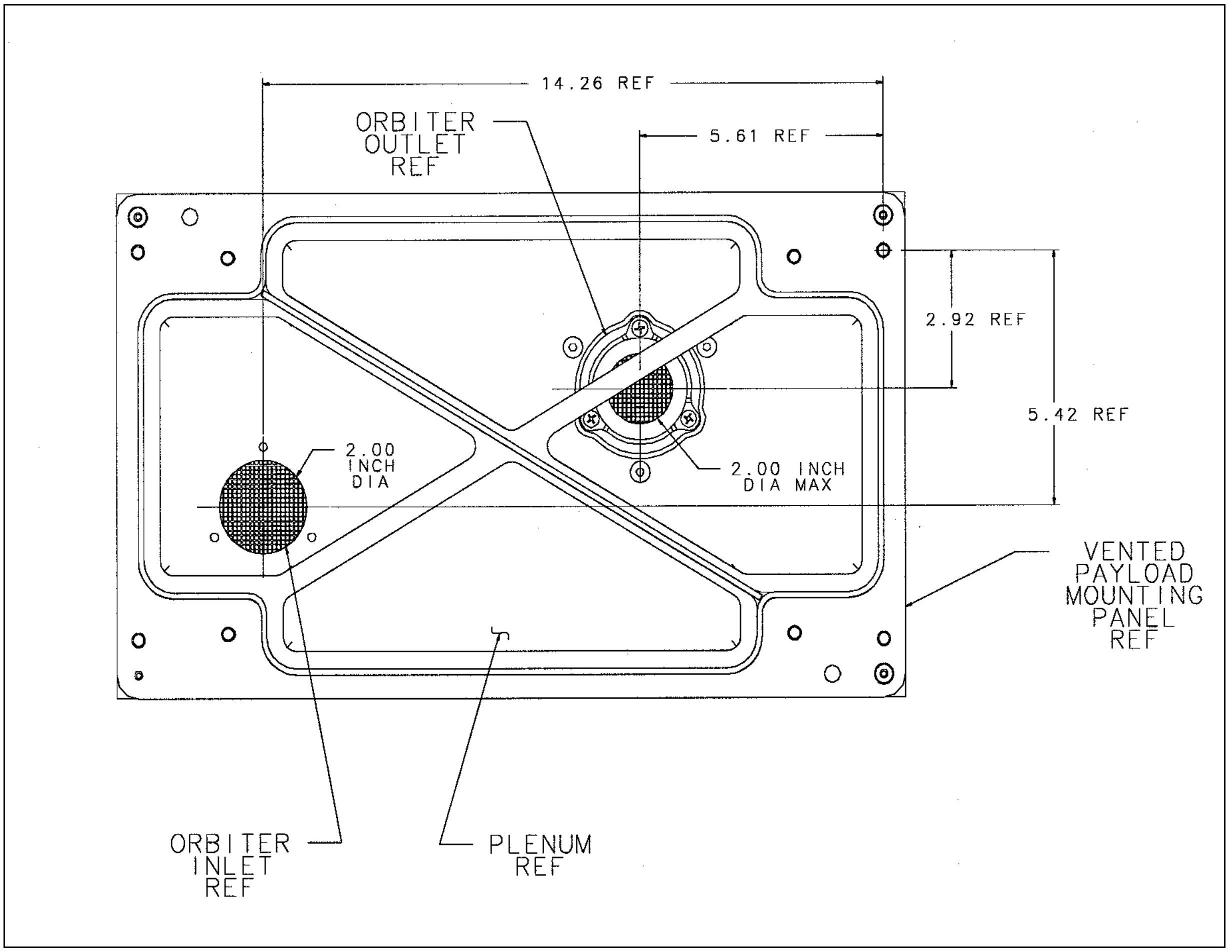


FIGURE 3.8.1-1 SINGLE PAYLOAD INLET/OUTLET INTERFACE PROVISIONS

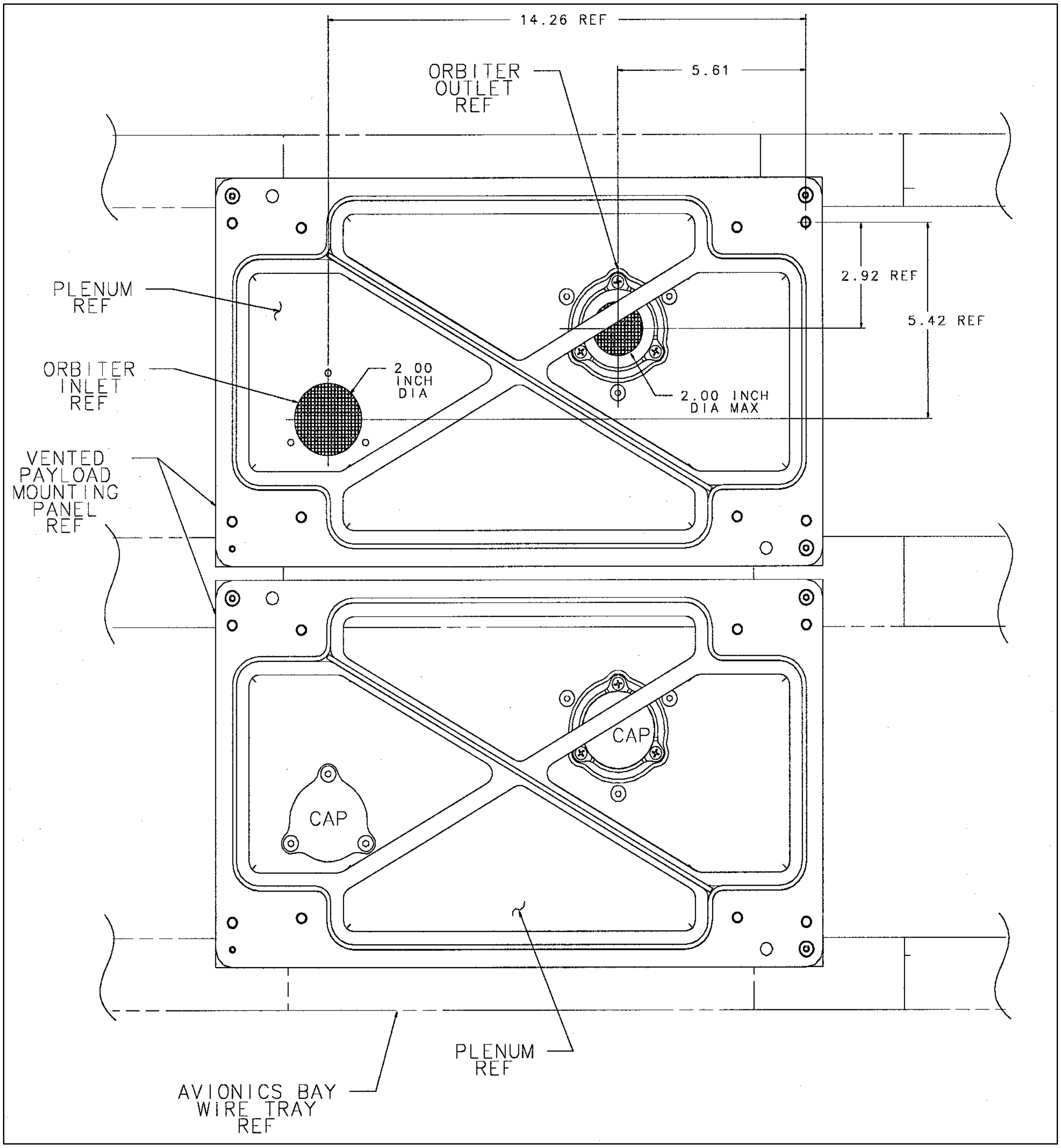


FIGURE 3.8.2-1 DOUBLE PAYLOAD INLET/OUTLET INTERFACE PROVISIONS
TOP HALF OF PAYLOAD INLET AND OUTLETS
(SHEET 1 OF 3)

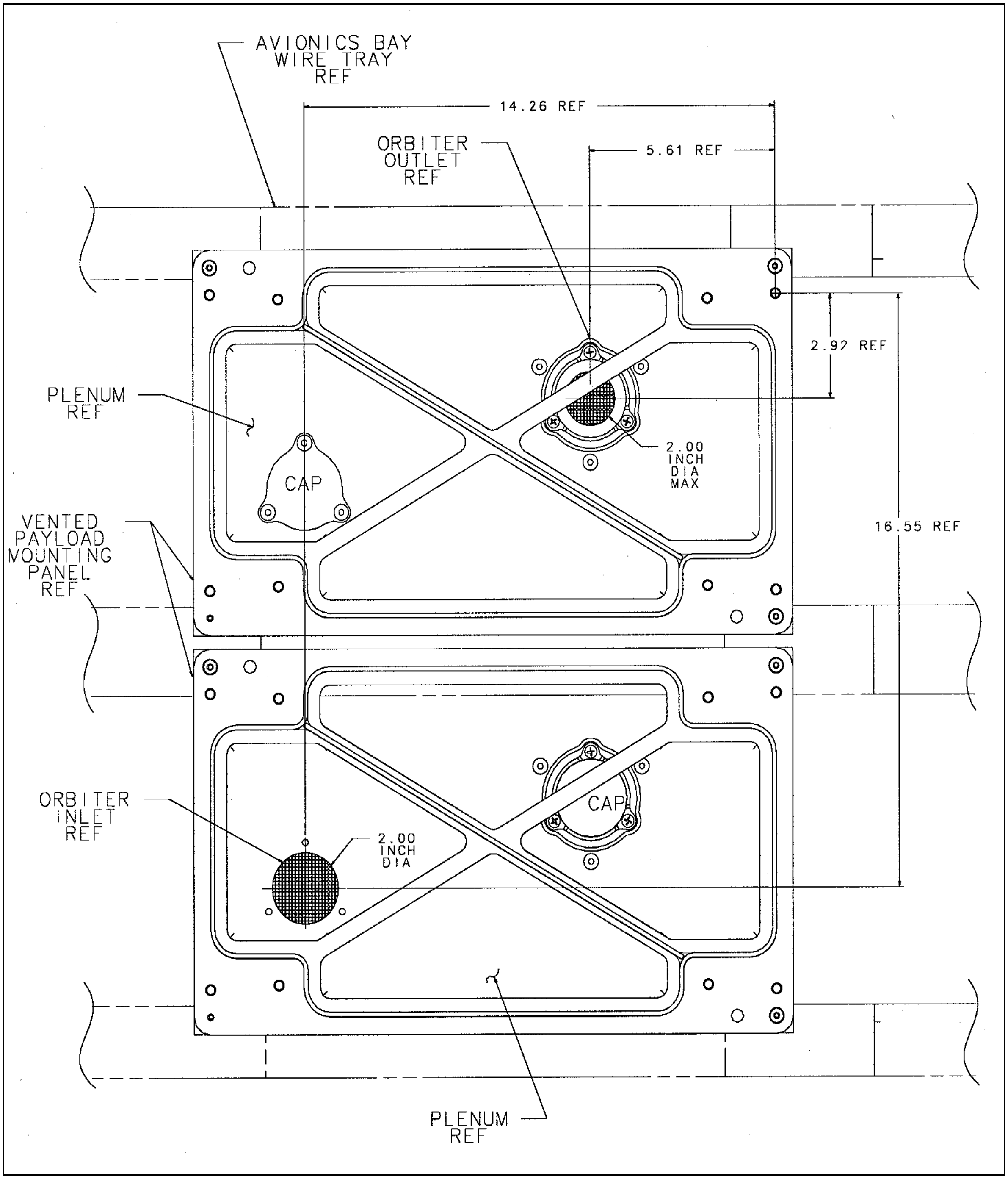


FIGURE 3.8.2-1 DOUBLE PAYLOAD INLET/OUTLET INTERFACE PROVISIONS (TOP HALF OF OUTLET/BOTTOM HALF OF INLET (MINIMUM 0.75 INCH RECIRCULATION GAP)
(SHEET 2 OF 3)

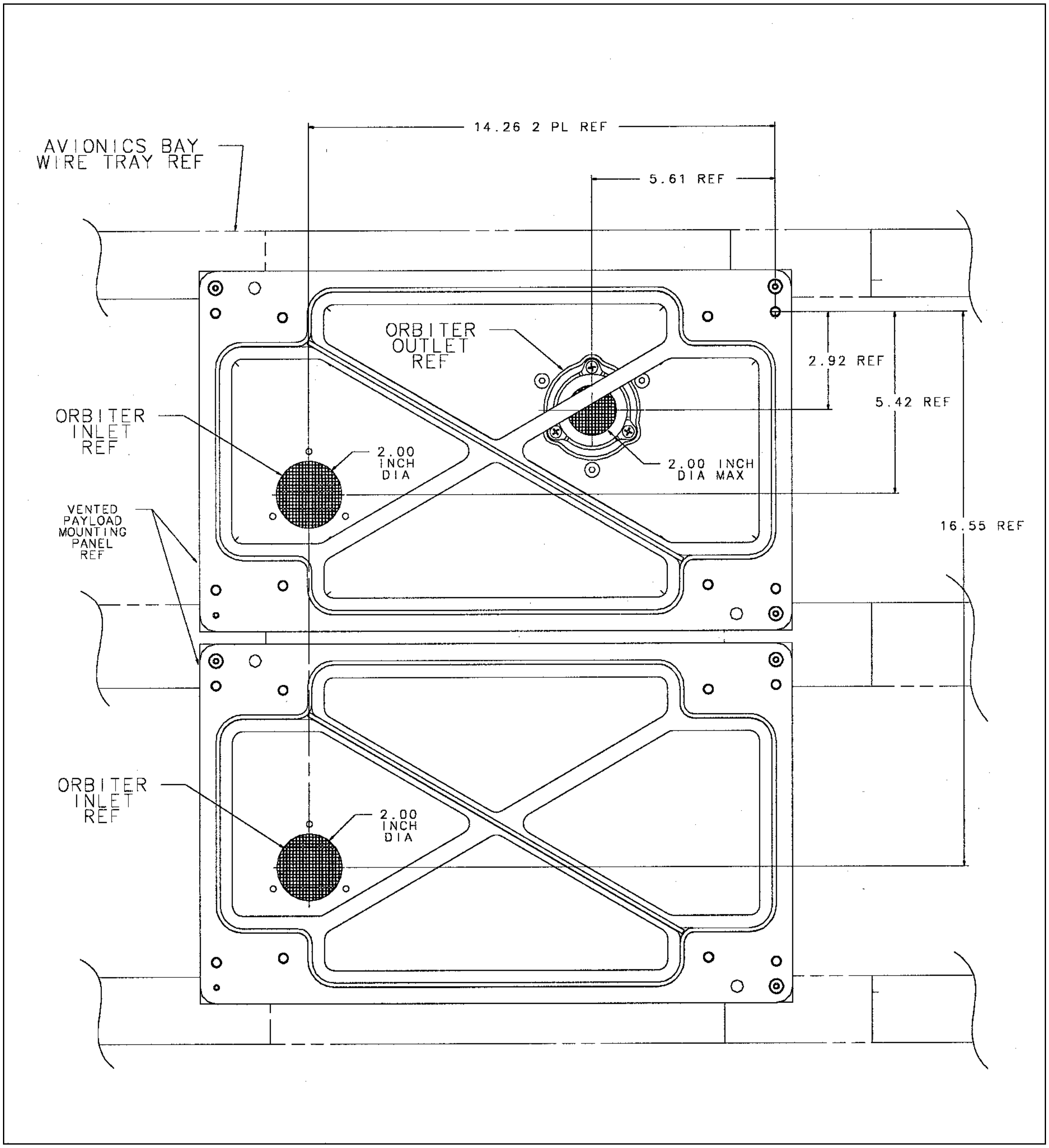


FIGURE 3.8.2-1 DOUBLE PAYLOAD INLET/OUTLET INTERFACE PROVISIONS - TOP HALF OF OUTLET/BOTTOM HALF OF INLET (NO MINIMUM 0.75 INCH RECIRCULATION GAP)
SHEET 3 OF 3)

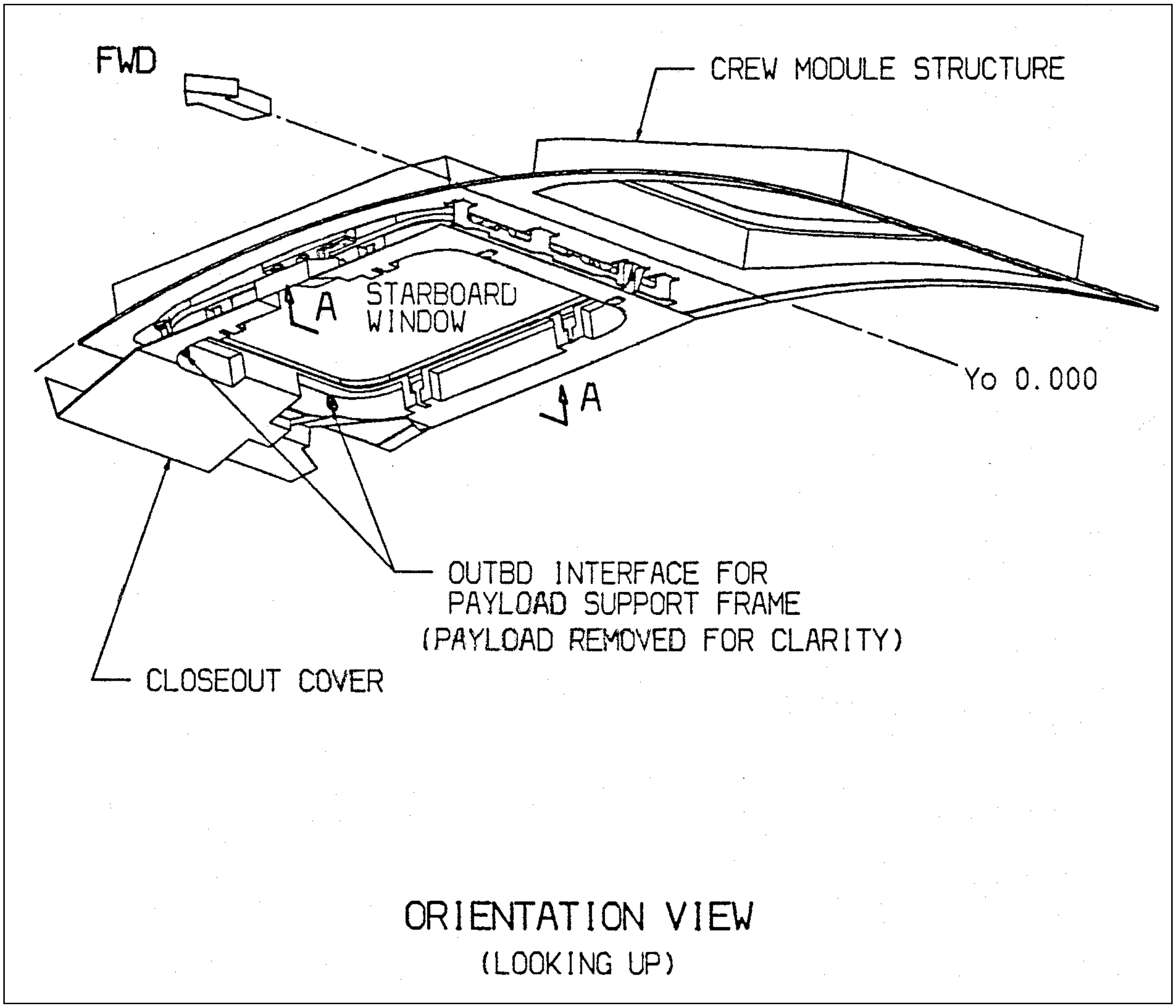


FIGURE 3.11-1 OVERHEAD WINDOW PAYLOAD REQUIREMENTS
(SHEET 1 OF 8)

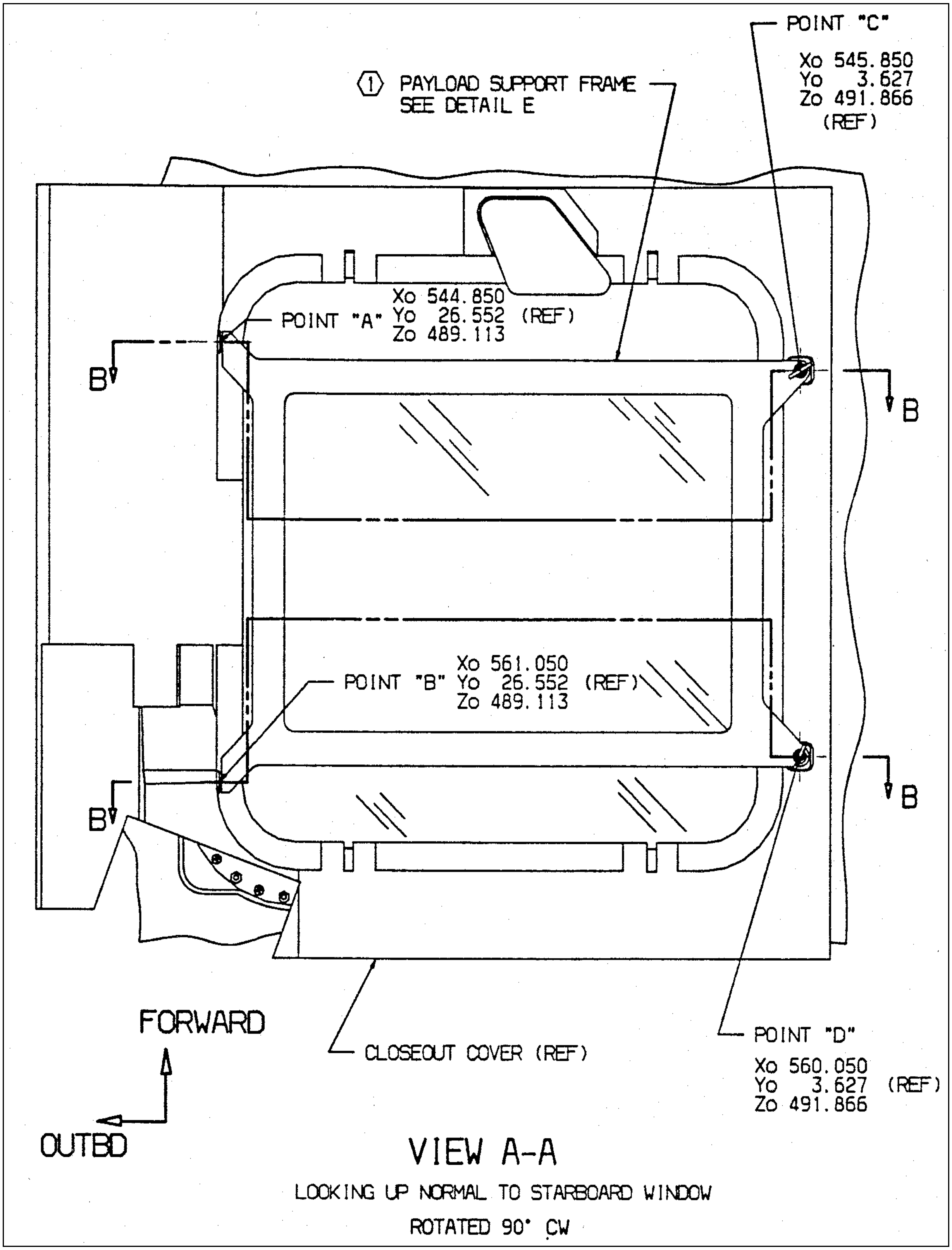


FIGURE 3.11-1 OVERHEAD WINDOW PAYLOAD REQUIREMENTS
(SHEET 2 OF 8)

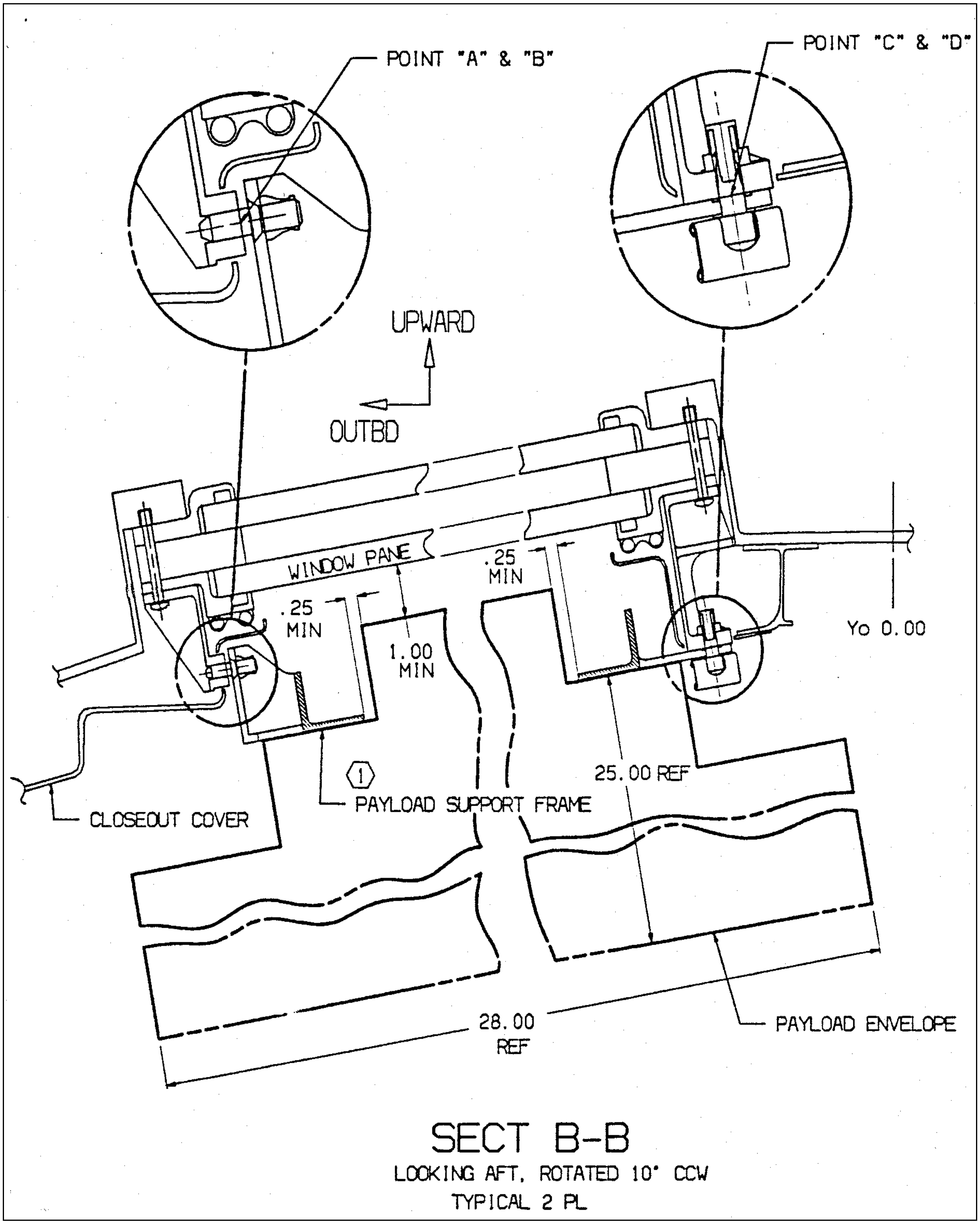


FIGURE 3.11-1 OVERHEAD WINDOW PAYLOAD REQUIREMENTS
(SHEET 3 OF 8)

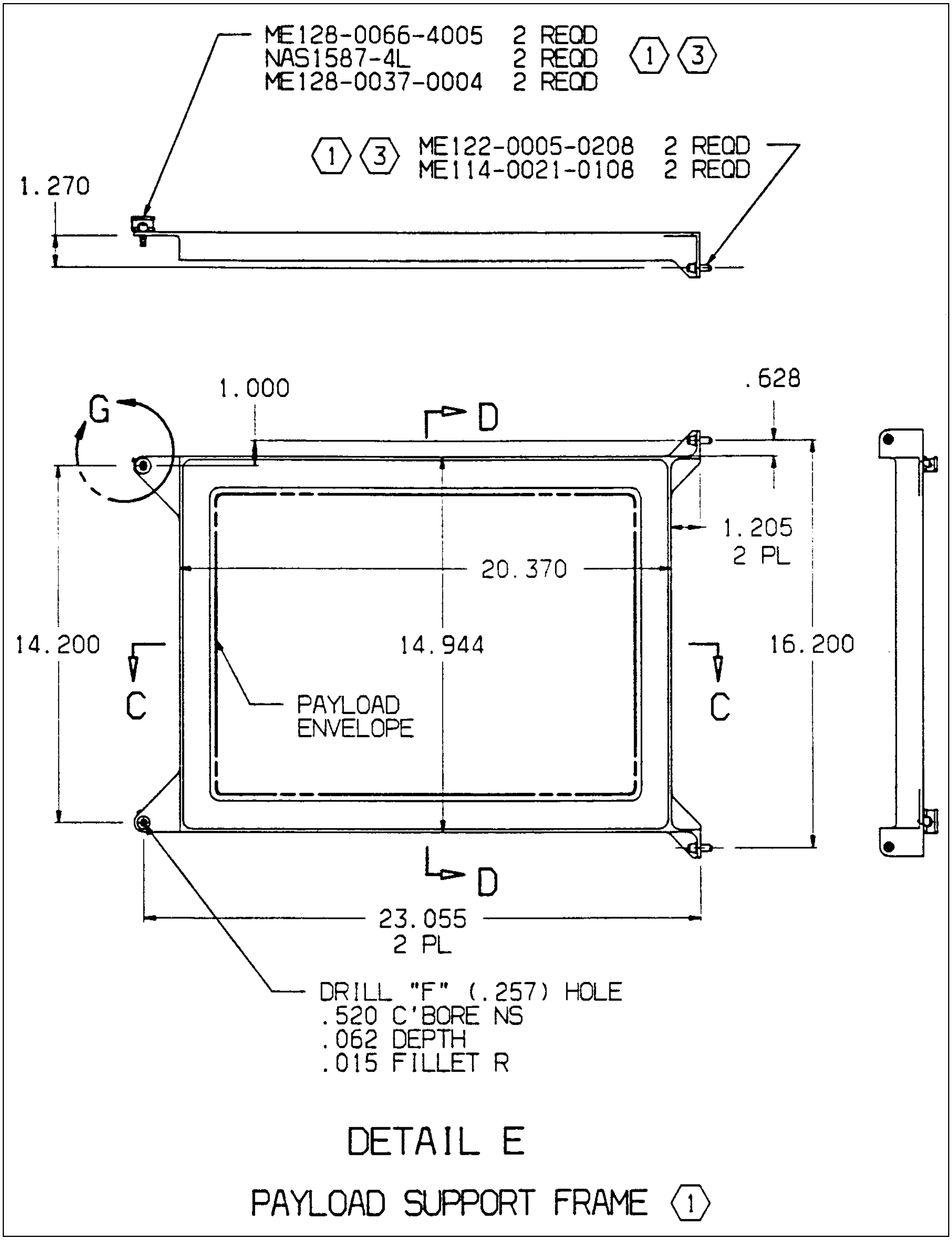


FIGURE 3.11-1 OVERHEAD WINDOW PAYLOAD REQUIREMENTS
(SHEET 4 OF 8)

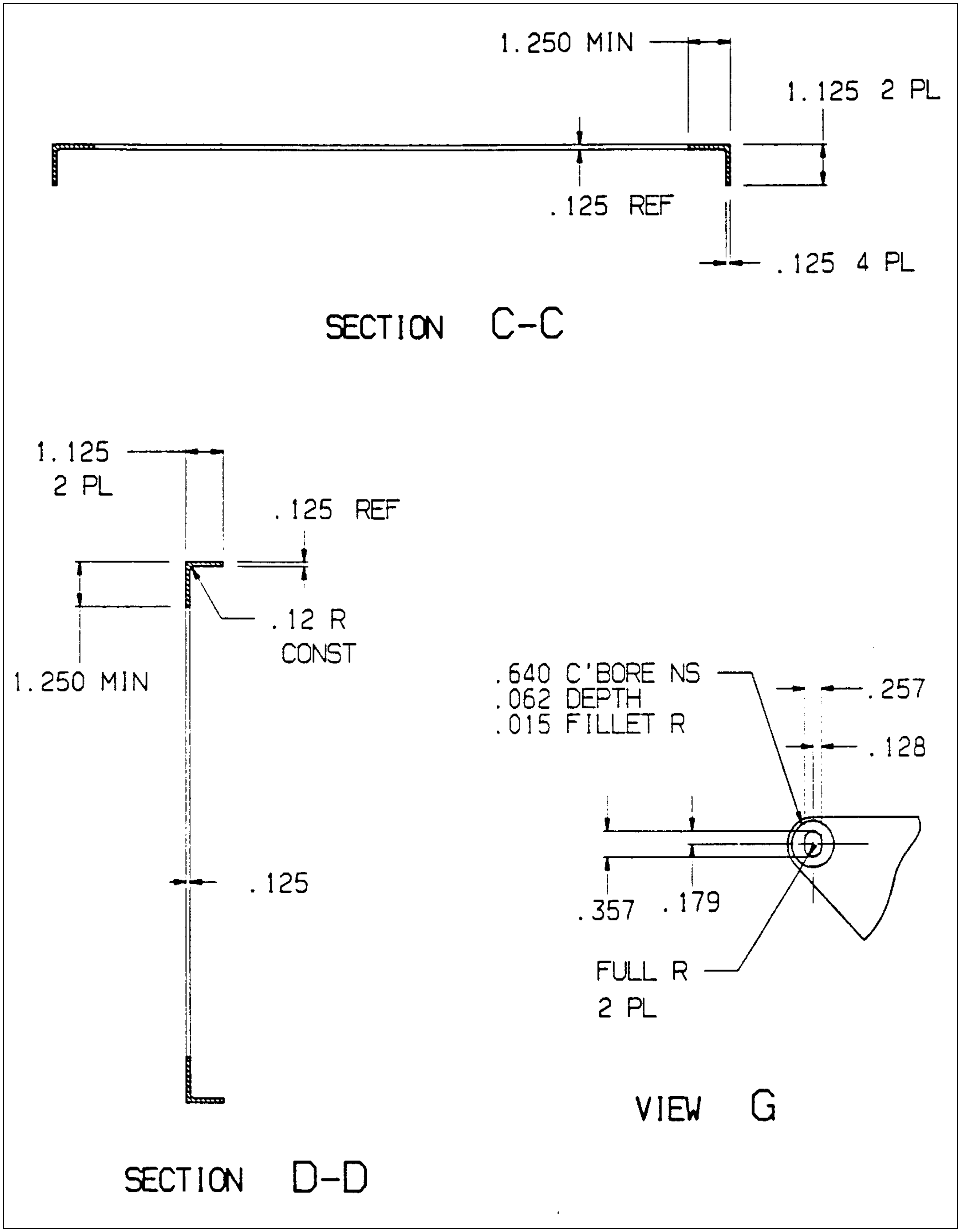


FIGURE 3.11-1 OVERHEAD WINDOW PAYLOAD REQUIREMENTS
(SHEET 5 OF 8)

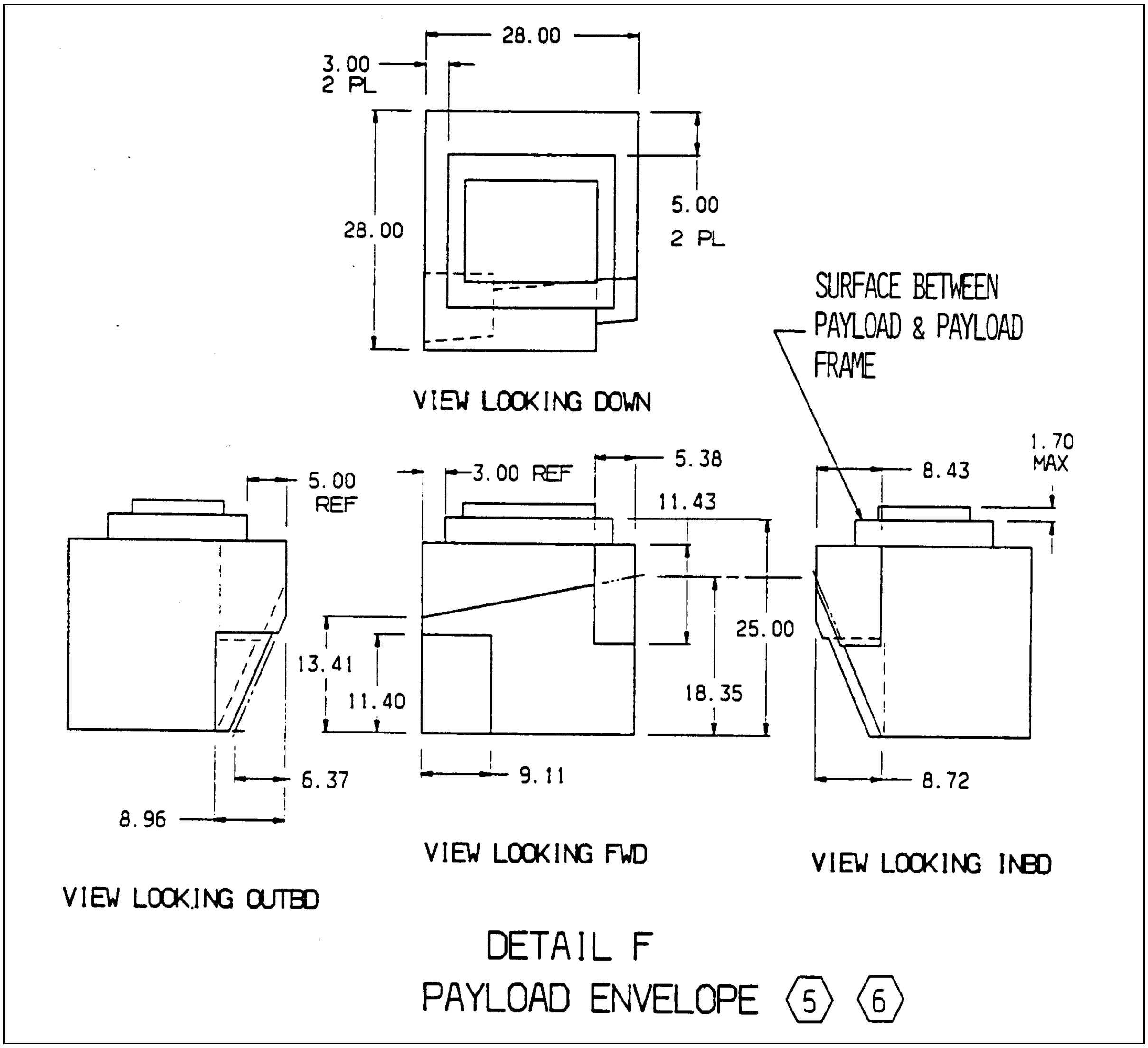


FIGURE 3.11-1 OVERHEAD WINDOW PAYLOAD REQUIREMENTS
(SHEET 6 OF 8)

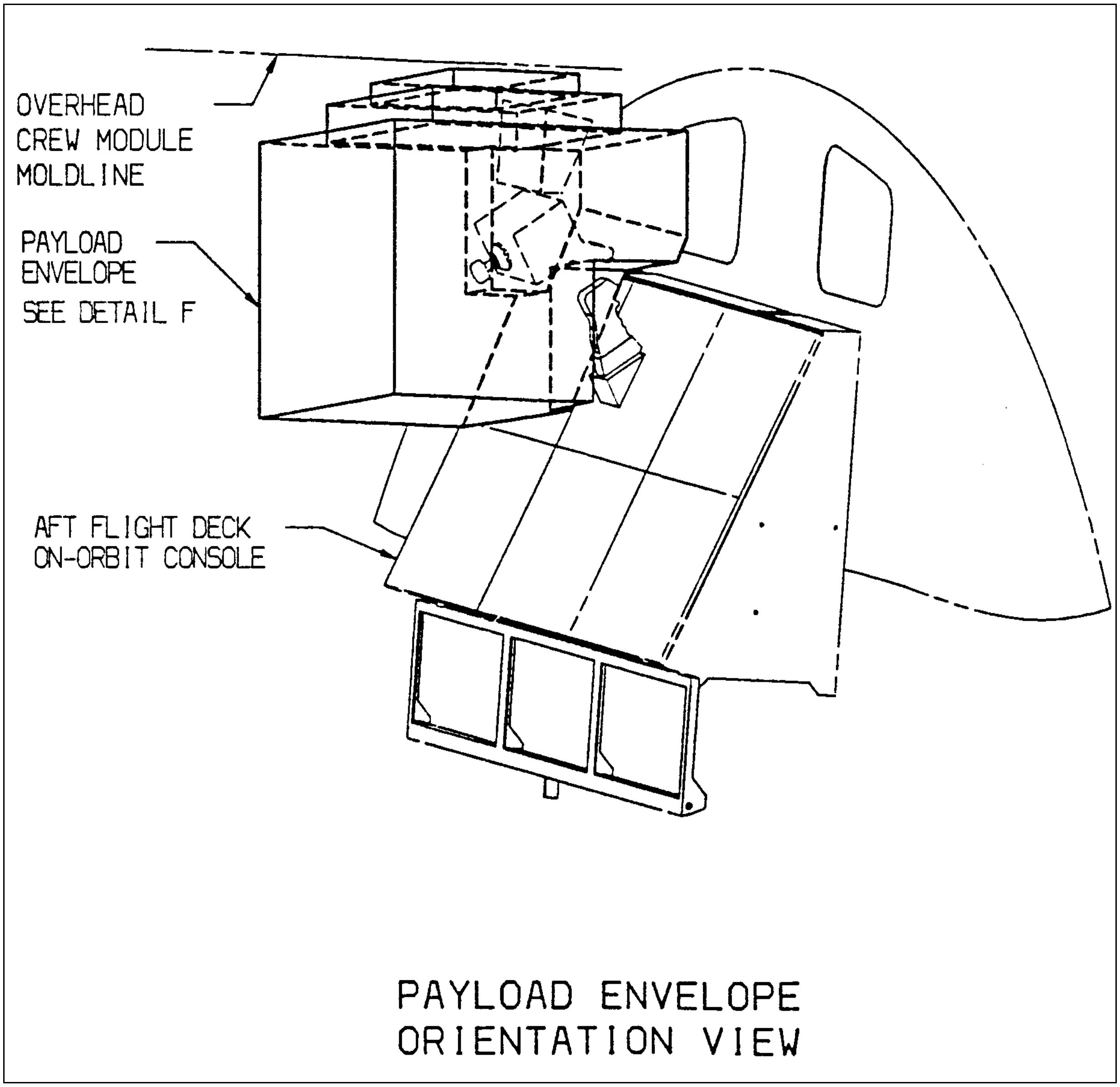


FIGURE 3.11-1 OVERHEAD WINDOW PAYLOAD REQUIREMENTS
(SHEET 7 OF 8)

NOTES:

1. PAYLOAD CUSTOMER PROVIDED HARDWARE.

2. DUE TO SIZE CONSTRAINTS, THE PAYLOAD SUPPORT FRAME SHALL NOT BE STOWED IN A MIDDECK LOCKER.

3. EQUIVALENT FASTENER HARDWARE MAY BE SUBSTITUTED.

4. THE PAYLOAD SUPPORT FRAME SHALL BE CAPABLE OF DEFLECTING 0.113 INCHES AT POINT "D" WHEN POINTS "A", "B", and "C", ARE SECURED TO THEIR MATING ORBITER PAYLOAD FITTINGS. CLOSING OF THE 0.113 INCH GAP AT POINT "D" SHALL NOT EXCEED A LOAD GREATER THAN 50 LBS.

5. THE OVERALL DIMENSIONS DENOTE THE MAXIMUM SIZE OF AN ASSEMBLED PAYLOAD. THE PAYLOAD SUBASSEMBLY COMPONENTS ARE LIMITED IN SIZE BY THE INTER-DECK ACCESS OPENING OF 26 BY 28 INCHES.

6. THE PAYLOAD ENVELOPE DIMENSION TOLERANCE IS +/-0.25.

7. THE PAYLOAD SHALL BE ATTACHED TO THE SUPPORT FRAME WITH A "BREAK-AWAY" INTERFACE SUCH AS VELCRO. IF THE PAYLOAD REQUIREMENTS PRECLUDE THE USE OF VELCRO, THEN CAPTIVE FASTENERS SHALL BE USED.

FIGURE 3.11-1 OVERHEAD WINDOW PAYLOAD REQUIREMENTS
(SHEET 8 OF 8)

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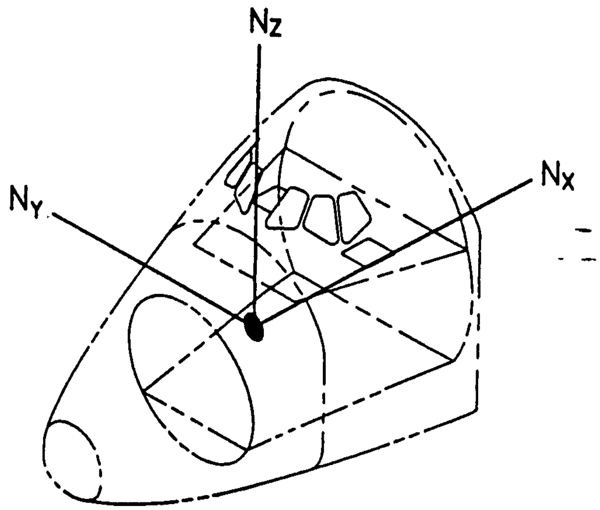
4.0 STRUCTURAL INTERFACES

4.1 Operational Inertia Forces

The limit load factors specified in Table 4.1-1 shall apply to payloads in the Middeck. These load factors encompass the maximized transient and random vibration responses at lift-off and transient response at landing. The lift-off and landing accelerations include a steady state X acceleration of -1.5g and Z acceleration of +1.0g respectively. Payloads that are stowed in middeck lockers fore ascent and descent are subjected to these loads through the locker and isolating foam. Loads associated with quasi-static flight events after lift-off and before landing are relatively lower, but payloads that change configuration on-orbit from their launch configuration shall consider accelerations due to RCS and OMS maneuvers. Middeck payload not stored in a middeck locker must have natural frequencies greater than 30 Hz with respect to their Orbiter attachment interface. The sign convention for the factors is defined in Figure 4.1-1.

TABLE 4.1-1 MIDDECK PAYLOAD DESIGN LOAD FACTORS

Flight Regime	Limit Load Factors (g)		
	Nx	Ny	Nz
Lift-off	+/-6.00	+/-3.40	+/-6.30
Landing	+/-6.25	+/-2.50	+/-12.50



Load factor is defined as the total external applied force divided by the corresponding total or component weight and carries the sign of the external applied force in accordance with Orbiter coordinate system. The load factors are to be applied in all axes simultaneously and in all combinations of positive and negative directions.

FIGURE 4.1-1 DIRECTIONS OF LOAD FACTORS

4.1.1 On-Orbit Accelerations

4.1.1.1 Reaction Control System Loads

During normal Orbiter attitude control and maneuver activities, thrusting of the Orbiter Reaction Control System (RCS) is exerted on Middeck Payloads. These accelerations are small compared to those associated with lift-off and landing events; however they may represent a design condition for payloads which change from their launch configuration while on orbit. Although the Vernier (VRCS) is typically used for Orbiter attitude control, the Primary RCS (PRCS)may be used either because the VRCS is unavailable or to satisfy unique requirements for attitude pointing or translational maneuvers. For this reason, payloads must be designed to withstand loads induced by PRCS thruster firings.

Translational maneuvers using the PRCS thrusters may be required for a variety of reasons including planned orbit adjustments and collision avoidance. Payloads which require translation maneuvers to accomplish their mission requirements must be designed to withstand the induced loads. For payloads which do not require translational maneuvers, an assessment of the load environment should be conducted to support mission operation planning and real time decision making in contingency situations.

The following paragraphs contain RCS-induced limit loads for preliminary design or assessment of the payload structure. The load factors are intended to predict payload internal loads caused by dynamic response to thruster firings as transmitted directly through the Orbiter structure to the payload. In certain cases, coupled dynamic loads analyses will be required to verify cargo element loads and deflections. If such an analysis is required, the Orbiter dynamic model and forcing functions shall be identified by NSTS.

4.1.1.1.1 PRCS Rotational Maneuver Loads

Limit load factors and angular accelerations associated with PRCS rotational maneuvers are specified in table 4.1.1.1.1-1. The load factors and angular accelerations are to be applied simultaneously and in all combinations for positive and negative directions.

4.1.1.1.2 PRCS Translational Maneuver Loads

Limit load factors and angular accelerations are associated with PRCS translational maneuvers in each for the orthogonal axes. Propellant and loads considerations will generally drive the decision regarding which is the preferred PRCS firing axis. The loads are consistent with PRCS firings required to produce the following velocity changes:

X-axis V = 6 fps
Y-axis V = 2 fps
Z-axis V = 5 fps

Loads experienced during the translational buarns for higher delta V's may be larger than those specified here.

The load factors and angular accelerations for each maneuver case are to be applied in all axes simultaneously and in all combinations of positive and negative directions.

4.1.1.1.2.1 PRCS Translational (With Simultaneous Attitude Control) Loads

During most longer duration PRCS translation the Orbiter attitude must be maintained using PRCS thruster firings. These attitude control firings are generally periodic in nature and can induce large payload response. The limit load factors and angular accelerations associated with PRCS translational maneuvers with simultaneous attitude control firings are specified in Table 4.1.1.1.2.1-1.

4.1.1.1.2.2 PRCS Translational (Without Attitude Control) Loads

For some PRCS translational maneuvers simultaneous Orbiter attitude control may not be required. Preliminary design limit load factors and angular accelerations associated with PRCS translational maneuvers without attitude control firings are specified in Table 4.1.1.1.2.2-1.

4.1.1.2 Orbiter Maneuvering System Loads

Thrusting of the Orbiter Maneuvering System (OMS) engines will cause accelerations to be exerted on payloads. The accelerations are small compared to those associated with lift-off and landing events; however they may represent a design condition for cargo elements or components which change from their normal stowed configuration while on on-orbit. Payloads which require an OMS burn to accomplish their mission requirements must be designed to withstand the induced loads. For payloads which do not require an OMS burn, an assessment of the load environment should be conducted to support mission operation planning and real time decision making in contingency situations.

Table 4.1.1.2-1 specifies limit load factors and angular accelerations for preliminary design or assessment of both dual engine and single engine OMS firing. The loads are intended to conservatively account for the effects of OMS engine thrust, overshoot, engine misalignment, simultaneous PRCS roll axis attitude control and the effects of Orbiter/payload dynamics. Use of these design loads should ensure that no OMS operational constraints are required to limit cargo element loads. In certain cases, coupled dynamic loads analyses will be required to verify cargo element load and deflections. If such an analysis is required, the Orbiter dynamic model and forcing functions shall be identified by the SSP.

The load factors and angular accelerations for each maneuver case are to be applied in all axes simultaneously and in all combinations of positive and negative directions.

TABLE 4.1.1.1.1-1 PRCS ROTATIONAL MANEUVER LOAD FACTORS

Load Factor (g)			Angular Acceleration (Rad/Sec^2)		
Nx	Ny	Nz	¨	¨	¨
$\pm$0.028	$\pm$0.263	$\pm$0.396	$\pm$0.176	$\pm$0.159	$\pm$0.105

TABLE 4.1.1.1.2.1-1 LIMIT LOAD FACTORS FOR PRCS TRANSLATIONAL MANEUVERWITH SIMULTANEOUS ATTITUDE CONTROL

Translation Axis	Load Factor (g)			Angular Acceleration (Rad/Sec^2)		
	N_x	N_y	N_z	¨	¨	¨
+Xb	±0.181	±0.039	±0.169	±0.01	±0.01	±0.01
-Xb	±0.188	±0.173	±0.318	±0.09	±0.09	±0.09
±Yb	±0.027	±0.582	±0.394	±0.2	±0.2	±0.2
+Zb	±0.089	±0.271	±0.387	±0.1	±0.1	±0.1
-Zb	±0.167	±0.482	±0.624	±0.2	±0.2	±0.2

Note: Maneuver axes are relative to the Obiter body axis system (+X towards vehicle nose, +Y towards starboard wing, +Z completes right hand system). Load factors and angular accelerations are relative to the Orbiter structural system.

TABLE 4.1.1.1.2.2-1 LIMIT LOAD FACTORS FOR PRCS TRANSLATIONAL MANEUVER WITHOUT ATTITUDE CONTROL

Translation Axis	Load Factor (g)			Angular Acceleration (Rad/Sec^2)		
	N_x	N_y	N_z	¨	¨	¨
+Xb	±0.045	±0.004	±0.031	±0.0005	±0.0005	±0.0005
-Xb	±0.045	±0.004	±0.031	±0.0005	±0.0005	±0.0005
±Yb	±0.010	±0.134	±0.026	±0.002	±0.003	±0.002
+Zb	±0.080	±0.006	±0.201	±0.0005	±0.0005	±0.0005
-Zb	±0.150	±0.010	±0.251	±0.0005	±0.0005	±0.0005

Note: Maneuver axes are relative to the Orbiter body axis system (+X toward vehicle nose, +Y towards starboard wing, +Z completes right hand system). Load factors and angular accelerations are relative to the Orbiter structural system.

TABLE 4.1.1.2-1 LIMIT LOAD FACTORS OMS MANEUVER

Translation Axis	Load Factor (g)			Angular Acceleration (Rad/Sec^2)		
	Nx	Ny	Nz	¨	¨	¨
Two Engine Burn	±0.401	±0.034	±0.319	±0.016	±0.01	±0.015
Single Engine Burn	±0.358	±0.252	±0.388	±0.09	±0.09	±0.09

Note: Maneuver axes are relative to the Orbiter body axis system (+X toward vehicle nose, +Y towards starboard wing, +Z completes right hand system). Load factors and angular accelerations are relative to the Orbiter structural system.

4.2 Emergency Landing Load Factors

Emergency landing load factors specified in Table 4.2-1 shall apply to payload elements mounted in the Middeck. They shall apply to components whose failure could result in injury to personnel or prevent egress from the vehicle. These load factors shall act independently and the longitudinal load factor (Nx) shall be directed in all directions within 20^{o} of the longitudinal axis.

TABLE 4.2-1
EMERGENCY LANDING LOAD FACTORS

Ultimate Inertia Load Factors (g)		
Nx	Ny	Nz
+20.0 -3.3	+3.3 -3.3	+10.0 -4.4

4.3 Random Vibration

The random vibration environments applicable to components mounted in the Middeck during launch and acent shall be as follows:

20	-	150	Hz	+6.00 dB/Octave
150	-	1000	Hz	0.03 g^2/Hz
1000	-	2000	Hz	-6.00 dB/Octave

Composite = 6.5 g(rms)

Environment exposure duration = 7.2 sec/flight in each of X_o, Y_o, Z_o

The exposure duration of 7.2 seconds/flight does not include a fatigue scatter factor. A fatigue scatter factor appropriate for the materials and method of construction is required and shall be not less than 4.0.

4.4 Kick/Push-Off Loads

Payload-provided middeck equipment shall be designed for a 125 pound limit load distributed over a 4 inch x 4 inch area (in the event that the middeck equipment can come into direct crew contact).

4.5 Factors of Safety for Structural Design

The design of payload structures shall assure an ultimate factor of safety = 1.4. Pressurized lines and fittings less than 1.5 inch in diameter shall have an ultimate factor of safety = 4.0. Those 1.5 inches or larger in diameter shall have an ultimate factor of safety = 1.5. Pressure vessels shall have an ultimate factor of safety = 1.5. Structural factors of safety shall be verified in accordance with NSTS 1700.7B during the Payload safety process.

4.6 Fracture Control

Payload structural components, including all pressure vessels, the failure of which would cause damage to the Orbiter or injury to personnel, shall be analyzed to preclude failures caused by propagation of pre-existing flaws. Fracture control of critical structural components shall be verified in accordance with NSTS 1700.7B and NHB 8071.1 during the Payload safety review process.

4.7 Acoustics

Equipment and payloads to be mounted in the Middeck shall satisfy the acoustic requirements as defined in the following paragraphs.

4.7.1 Lift-Off and Ascent Acoustic

Table 4.7.1-1 represents the minimum level to which equipment to be flown in the middeck must be certified to be considered safe to fly on the Orbiter.

4.7.2 On-Orbit Acoustic Noise Limit

Maximum continuous sound pressure levels in the Orbiter Crew Module for normal on-orbit operations resulting from all Orbiter installed equipment are shown in Figure 4.7.2-1. The maximum sound pressure levels for intermittent Orbiter equipment are given in NASA Std. 145A in NSTS 08080-1.

4.7.3 Payload Generated Acoustic Noise

Individual payload elements shall not emit continuous acoustic noise into the crew working/living spaces exceeding the level shown in Figure 4.7.3-1 and Figure 4.7.3-2. As measured one foot from the noise radiating surfaces(s). Maximum noise levels for intermittent noise generated by payload elements shall meet the limits of NASA Std. 145A in NSTS 08080-A.

4.7.4 Acoustical Noise Definitions

4.7.4.1 Significant Noise Source

A significant noise source is any individual piece of equipment, or group of equipment items, which collectively function as an operating system, that generate an A-weighted sound pressure level (SPL) equal to or in excess of 55dBA, measured at a distance of 0.3 meters (1-foot) from the loudest source or radiating surface. The loudest source or radiating surface shall be determined by successively measuring the A-weighted SPL's with the microphone pointed directly at, and 0.3 meters (1-foot) distance from, all parts (surfaces/openings) of the equipment.

4.7.4.2 Continuous Noise Source

A significant noise source which exists for a cumulative total of eight (8) hours or more in any twenty-four (24) hour period is considered a continuous noise source.

4.7.4.3 Intermittent Noise Source

A significant noise source which exists for a cumulative total time of eight (8) hours or less in a twenty-four (24) hour period is considered an intermittent noise source.

4.7.4.4 Acoustical Reference

All SPL in decibels are referenced to 20 micropascals (2x10-5 N/m^2).

4.7.4.5 Shuttle Systems

Shuttle systems are manned habitable volumes such as the Orbiter crew module middeck and flight deck, Spacelab, and other habitable volumes.

4.7.4.6 Equipment
Equipment is defined as the hardware items that produce and emit acoustic noise.

TABLE 4.7.1-1
MIDDECK ACOUSTIC ENVIRONMENT

1/3 Octave Band Center Frequency (Hz)	Sound Pressure Level - dB Ref. X 10^{-5}N/m^2(20 microPascals)	
	Lift-Off	Aeronoise
	5 seconds/Misson*	10 Seconds/Mission*
31.5	107	99
40.0	108	100
50.0	109	100
63.0	109	100
80.0	108	100
100.0	107	100
125.0	106	100
160.0	105	99
200.0	104	99
250.0	103	99
315.0	102	98
400.0	101	98
500.0	100	97
630.0	99	97
800.0	98	96
1000.0	97	95
1250.0	96	94
1600.0	95	93
2000.0	94	92
2500.0	93	91
OVERALL	117.5	111

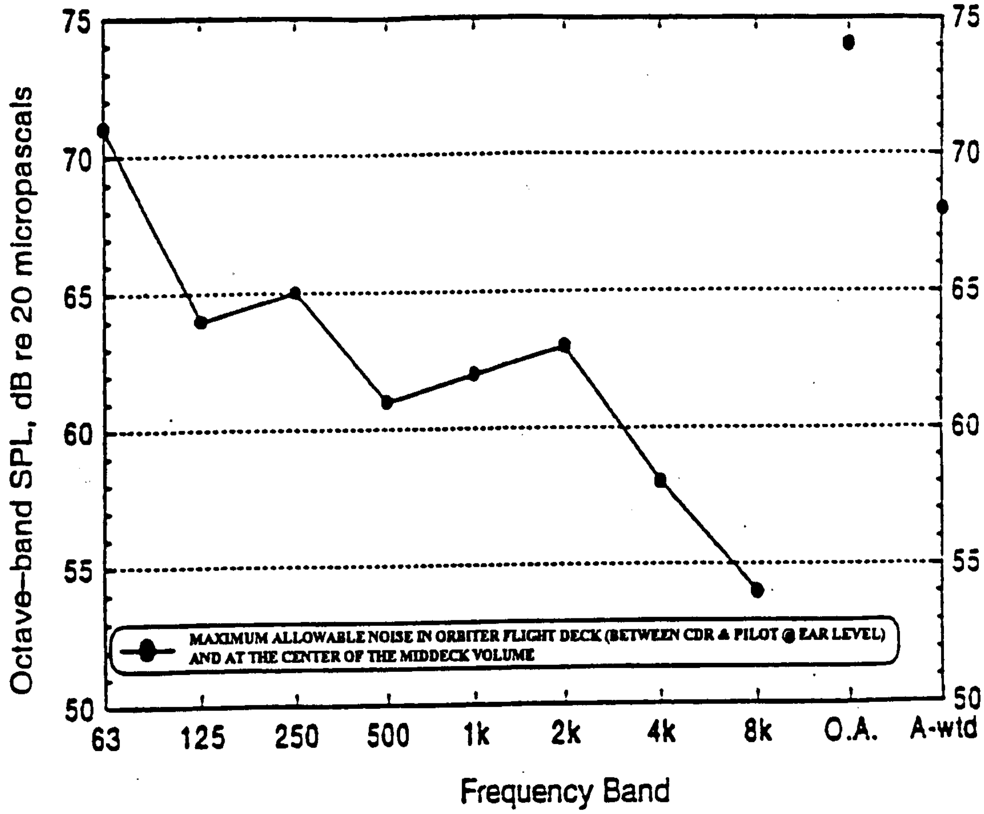
*Time per flight does not include a scatter factor

TABLE 4.7.3-1
INTERMITTENT NOISE LIMITS

A-Weighted SPL* (BA)	Maximum Allowable Duration**
55-60	8 Hours
61-65	4 Hours
66-70	2 Hours
71-75	1 Hour
76-80	5 Minutes
81-85	1 Minute
86 & Above	Not Allowed

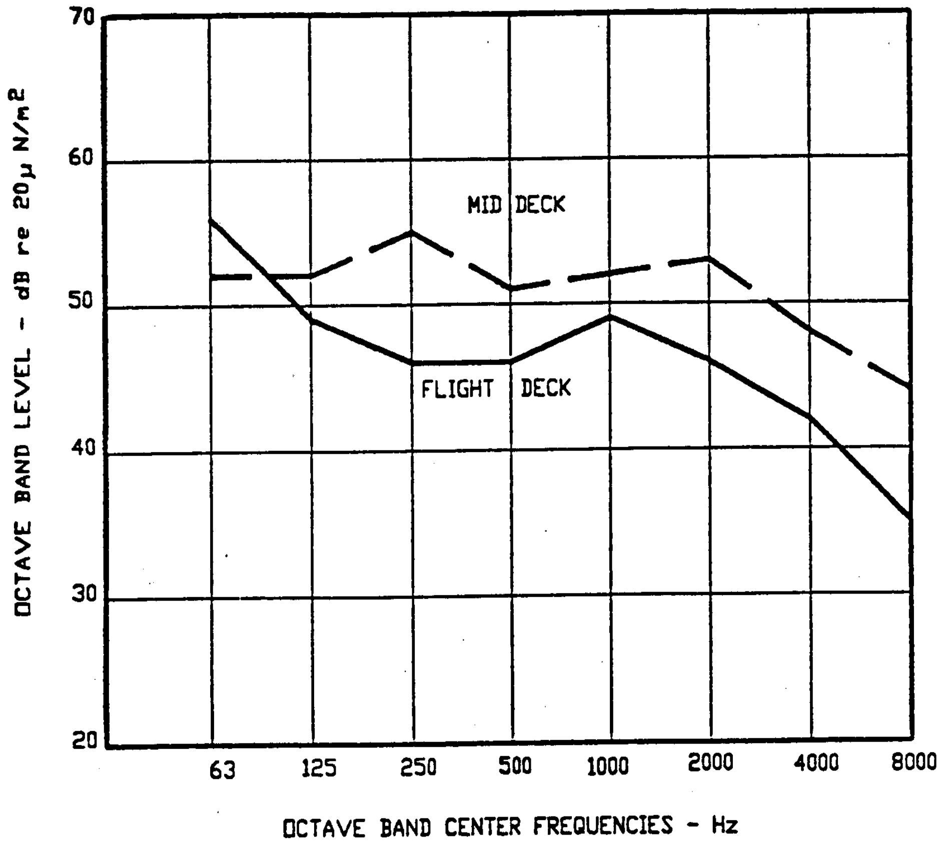
* A-Weighted Sound Pressure Level, dB re 20 micropascals. Measured at 0.3 meters distance from noisiest surface with equipment operating in the mode or condition that produce the maximum acoustic noise. Round dBA to nearest whole number.

**Per 24-hour period.



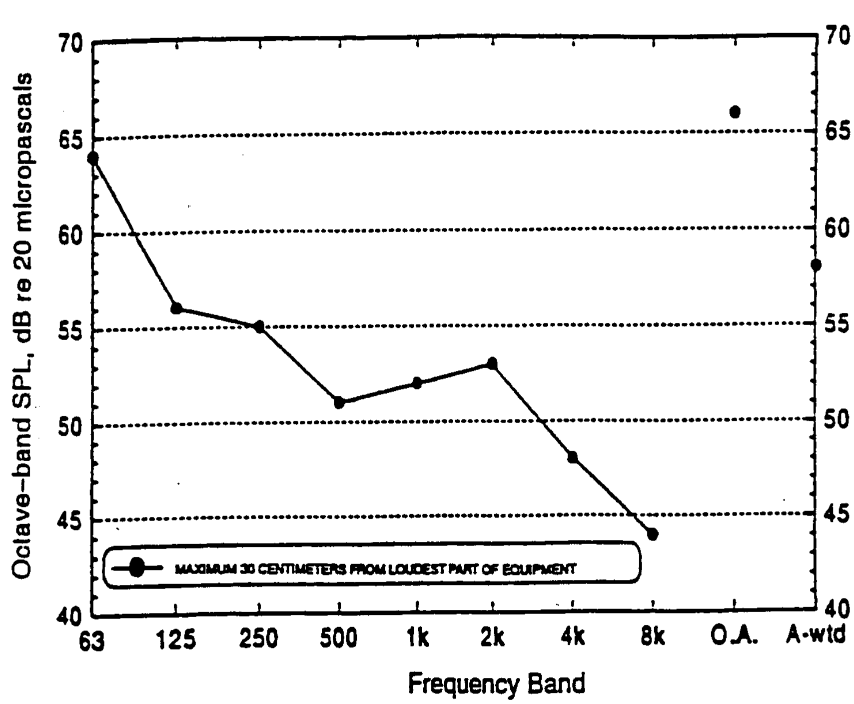
FREQ. BAND	63	125	250	500	1000	2000	4000	8000	O.A.	A-wtd
LIMIT	71	64	65	61	62	63	58	54	74	68

FIGURE 4.7.2-1 ON-ORBIT CREW MODULE ACOUSTIC NOISE LEVELS



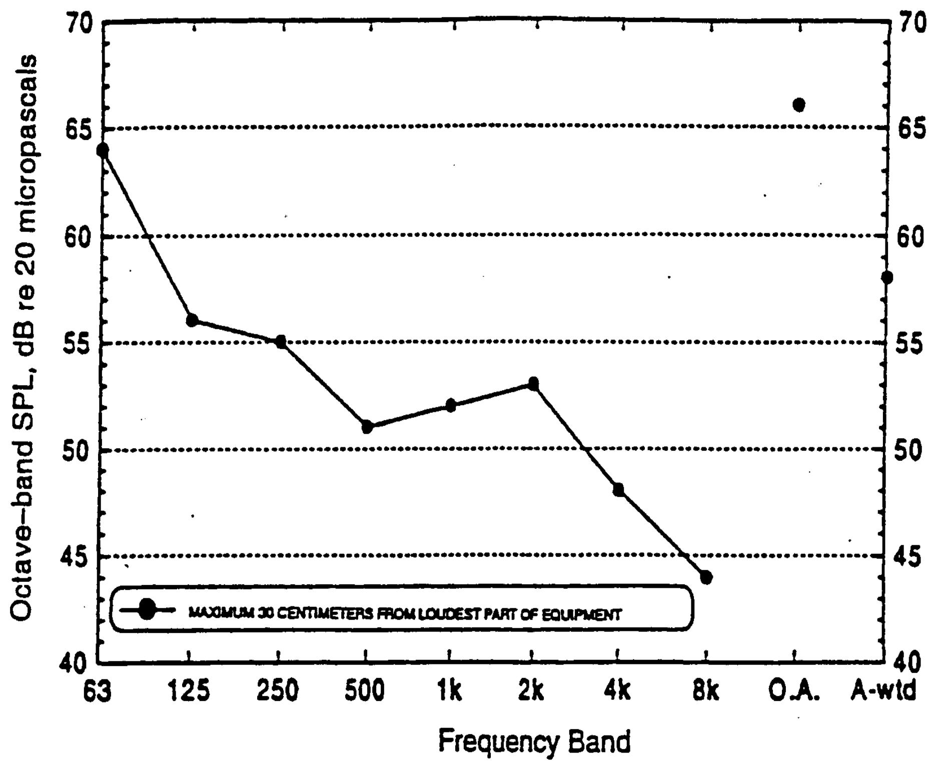
FREQ. Hz	63	125	250	500	1000	2000	4000	8000	O/A	dBA
FLIGHT DECK	56	49	46	46	49	46	42	35	58	53
MID DECK	52	52	55	51	52	53	48	44	61	58

FIGURE 4.7.3.1-1 PAYLOAD GENERATED ACOUSTIC NOISE
(BEFORE APRIL 4, 1994)



FREQ. BAND	63	125	250	500	1000	2000	4000	8000	O.A.	A-wtd
LIMIT	64	56	55	51	52	53	48	44	66	58

FIGURE 4.7.3.1-2 PAYLOAD GENERATED ACOUSTIC NOISE
(AFTER APRIL 1, 1994)



FREQ. BAND	63	125	250	500	1000	2000	4000	8000	O.A.	A-wtd
LIMIT	64	56	55	51	52	53	48	44	66	58

FIGURE 4.7.3.2-1 ISS PAYLOAD GENERATED ACOUSTIC NOISE

4.8 Interface Loads

4.8.1 Standard Heavy Weight Modular Stowage Locker

The maximum weight of a payload stowed in a middeck locker, excluding trays, foam, protective provisions, and external cables, shall not exceed 54 pounds. The maximum weight of the standard modular locker, fully packed including payloads, protective provisions and trays is 70 pounds. Large stowage tray weight is approximately 3.4 pounds. Each small stowage tray weight is approximately 2.45 pounds.

The Xo center of gravity for a fully packed locker shall be no more than 10 inches from the locker wire tray attachment face. The empty standard heavy weight modular stowage locker weighs 11.5 pounds and has an Xo CG of 10.0 inches from the wiretray interface. The 10.0 inches Xo CG also includes the 0.056 inch thickness of the debris panel and 0.25 inch thickness of the standard heavy weight locker rear wall.

4.8.2 Adapter Plates and Mounting Panels

Weight to C.G. relationships for payload attached to adapter plate and mounting panels shall be as described in the following paragraphs.

4.8.2.1 Payloads Attached to a Single Adapter Plate

A standard payload when mounted on a single adapter plate must conform to the maximum load and c.g. requirements shown in Figure 4.8.2-1. Standard payloads can be mounted in bays 1, 2, and 3A.

4.8.2.2 Payloads Attached to a Double Adapter Plate

A standard payload when mounted on a double adapter plate must conform to the maximum load and C.G. requirements shown in Figure 4.8.2-2. Standard payloads can be mounted in Bays 1, 2 and 3A.

4.8.2.3 Payloads Attached to Payload Mounting Panels

Weight to center of gravity relationships for payloads attached to either a single payload mounting panel or two mounting panels are shown in Figure 4.8.2-1 and Figure 4.8.2-2 respectively.

4.8.2.4 Payloads Attached to Vented Payload Mounting Panel

Weight to center of gravity relationships for payloads attached to either a single vented payload mounting panel or two vented mounting panels are shown in Figure 4.8.2-1 and Figure 4.8.2-2 respectively.

4.9 Payload Hardware Interface

Payload hardware (including the hardware frames) shall be designed to withstand the kick/push-off loads specified in Paragraph 4.4.

4.10 Emergency Egress Net and MF71 Middeck Net Retention Interfaces

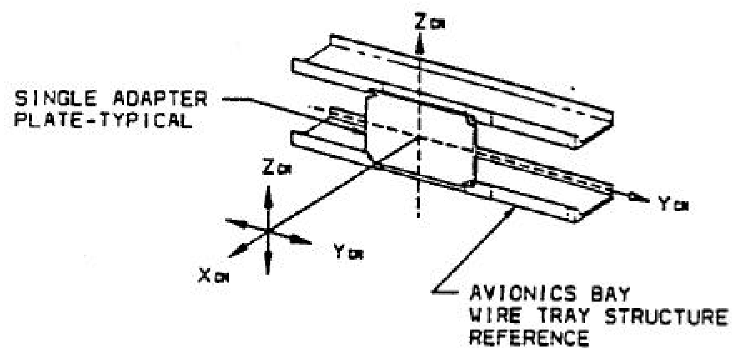
The following requirements in sections 4.10.1 and 4.10.2 are optional for middeck payloads desiring maximum manifesting flexibility in Avionics Bays 2 and 3A. Section 4.10.1 applies only to Orbiters OV-103, OV-104, and OV-105, and section 4.10.2 applies to all Orbiters.

4.10.1 Emergency Egress Net (Trampoline) Interface

While Orbiters OV-103, OV-104, and OV-105 are vertical, an Emergency Egress Net is attached over the airlock tunnel to lockers located in column MA16 of Avionics Bay 3A. The net, Figure 4.10.1-1, is attached with snap hooks to locker net retention fittings, Figures 4.10.1-2 and 4.10.1-3, one fitting per standard locker**.** Locker replacements desiring the mission flexibility of being able to locate in this column and to fly in Orbiters OV-103, 104, and 105, shall have net retention fittings capable of loads indicated in Figure 4.10.1-4. Net retention fitting locations are shown in Figure 4.10.1-5. Double sized payloads wishing the flexibility of being installed in the MA16 column shall provide a center and bottom net retention fitting capable of supporting Egress Net snap hooks. The Emergency Egress Net is not installed on OV-102, and therefore, net retention fittings are not required for locker replacement payloads to be installed at locations shown in Figure 4.10.1-5 on OV-102.

4.10.2 MF71 Middeck Net Retention Interface

During all flight phases, a retention net is installed with one side attached to net retention fittings located at the bottoms of lockers located in column MF71 of Avionics Bay 2 per Figure 4.10.2-1. The net is attached with snap hooks to the locker net retention fittings similar to that shown for the Emergency Egress Net in Figures 4.10.1-2 and 4.10.1-3, one fitting per standard locker. Locker replacements desiring the mission flexibility of being able to locate in this column shall have net retention fittings capable of the loads indicated in Figure 4.10.2-2. Due to RSK (Recumbant Seat Kit) foot support installation, locker position MF71K will not be available for locker replacement payloads on crew rotation flights.



Center of Plate

CG (IN.) X	UNIT WT (LB)
14.0	54.1
13.0	57.6
12.0	61.8
11.0	66.3
10.0	70.0

+/- 0.5" in Y and Z

CG (IN.) X	UNIT WT (LB)
14.0	50.2
13.0	53.4
12.0	57.2
11.0	61.4
10.0	66.4

+/- 1.0" in Y and Z

CG (IN.) X	UNIT WT (LB)
14.0	46.8
13.0	49.8
12.0	53.2
11.0	57.1
10.0	61.6

+/- 1.5" in Y and Z

CG (IN.) X	UNIT WT (LB)
14.0	43.7
13.0	46.5
12.0	49.6
11.0	53.2
10.0	57.4

NOTES:

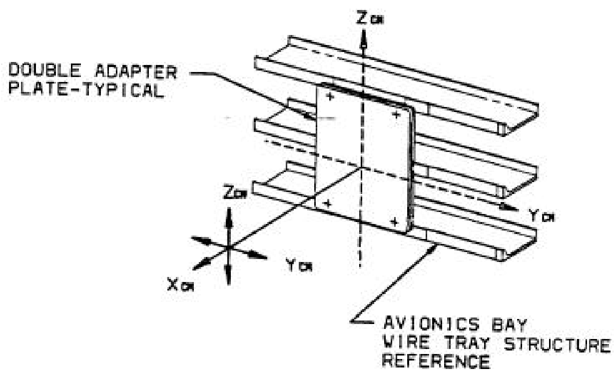
1. TABLES REPRESENT Y AND Z CG EXCURSIONS RANGING FROM 0.0 TO 1.5 INCHES FROM THE CENTER OF THE PLATE. THE ALLOWABLE WEIGHT AND X CG LOCATION MAY BE INTERPOLATED FOR INTERMEDIATE VALUES OF Y AND Z CG LOCATIONS.

2. ALLOWABLE WEIGHTS INCLUDE MOUNTING HARDWARE WEIGHT.

3. X CG LOCATION IS REFERENCED IN INCHES MEASURED FROM THE FACE OF THE WIRE TRAY STRUCTURAL INTERFACE, Y AND Z CG LOCATION IS FROM THE GEOMERTRIC CENTER OF THE PLATE.

4. POWER AND DATA CABLE WEIGHTS ARE NOT INCLUDED IN THE MAXIMUM PAYLOAD WEIGHT CALCULATIONS.

FIGURE 4.8.2-1 MAXIMUM PAYLOAD WEIGHT AND CENTER-OF-GRAVITY FOR SINGLE ADAPTER PLATE OR SINGLE PAYLOAD MOUNTING PANEL



Center of Plate

CG (IN.) X	UNIT WT (LB)
14.0	92.1
13.0	97.5
12.0	103.5
11.0	110.3
10.0	118.1

+/- 0.5" in Y and Z

CG (IN.) X	UNIT WT (LB)
14.0	86.2
13.0	91.2
12.0	96.8
11.0	103.0
10.0	110.2

+/- 1.0" in Y and Z

CG (IN.) X	UNIT WT (LB)
14.0	81.0
13.0	85.5
12.0	90.7
11.0	96.5
10.0	103.1

+/- 1.5" in Y and Z

CG (IN.) X	UNIT WT (LB)
14.0	76.2
13.0	80.5
12.0	85.3
11.0	90.6
10.0	96.8

NOTES:

1. TABLES REPRESENT Y AND Z CG EXCURSIONS RANGING FROM 0.0 TO 1.5 INCHES FROM THE CENTER OF THE PLATE. THE ALLOWABLE WEIGHT AND X CG LOCATION MAY BE INTERPOLATED FOR INTERMEDIATE VALUES OF Y AND Z CG LOCATIONS.

2. ALLOWABLE WEIGHTS INCLUDE MOUNTING HARDWARE WEIGHT.

3. X CG LOCATION IS REFERENCED IN INCHES MEASURED FROM THE FACE OF THE WIRE TRAY STRUCTURAL INTERFACE, Y AND Z CG LOCATION IS FROM THE GEOMERTRIC CENTER OF THE PLATE.

4. POWER AND DATA CABLE WEIGHTS ARE NOT INCLUDED IN THE MAXIMUM PAYLOAD WEIGHT CALCULATIONS.

FIGURE 4.8.2-2 MAXIMUM PAYLOAD WEIGHT AND CENTER-OF-GRAVITY FOR DOUBLE ADAPTER PLATES OF TWO PAYLOAD MOUNTING PANELS

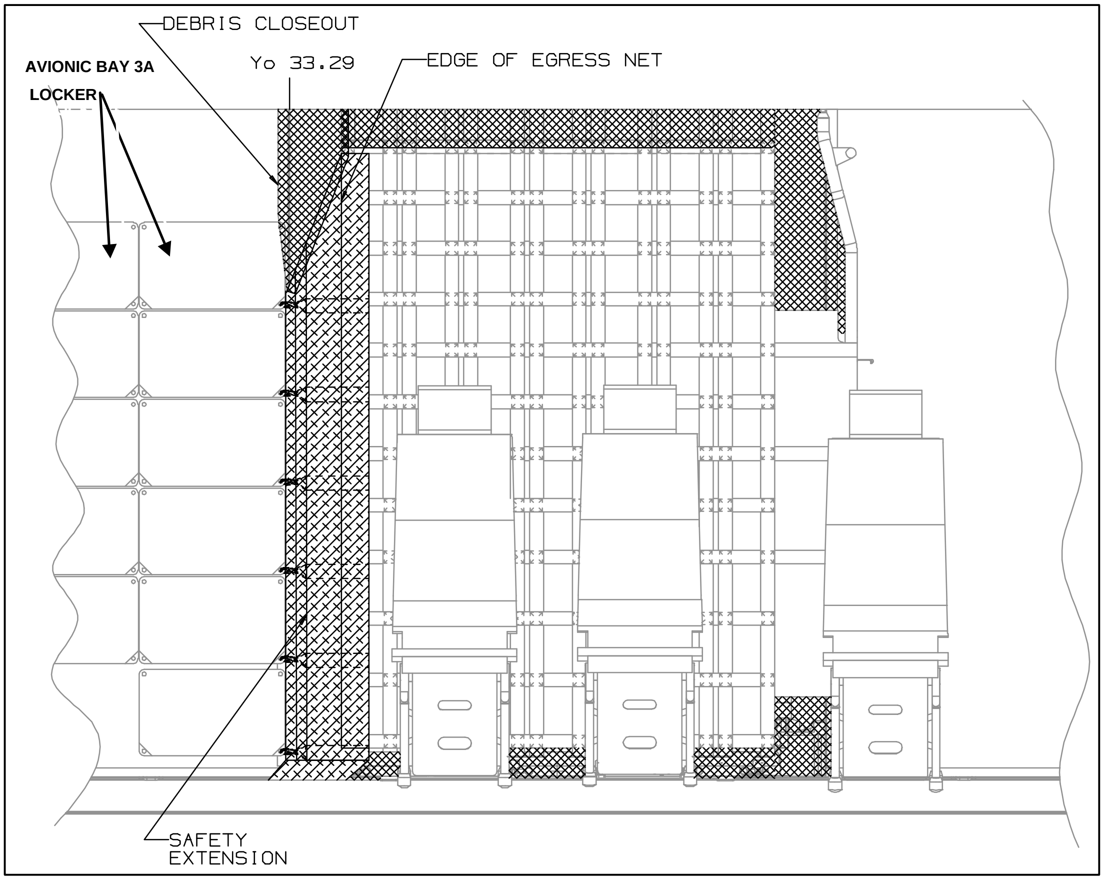


Figure 4.10.1-1
View Looking Aft at Avionics Bay 3A with Emergency Egress Net Installed
Orbiters OV-103, -104, and –105 Only

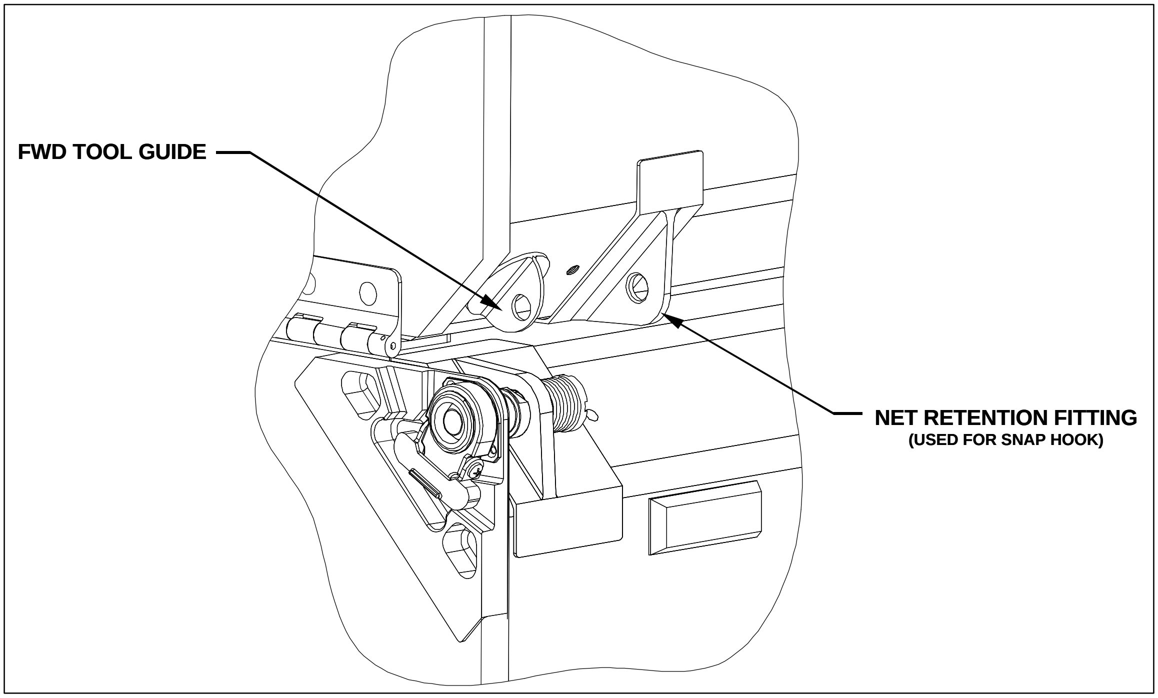


Figure 4.10.1-2
Sheet 1 of 2
Net Retention Fitting Location at Bottom of Standard Locker

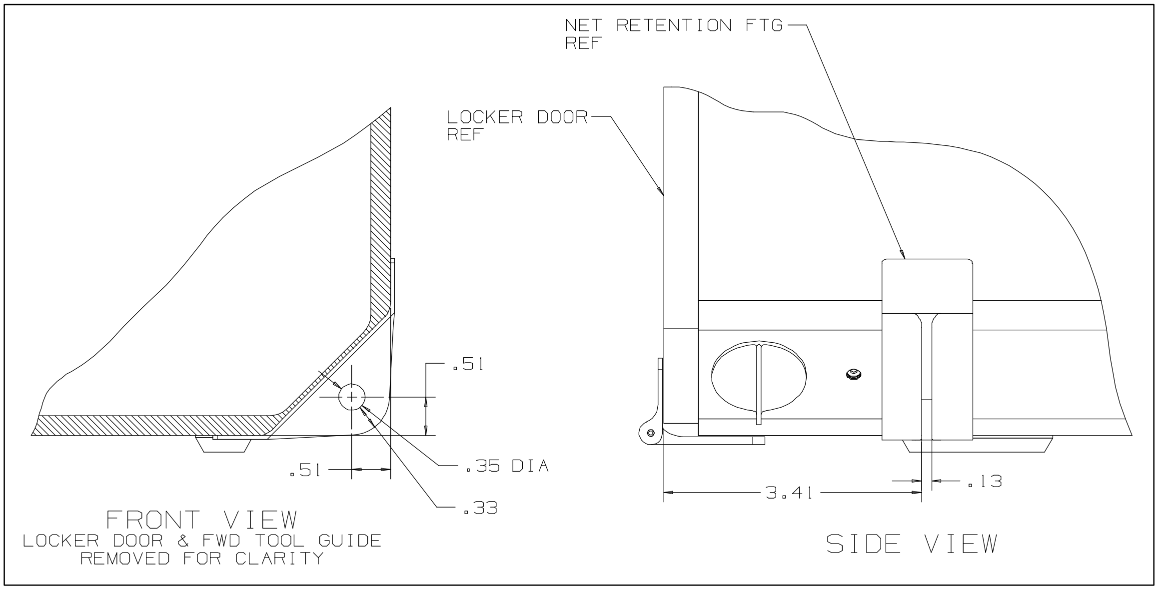


Figure 4.10.1-2
Sheet 2 of 2
Net Retention Fitting Location at Bottom of Standard Locker

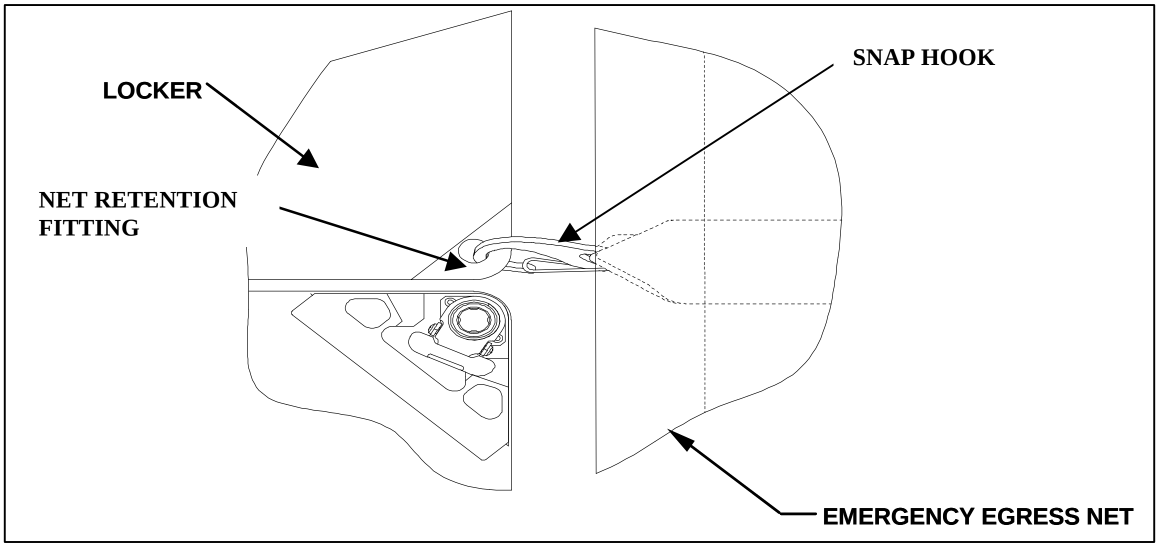


Figure 4.10.1-3
Detail of Locker to Emergency Egress Net Interface

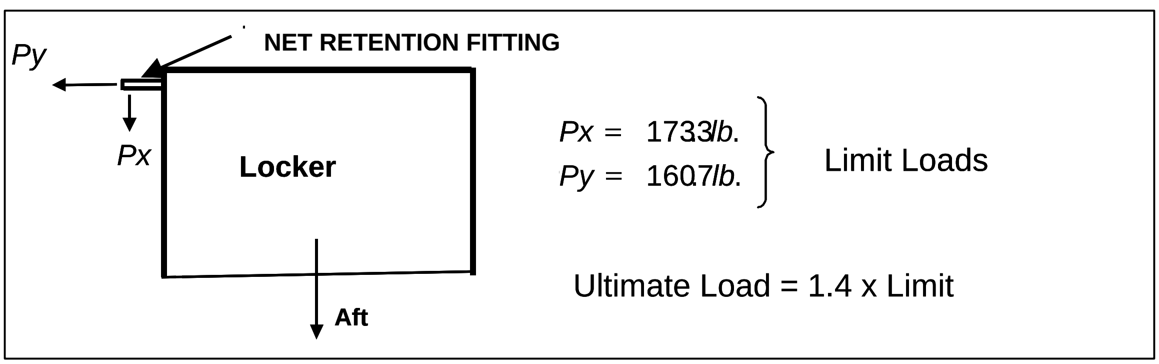


Figure 4.10.1-4
Loads on Emergency Egress Net Retention Fittings

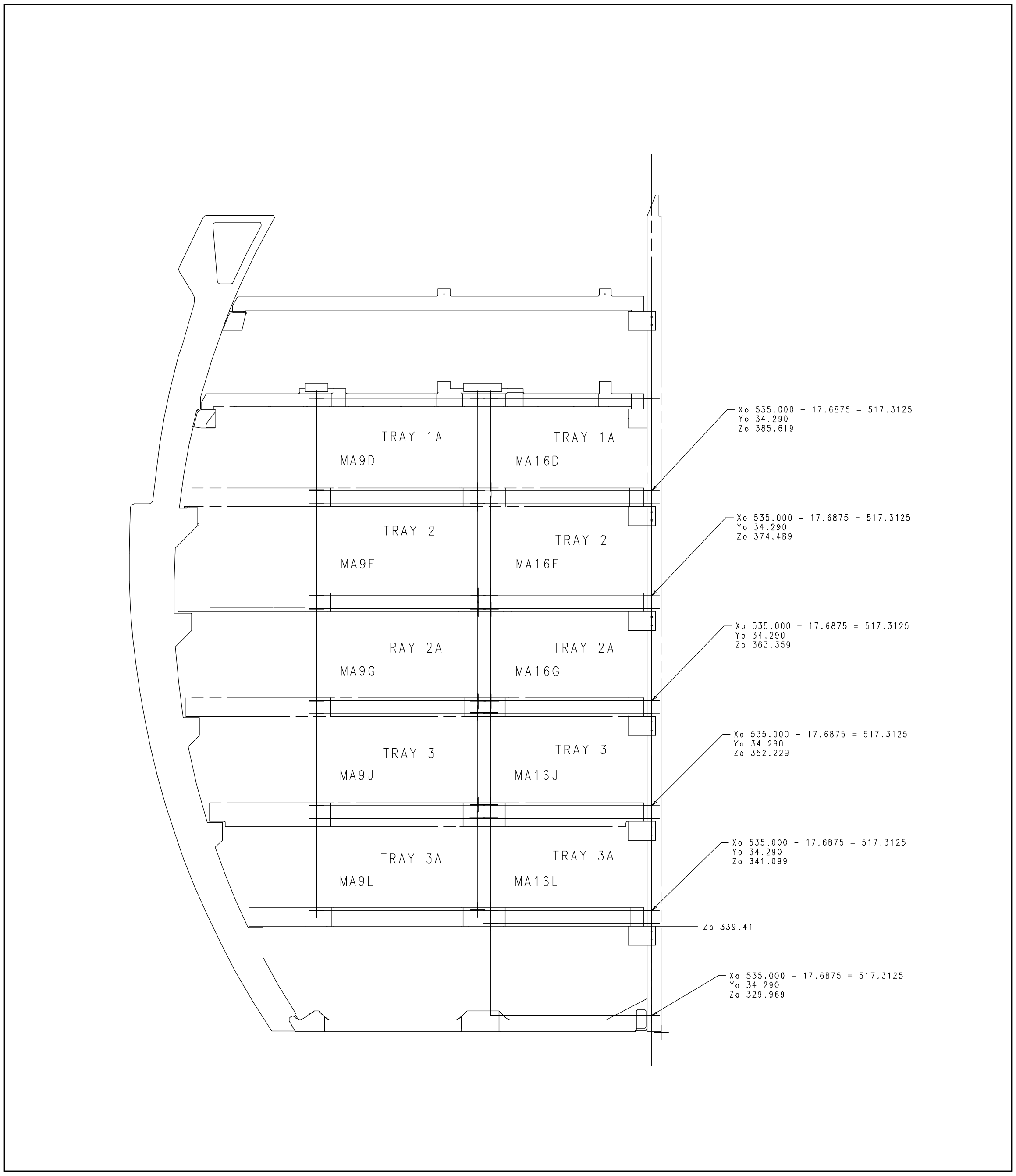


Figure 4.10.1-5
Column MA16 Emergency Egress Net Retention Fitting Locations

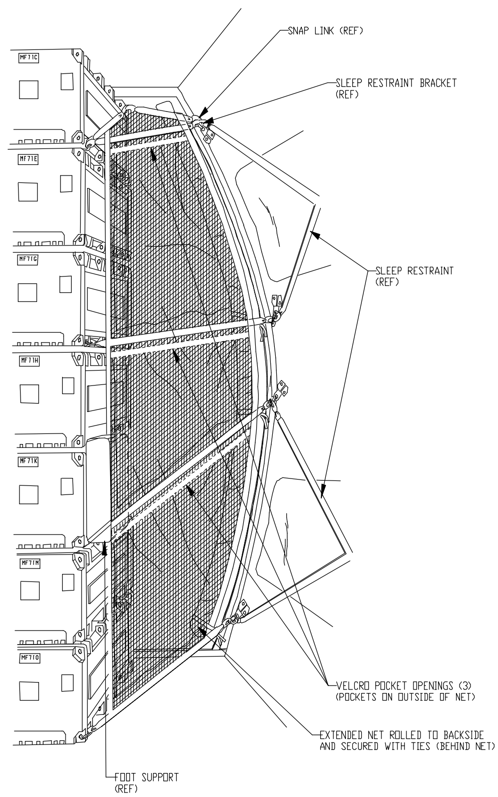


Figure 4.10.2-1
MF71 Middeck Net Retention Interface

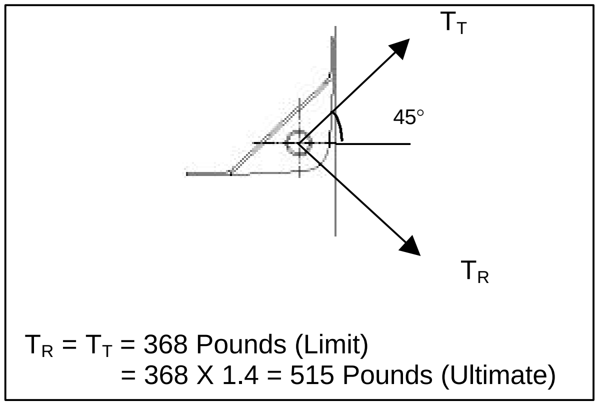


Figure 4.10.2-2
Loads on MF71 Middeck Net Retention Fittings

5.0 ENVIRONMENTAL CONDITIONS

5.1 Payload Element Cleanliness

The external surfaces of the Payload Element shall be cleaned prior to its installation into the Orbiter Middeck. Cleanliness shall conform with a visibly clean level as specified in SN-C-0005. Cleaning fluids shall comply with the requirements specified in NSTS 08242.

5.2 Payload Effluents

The Payload shall provide for safe containment of any by-product of payload experiment-gaseous, liquid or solid. No toxic or any other gases shall be discharged into the middeck environment.

5.3 Illumination

Any special illumination shall be provided by the Payload.

5.4 Nuclear Radiation

Materials used in any payload subsystem, containing natural or manmade radioisotopes (in any quantity, including trace amounts) shall be avoided without prior approval by waiver obtained from NASA-JSC. The waiver request shall specify the radioisotope species, quantities or activities, and other pertinent data such as the exact location within the middeck area where the material is to be installed. Waivers shall be processed in the safety review process.

6.0 THERMAL INTERFACE

6.1 Environmental Conditions

The environmental conditions for the Middeck will vary as follows:

Dew Point	+61°F to +39°F
Cabin Pressure	14.7 ± 0.2 PSIA (Normal Operation)
	8.0 ± 0.2 PSIA (Abort Operations - To be considered for Structural Design Purposes. Payload required to be powered off.)
	16.0 PSIA Maximum On-Orbit (Relief valve Operation)
	18.1 PSIA maximum (Ground Pressurization Test)
	Reduced cabin pressure EVA procedure: 10.2 ± 0.5 psia (± 0.2 PSIA dynamic operating range, ± 0.3 PSIA sensor bias error)
Cabin Rate of Pressure Change	
Nominal Ops	2.0 psi/min Repressurization/Depressurization
Contingency (other than Bailout)	9.0 psi/min Depressurization/Repressurization
Particulate Level	Cabin air
Cabin O_2 Concentration	25.9 percent at 14.7 ± 0.2 PSIA 30.0 percent maximum at 10.2 PSIA

Contingency hold in Cabin (payload required to be powered off)	32.0 percent at 8 psia
Temperature (Cabin Air)	65 - 80 ºF Nominal on-orbit operations 80 ºF Peak launch/ascent 75 ºF Peak entry/landing 95 ºF Peak contingency operations 32 - 120 ºF Ferry flight
Temperature (Structure)	120^0 F Max (All Mission Phases)

Note: All payload hardware located in the orbiter crew cabin shall be certified safe for the above environments.

6.1.1 Emergency Bailout Requirements

Payloads located within the crew compartment area shall be designed to meet the following depressurization requirements in order to insure they will not present a hazard to the crew or to the Orbiter which could jeopardize crew survivability or impede crew egress during emergency bailout procedures:

Cabin Pressure Range	Initial (Max) 15.2 PSIA
Final (Min)	3.95 PSIA
Max Depressurization Rate	24.0 PSI/Minute

6.2 Payload Element Cooling

6.2.1 Payload Waste Heat Dissipation

Payload waste heat shall be dissipated to middeck cabin air or avionics bay air. A payload may be cooled with or without payload provided capability to internally circulate cabin or avionics bay air. A payload may be cooled with passive cooling, non-ducted air cooling, or ducted air cooling. Payloads which are required to operate during EVA or EVA pre-breathe periods shall design cooling based on 10.2 PSIA cabin pressure.

6.2.1.1 Maximum Allowable Heat Loads

Maximum allowable heat loads are established to maintain cabin air at the crew comfort temperature of 80 degrees F during the on-orbit phase, 80 degrees F during the pre-launch/ascent phase, and 75 degrees F during the entry/landing phase. In addition, the avionics bay air inlet temperature shall not exceed 80 degrees F, except for transients up

to 95 degrees F during the pre-launch/ascent and entry/landing phases. Figures 6.1-1 and 6.1-2 specify the ascent/entry avionics bay inlet air temperature profiles.

The maximum allowable heat load for payload generated waste heat dissipated to either the cabin or avionics bays cooling systems will be dependent upon the mission payload manifest. This heat load limit is dependent upon ducted and non-ducted cooling payload combinations in the cabin, avionics bays, and payload bay, as well as cooling configurations and cabin pressure requirements for the mission, and shall be consistent with the maximum electrical power per Section 7.0.

The maximum heat loads to the cabin for non-ducted and passively cooled middeck payloads shall include both convection and radiative payload heat loss. On-orbit maximum allowable passive heat loads shall be as shown in Figures 6.2.1.1-1 and 6.2.1.1-2. The on-orbit allowable will be reduced if payload active cooling is required. Payload passive cooling is not available during 10.2 psia operations when the FPMs are in payload position. It shall be the responsibility of the SSP to manifest a complement of compatible payloads. This compatibility will be determined by a mission specific integrated thermal analysis that ensures cabin air and avionics bay inlet temperature requirements are met.

6.2.1.2 Passive Cooling

Payloads generating waste heat and not incorporating in the design a means of rejecting this heat to the cabin air by means of a fan or similar means shall be constrained to the following maximum continuous heat load:

Payload Container	Heat Load
Standard Stowage Locker	60W

The SP design value for the convective heat transfer coefficient is 0.25 Btu/hr ^{o}F ft^{2} for 14.7 PSIA or 0.17 Btu/hr ^{o}F ft^{2} for 10.2 PSIA cabin pressure.

6.2.1.3 Payload Limitations on Heat conducted to Structure

All payload internal temperature requirements shall be met by heat rejection to only the middeck cabin ambient air and active air cooling circulated through the payload. Payloads shall not be designed to conduct payload heat to the Orbiter attach structure. Payloads shall not be required to be thermally isolated from the Orbiter attach structure. By design on the Orbiter sided, the conductive heat path through the Orbiter attach structure will be small.

6.2.1.4 Non-Ducted Air Cooling

A non-ducted air cooled payload may be cooled with a payload provided fan to internally circulate middeck cabin air. When a payload provides an air circulation fan which discharges to the cabin, the maximum air outlet temperature shall not exceed 120 degrees F. Usage of the non-ducted air capability will be dependent upon maximum power available per Section 7.0 and on the aft flight deck accommodations.

6.2.1.4.1 Non-Ducted Payload Contamination Protection

The non-ducted payload design shall be compatible with ingestion of up to 1 gram of lint-like contamination from the cabin and/or 1.0 square inch material blockage or provide protection from that contamination (the Orbiter avionics filters are designed to provide a flow area of 1 to 5 square inches/lbm/hr using 50 by 250 micron pleated filter. Additionally, the cooling system design shall not contribute to further contamination of the cabin or avionics bays.

6.2.1.5 Ducted Air Cooling

The ducted cooling for middeck mounted payloads in avionics Bays 1, 2, and 3A will be provided via a soft interface where payloads shall be required to provide their own circulation fan as shown in Figure 6.2.1.5-1. The payload hot exhaust air will be circulated into the soft interface air plenum where the Orbiter outlet duct shall be attached. The Orbiter outlet duct shall draw in the payload hot exhaust air in order to minimize payload air recirculation. The maximum middeck ducted air cooling capability shall be 1600 watts from avionics Bays 1, 2, and 3A. Ducted air cooling capability shall only be available on OV-103 and subs as shown in Table 6.2.1.5-1. Total ducted air cooling air flow available to all manifested payload electronics located in the middeck shall be dependent on the air flow distribution in each of the avionics bays.

If the payload air flow is greater than the Orbiter provided air flow, then payload air flow recirculation will occur. Inlet air temperature to the payload shall be dependent upon the payload flow recirculation and payload heat dissipation. Figures 6.2.1.5.1-1 and 6.2.1.5.1-2 show the effect of recirculation on the inlet air temperatures for Orbiter flow rates of 18 CFM and 36 CFM, respectively. For 18 CFM Orbiter flow rate, the payload flow rates may be up to 27 CFM. For 36 CFM Orbiter flow rate, the payload flow rates may be up to 54 CFM. The delta T across the payload may be calculated from T out minus payload inlet temperature.

6.2.1.5.1 Bay 1 Ducted Air Cooling Capability

Total Orbiter Bay 1 air cooling capability shall be as shown in Table 6.2.1.5.1-1.

6.2.1.5.1.1 Bay 1 Standard Air Flow Capability

The standard Orbiter air flow rate capability for an individual middeck payload shall be 18 or 36 cubic feet per minute (CFM). Usage of either 18 or 36 (CFM) Orbiter allocation shall be dependent upon mission requirements for launch and landing payloads. No on-orbit flow balancing shall be allowed to change the standard allocation. The launch and the landing payload Orbiter flow requirements shall be identical. The standard available Orbiter air flow/location configurations shall be shown in Table 6.2.1.5.1.1-1. The amount of air available will be dependent upon the total Orbiter payload manifest.

6.2.1.5.2 Bay 2 Ducted Air Cooling Capability

Total Orbiter Bay 2 air cooling capability shall be as shown in Table 6.2.1.5.2-1.

6.2.1.5.2.1 Bay 2 Standard Air Flow Capability

The standard Orbiter air flow rate capability for an individual middeck payload shall be 18 cubic feet per minute (CFM). No on-orbit flow balancing shall be allowed to change the standard allocation. The launch and the landing payload Orbiter flow requirements shall be as shown in Table 6.2.1.5.2.1-1. The amount of air available will be dependent upon the total Orbiter payload manifest.

6.2.1.5.3 Bay 3A Ducted Air Cooling Capability

Total Bay 3A air cooling capability shall be as shown in Table 6.2.1.5.3-1.

6.2.1.5.3.1 Bay 3A Standard Air Flow Capability

The standard Orbiter air flow rate capability for an individual middeck payload shall be 18 or 36 cubic feet per minute (CFM). Usage of either 18 or 36 CFM Orbiter allocation shall be dependent upon mission requirements for launch and landing payloads. No on-orbit flow balancing shall be allowed to change the standard allocation. The launch and landing payload Orbiter flow requirements shall be identical. The standard available Orbiter air flow/location configurations shall be shown in Table 6.2.1.5.3.1-1 and 6.2.1.5.3.1-2. The amount of air available will be dependent upon the total Orbiter payload manifest.

6.2.1.5.4 Payload Outlet Air Pressure Requirement

Air pressure at payload outlet shall be no greater than 0.1 inch water.

6.2.1.5.5 Ducted Payload Air Cooling Interface

The ducted air cooling functional interface for single and double payloads shall be as defined in the following paragraphs. Ducted cooling configurations shall be limited to four allowable configurations, one for single and three for double.

6.2.1.5.5.1 Single Size Payload Air Cooling Interface

For single size payloads the air inlet and outlet functional interface shall be as shown in Figure 6.2.1.5.6.1-1.

6.2.1.5.5.2 Double Size Payload Air Cooling Interface

For double size payloads with the air inlets and outlets on the top half of the payload, the air cooling functional interface will be as shown in Figure 6.2.1.5.5.2-1. With this configuration, payload flow may be greater than the Orbiter outlet air flow. This configuration does not require a payload provided minimum gap.

For double size payloads with inlet on bottom half and outlet on top half of payload, the air cooling functional interface will be as shown in either Figure 6.2.1.5.5.2-2 or 6.2.1.5.5.2-3.

Figure 6.2.1.5.5.2-2 configuration shall be used if there is a minimum of 0.75 inch gap between the vented payload mounting panel and the payload to allow air recirculation

from the plenum to air inlet. This gap may be part of payload design. With this configuration, payload flow may be greater than the Orbiter outlet air flow.

Figure 6.2.1.5.5.2-3 shall be used whether or not there is a payload provided minimum 0.75 inch gap. This configuration requires the payload fan air flow rate to be less than or equal to the Orbiter outlet air flow rate.

6.2.1.5.6 Ducted Payload Contamination Protection

The ducted payload design shall be compatible with ingestion of up to 1 gram of lint-like contamination from the cabin and/or 1.0 square inch material blockage or provide protection from that contamination (the Orbiter avionics filters are designed to provide a flow area of 1 of 5 lbm^2/hr using 50 by 250 micron pleated filter. Additionally, the cooling system design shall not contribute to further contamination of the cabin or avionics bay.

6.2.1.5.7 Cabin and Avionics Bay Air Mixing Limitations

Ducted air cooling payloads shall be designed to preclude mixing of cabin and avionics bay air. Mixing of cabin and avionics bay air will be allowable for a maximum 30 minutes per day and only if event is attended by a crew member.

6.2.1.5.8 Ducted Payload Limitations on Heat Convected or Radiated to Cabin Air

Rejection of heat from the sides and front of a “ducted payload” to the cabin air by convection and radiation shall be limited to 10% of the payload’s total heat load.

6.2.2 External Surface Temperatures

External surface temperatures of the payload elements accessible and inaccessible to the crew shall not exceed 120°F. All surfaces exposed to cabin air shall be maintained above the maximum dew point temperature.

6.3 Air Leakage Requirements

6.3.1 Maximum Air Leakage Across Payload Mounting Surface

The maximum allowable leakage of cabin air into the payload recirculating air-cooling system is 3 scim (standard cubic inches per minute) for single sized payload and 6 scim for double sized payload when the orbiter cabin air temperature is 70°F and payload internal air cooling pressure is 0.5 inches of H_2O below a 14.7 psia cabin air pressure.
Leakage at the payload-to-Orbiter Vented Payload Mounting Panel (VPMP) interface is the responsibility of the Orbiter.

6.3.2 Payload Mounting Surface Physical Characteristics

The payload surface that mounts directly onto the Orbiter supplied VPMP shall have the following physical characteristics:

> Surface flatness is 0.010 inch maximum for both the single and double sized payloads. The allowable gap applies to the entire payload mounting surface when measured from a true plane.
>
> Surface finish is 125 micro-inches maximum for both the single and double sized payloads. The payload supplier is responsible for selecting a material that is corrosion compatible with the Shuttle interface hardware and the environments to which it will be exposed.

TABLE 6.2.1.5-1
MAXIMUM DUCTED AIR COOLING CAPABILITY AVAILABILITY (1) (2)

VEHICLE/ YEAR EFFECTIVITY	BAY 1	BAY 2	BAY 3A
OV-102	NA	NA	NA
OV-103 6/2000	400 W/36 CFM	200 W/18 CFM	1000 W/180 CFM
OV-104 TBD	400 W/36 CFM	200 W/18 CFM	1000 W/180 CFM
OV-105 TBD	400 W/36 CFM	200 W/18 CFM	1000 W/180 CFM

NOTE:

(1) COOLING CAPABILITY IDENTIFIED AT 14.7 PSIA CONDITIONS ONLY

(2) MAXIMUM CAPABILITY ASSUMES NO ACTIVE AIR COOLING REQUIRED FOR ORBITER TACAN SUPPORT

TABLE 6.2.1.5.1-1
MAXIMUM BAY 1 DUCTED AIR COOLING CAPABILITY

CABIN PRESSURE (PSIA)	COOLING CAPABILITY (WATTS) (1)	FLOW RATE (CFM)	AVG DELTA T ACROSS P/L (DEG F) (2)	INLET TEMPERATURE (DEG F) (3)
14.7	400	36	35	65-80 (Normal Operations) 95 Max Peak (Ascent/Descent) (4)

Notes:
(1) Maximum capability assumes no active air cooling required for TACAN support. For current (March 1996) OV-105 configuration, reduction of 150 W required for Orbiter TACAN support.
(2) Average payload delta T shown for reference.
(3) Inlet temperature of 80 deg F assumes no heat transfer from payload to Orbiter attach structure and no payload flow recirculation.
(4) Transient profiles per Figures 6.1-1 and 6.1-2.
(5) Cooling is not available until TBD.

TABLE 6.2.1.5.1.1-1
BAY 1 STANDARD ORBITER AIR FLOW/MIDDECK LOCATIONS

CONFIGURATION	LOCKER LOCATION	FLOW RATE (CFM)
-001	MF14G	0
-001	MF28E	0
-002	MF14G	0
-002	MF28E	36
-003	MF14G	18
-003	MF28E	18
-004	MF14G	36
-004	MF28E	0
-005	MF14G	0
-005	MF28E	36
-006	MF14G	18
-006	MF28E	18
-007	MF14G	36
-007	MF28E	0
-008	MF14G	0
-008	MF28E	0

TABLE 6.2.1.5.2-1
MAXIMUM BAY 2 DUCTED AIR COOLING CAPABILITY

CABIN PRESSURE (PSIA)	COOLING CAPABILITY (WATTS) (1)	FLOW RATE (CFM)	AVG DELTA T ACROSS P/L (DEG F) (2)	INLET TEMPERATURE (DEG F) (3)
14.7	325	30	35	65-80 (Normal Operations) 95 Max Peak (Ascent & Descent) (4)
10.2	225	30	35	65-80 (Normal Operations)

Notes:

(1) Maximum capability assumes no active air cooling required for Orbiter TACAN support.
For Current (March 1996) OV-103 and OV-104 Orbiter configuration, reduction of 150 W required for Orbiter TACAN support.

(2) Average payload delta T shown for reference

(3) Inlet temperature of 80 deg F assumes no heat transfer from payload flow recirculation

(4) Transient profiles per Figures 6.1-1 and 6.1-2.

(5) Bay 2 cooling not presently available (Refer to Table 6.2.1.5-1)

TABLE 6.2.1.5.2.1-1
BAY 2 STANDARD ORBITER AIR FLOW/MIDDECK LOCATIONS

CONFIGURATION	LOCKER LOCATION	FLOW RATE (CFM)
-001	MF71E	18
-002	MF71E	18
-003	MF71E	18
-004	MF71E	18
-005	MF71E	0
-006	MF71E	0
-007	MF71E	0
-008	MF71E	0

TABLE 6.2.1.5.3-1
MAXIMUM BAY 3A DUCTED AIR COOLING CAPABILITY (6)

CABIN PRESSURE (PSIA)	COOLING CAPABILITY (WATTS) (1) (2)	FLOW RATE (CFM)	AVG DELTA T ACROSS P/L (DEG F) (3)	INLET TEMPERATURE (DEG F) (4)
14.7	1000	180	17.5	65-80 (Normal Operations) 95 Max Peak (Ascent/Descent) (5)

Notes:
(1) Capability assumes no active air cooling required for TACAN support.
(2) Capability assumes UHF communications box installed in Bay 3A.
(3) Average payload delta T shown for reference.
(4) Inlet temperature of 80 deg F assumes no heat transfer payload flow recirculation.
(5) Transient profiles per Figures 6.1-1 and 6.1-2.
(6) Refer to Table 6.2.1.5-1 for vehicle availability.

TABLE 6.2.1.5.3.1-1
BAY 3A STANDARD ORBITER AIR FLOW/MIDDECK LOCATION
CONFIGURATION “1”

LOCKER LOCATION	FLOW RATE
MA9D	36
MA9F	0
MA9G	36
MA9J	36
MA16D	0
MA16F	36
MA16G	0
MA16J	36

TABLE 6.2.1.5.3.1-2
BAY 3A STANDARD ORBITER AIR FLOW/MIDDECK LOCATION
CONFIGURATION “2”

LOCKER LOCATION	FLOW RATE (CFM)
MA9D	18
MA9F	18
MA9G	18
MA9J	36
MA16D	18
MA16F	18
MA16G	18
MA16J	36

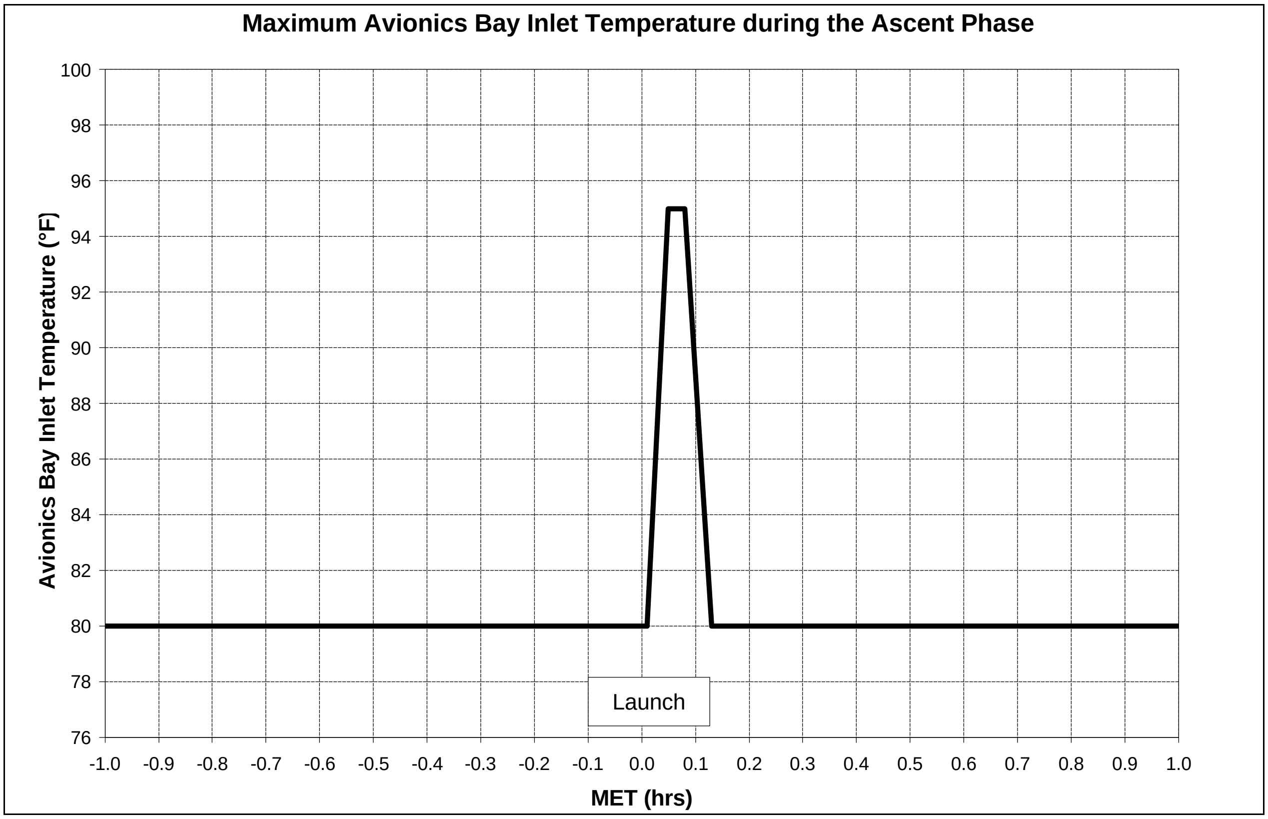


FIGURE 6.1-1
PAYLOAD INLET TEMPERATURE PROFILE DURING THE PRLAUNCH/ASCENT PHASE

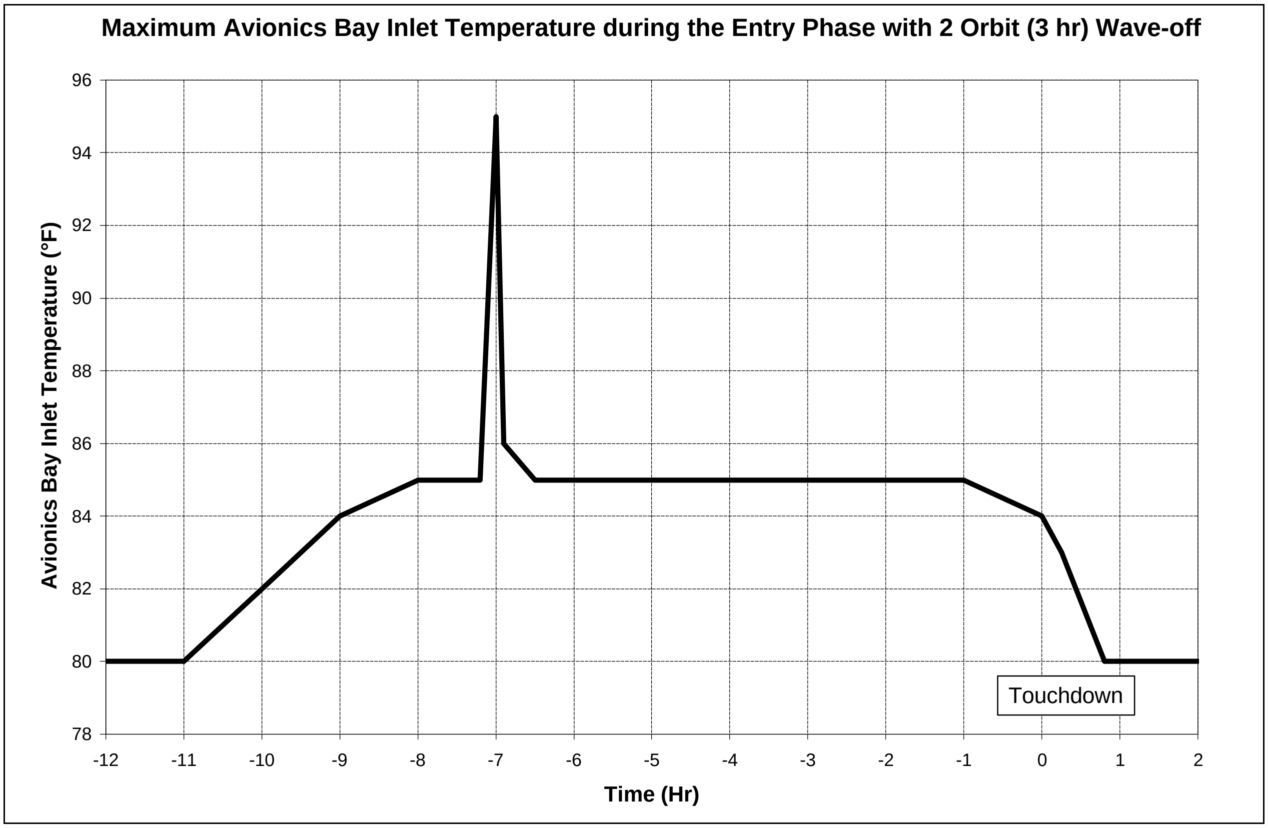
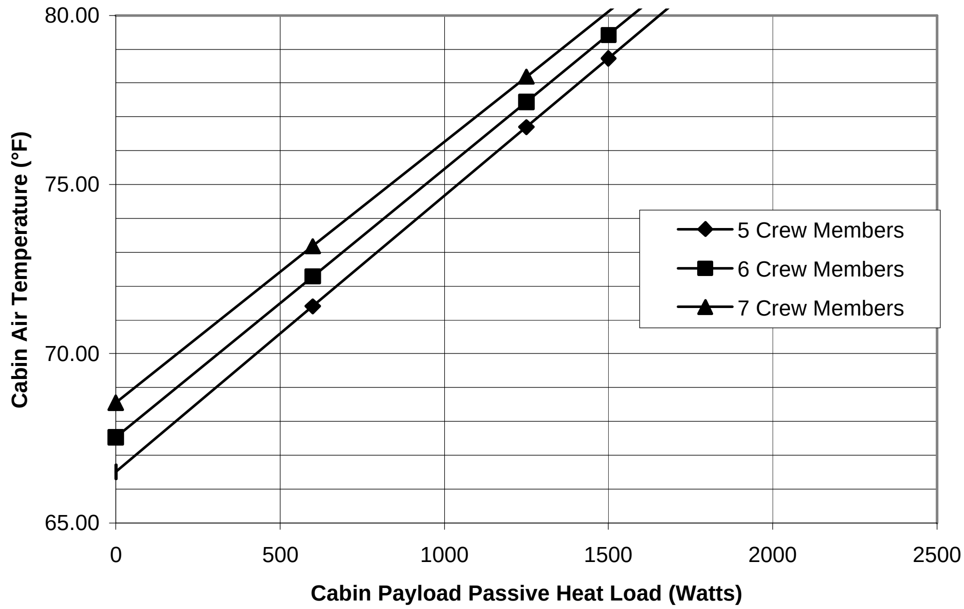


FIGURE 6.1-2
PAYLOAD INLET TEMPERATURE PROFILE DURING THE ENTRY/LANDING PHASE



Conditions:

Flow Proportioning Modules in 'Interchanger' Position
Interchanger Freon Flow rate = 4255 lb/hr
Cabin Pressure = 14.7 psia
Freon I/C Inlet Temperature = 38.5°F
QSOLAR = 637 Btu/hr
Interchanger Water Flow rate =850 lb/hr
Total Water Flow rate =1235 lb/hr
Air Bypass Valve at 'Full Cool'
QMS = 0
QPS = 0

Equations:

$$CTEMP = 62.43 + 8.15 \quad 10^{3} QCA + (NC \quad 5) \quad 1.13 \quad \frac{0.55QCA}{2500}$$

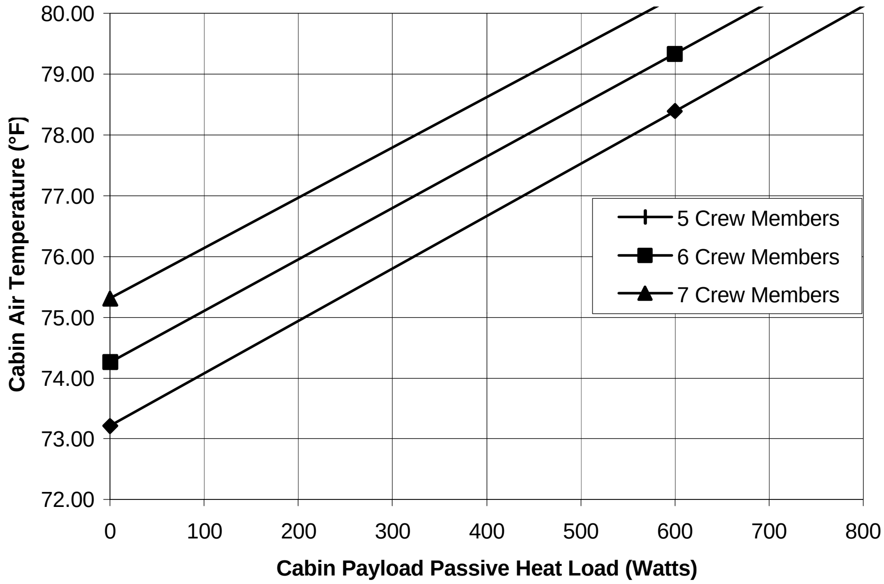
CTEMP=Cabin air temperature (°F)
QCA=Effective Cabin heat load (Watts)
NC=Number of Crewmembers

$$QCA = QTP + \frac{(QMS + QPS)}{1.72} \quad \frac{14.7}{PRESS}^{0.232}$$

QTP = Payload Passive Heat Load + 500* (Watts)
QMS = Mission Specialist Station Active Heat Load (Watts)
QPS = Payload Specialist Station Active Heat Load (Watts)
PRESS = Cabin Pressure (psia)

*Average Orbiter Passive Heat Load

FIGURE 6.2.1.1-1 PAYLOAD CABIN PASSIVE HEAT LOAD CAPABILITY AT 14.7 PSIA AND FPM's IN INTERCHANGER POSITION
(Sheet 1 of 2)



<u>Conditions:</u>

Flow Proportioning Modules in ‘Payload’ Position
Interchanger Freon Flow rate = 2810 lb/hr
Cabin Pressure = 14.7 psia
Freon I/C Inlet Temperature = 38.5°F
QSOLAR = 637 Btu/hr
Interchanger Water Flow rate =850 lb/hr
Total Water Flow rate =1235 lb/hr
Air Bypass Valve at ‘Full Cool’

<u>Equations:</u>

$$CTEMP = 68.89 + 8.64 \times 10^{-3} QCA + (NC - 5) \times \left(1.14 - \frac{0.45QCA}{2000}\right)$$

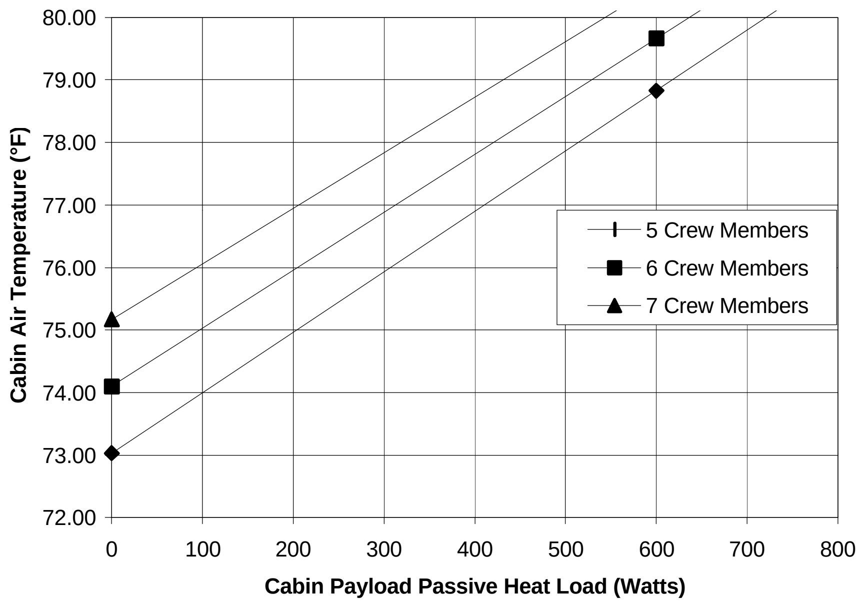
CTEMP=Cabin air temperature (°F)
QCA=Effective Cabin heat load (Watts)
NC=Number of Crewmembers

$$QCA = QTP + \frac{(QMS + QPS)}{1.72} \times \left(\frac{14.7}{PRESS}\right)^{0.232}$$

QTP = Payload Passive Heat Load + 500* (Watts)
QMS = Mission Specialist Station Active Heat Load (Watts)
QPS = Payload Specialist Station Active Heat Load (Watts)
PRESS = Cabin Pressure (psia)

*Average Orbiter Passive Heat Load

FIGURE 6.2.1.1-1 PAYLOAD CABIN PASSIVE HEAT LOAD CAPABILITY AT 14.7 PSIA AND FPM’s IN PAYLOAD POSITION
(Sheet 2 of 2)



<u>Conditions:</u>

Flow Proportioning Modules in ‘Interchanger’ Position
Interchanger Freon Flow rate = 4255 lb/hr
Cabin Pressure = 10.2 psia
Freon I/C Inlet Temperature = 38.5°F
QSOLAR = 637 Btu/hr
Interchanger Water Flow rate =850 lb/hr
Total Water Flow rate =1235 lb/hr
Air Bypass Valve at ‘Full Cool’

<u>Equations:</u>

$$CTEMP = 68.20 + 9.66 \quad 10^{3} QCA + (NC \quad 5) \quad 1.26 \quad \frac{0.96QCA}{2500}$$

CTEMP = Cabin air temperature (°F)
QCA = Effective Cabin heat load (Watts)
NC = Number of Crewmembers

$$QCA = QTP + \frac{(QMS + QPS)}{1.72} \quad \frac{14.7}{PRESS}{}^{0.232}$$

QTP = Payload Passive Heat Load + 500* (Watts)
QMS = Mission Specialist Station Active Heat Load (Watts)
QPS = Payload Specialist Station Active Heat Load (Watts)
PRESS = Cabin Pressure (psia)

*Average Orbiter Passive Heat Load

FIGURE 6.2.1.1-2 PAYLOAD CABIN PASSIVE HEAT LOAD CAPABILITY AT 10.2 PSIA AND FPM’s IN INTERCHANGER POSITION

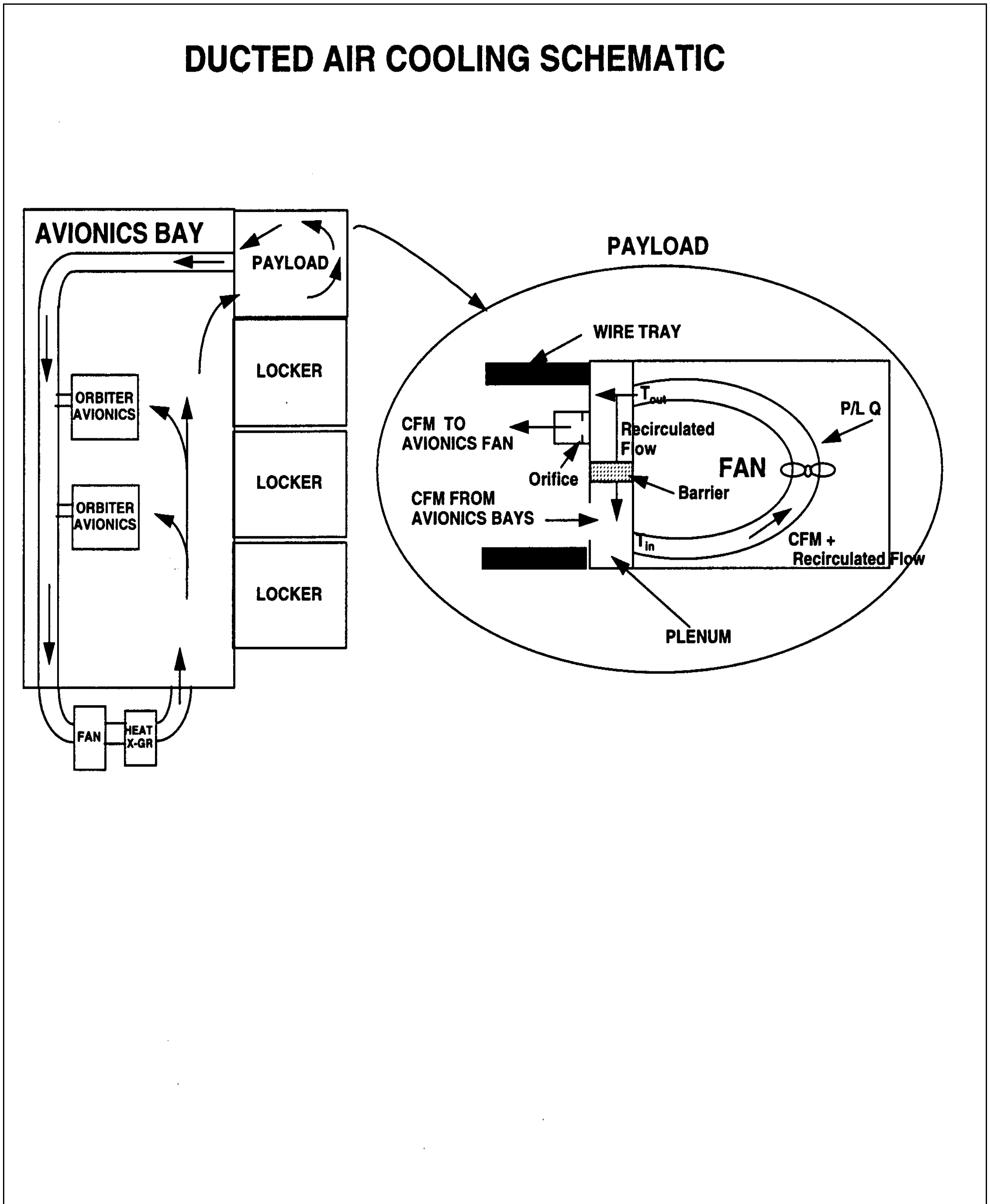


FIGURE 6.2.1.5-1 DUCTED AIR COOLING SCHEMATIC

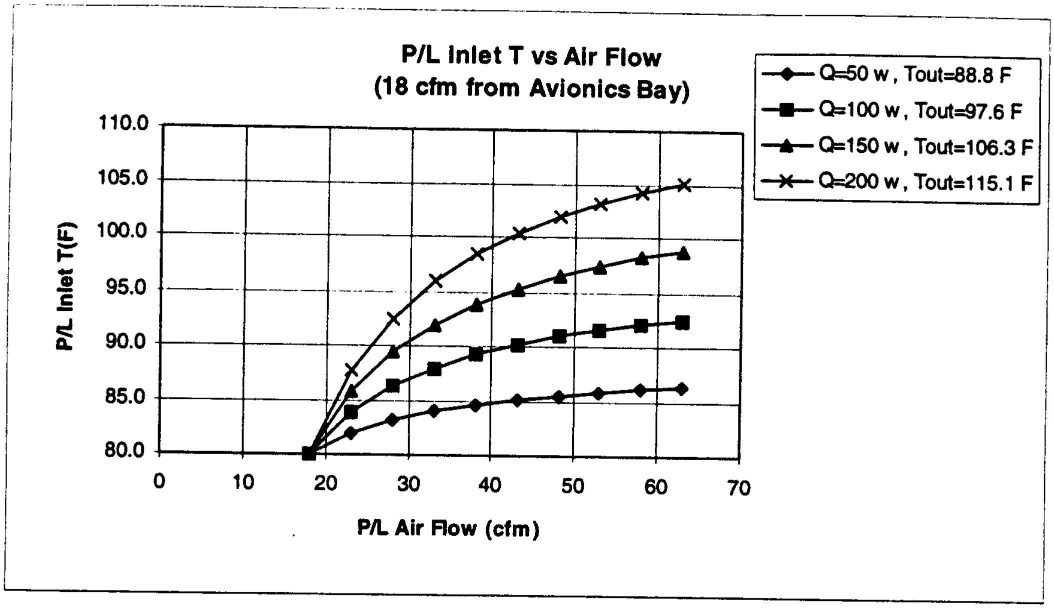


FIGURE 6.2.1.5.1-1 PAYLOAD INLET AIR TEMPERATURE WITH 18 CFM RECIRCULATION

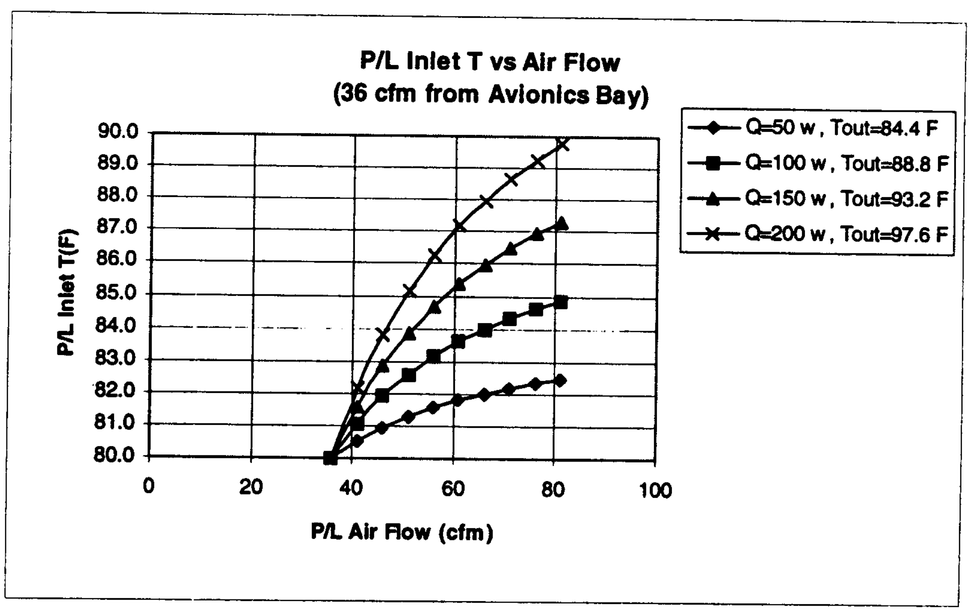


FIGURE 6.2.1.5.1-2 PAYLOAD INLET AIR TEMPERATURE WITH 36 CFM RECIRCULATION

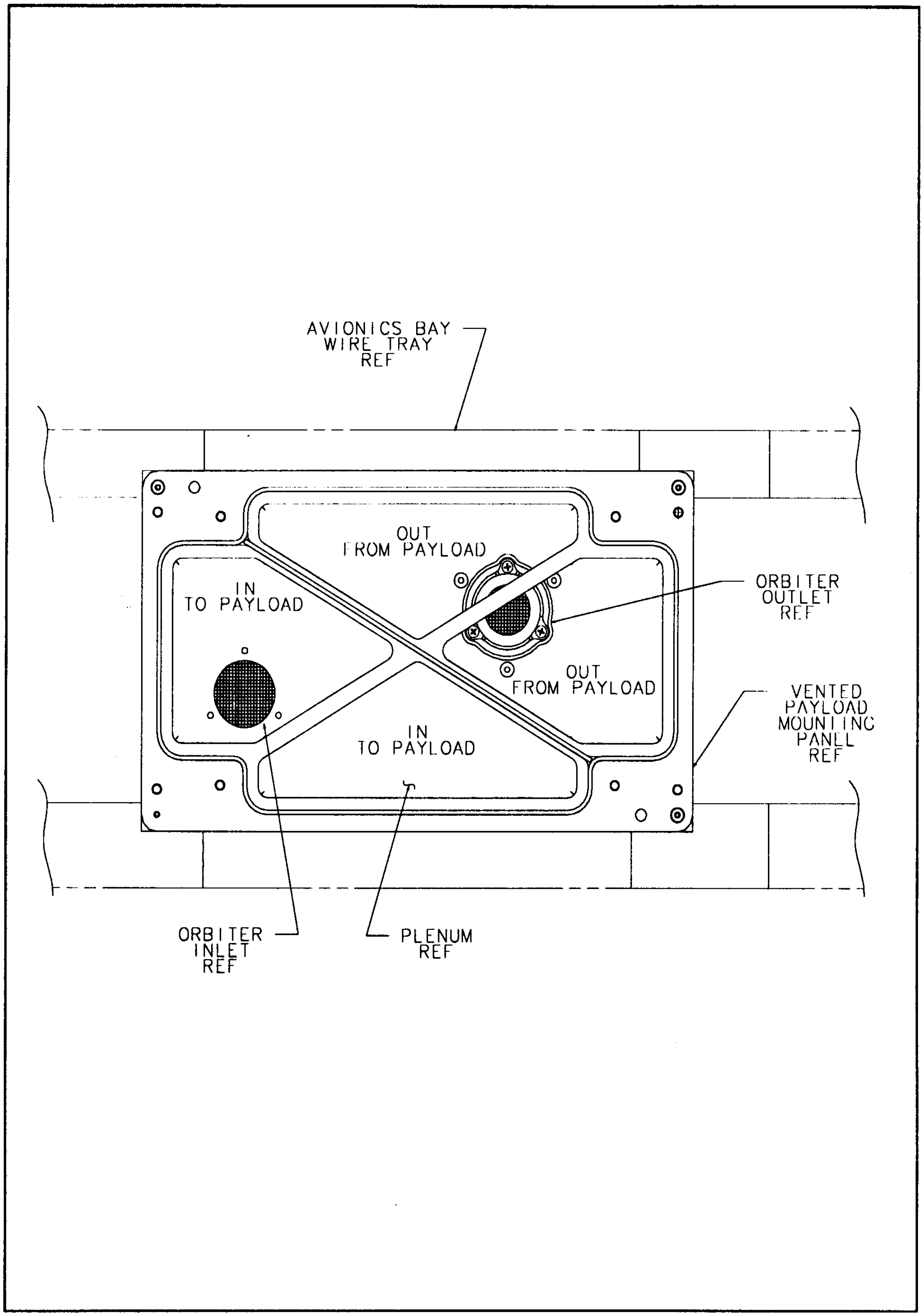


FIGURE 6.2.1.5.5.1-1 SINGLE SIZE PAYLOAD AIR FLOW FUNCTIONAL INTERFACE

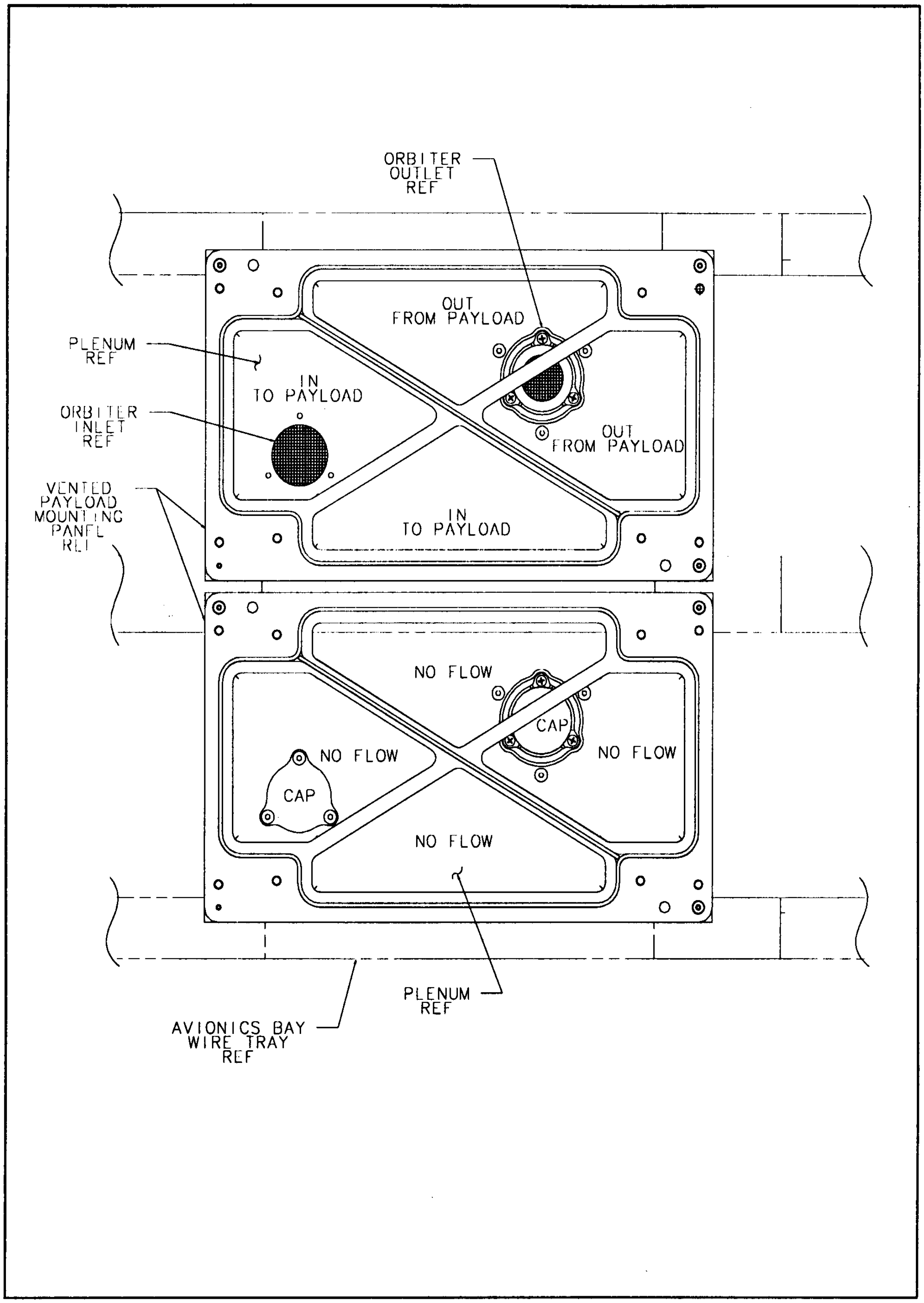


FIGURE 6.2.1.5.5.2-1 DOUBLE SIZE PAYLOAD AIR FLOW FUNCTIONAL INTERFACE-TOP PAYLOAD INLET AND OUTLETS

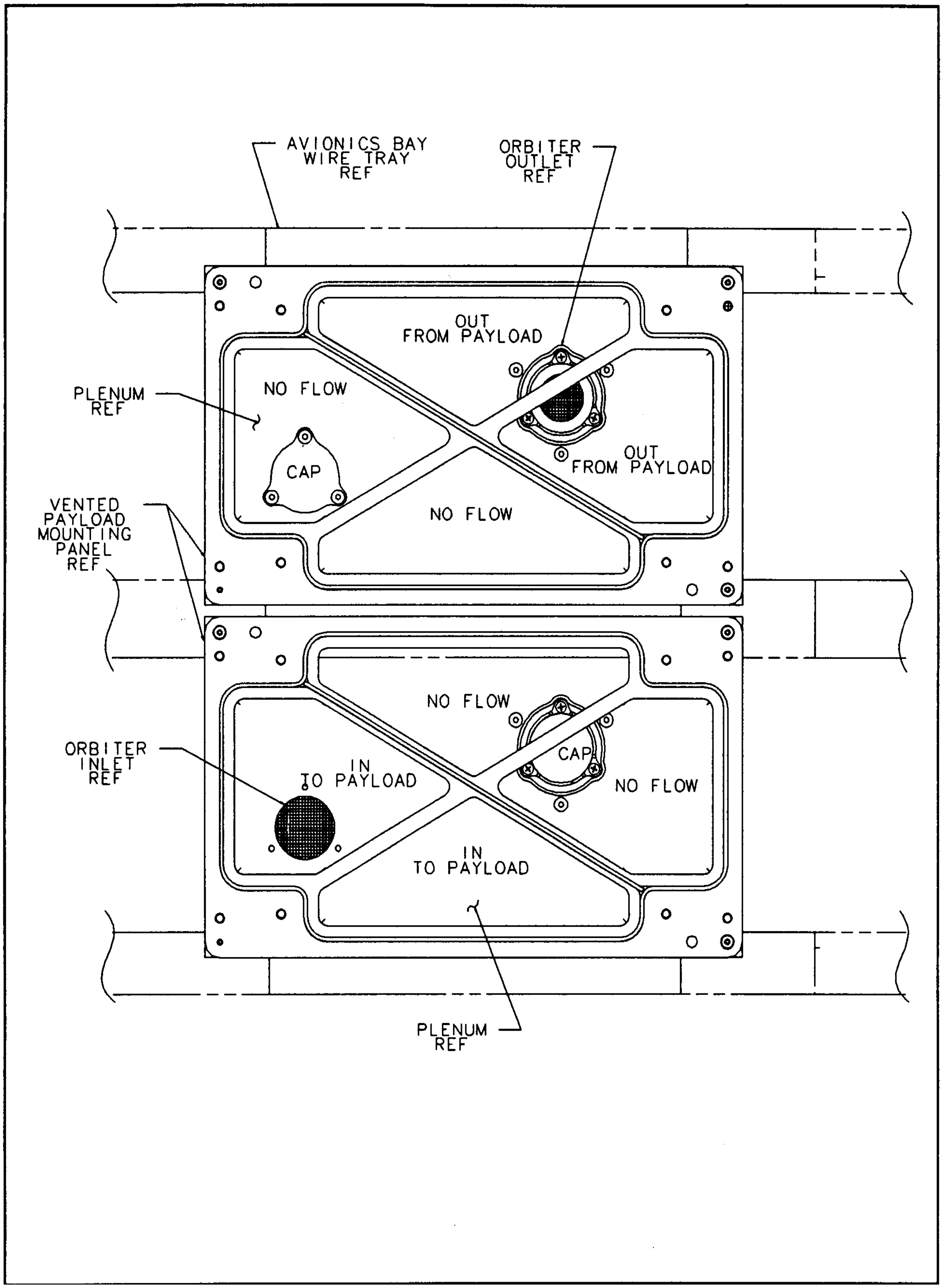


FIGURE 6.2.1.5.5.2-2 DOUBLE SIZE PAYLOAD AIR FLOW FUNCTIONAL INTERFACE - TOP OUTLET/ BOTTOM INLET (MINIMUM 0.75 INCH RECIRCULATION GAP)

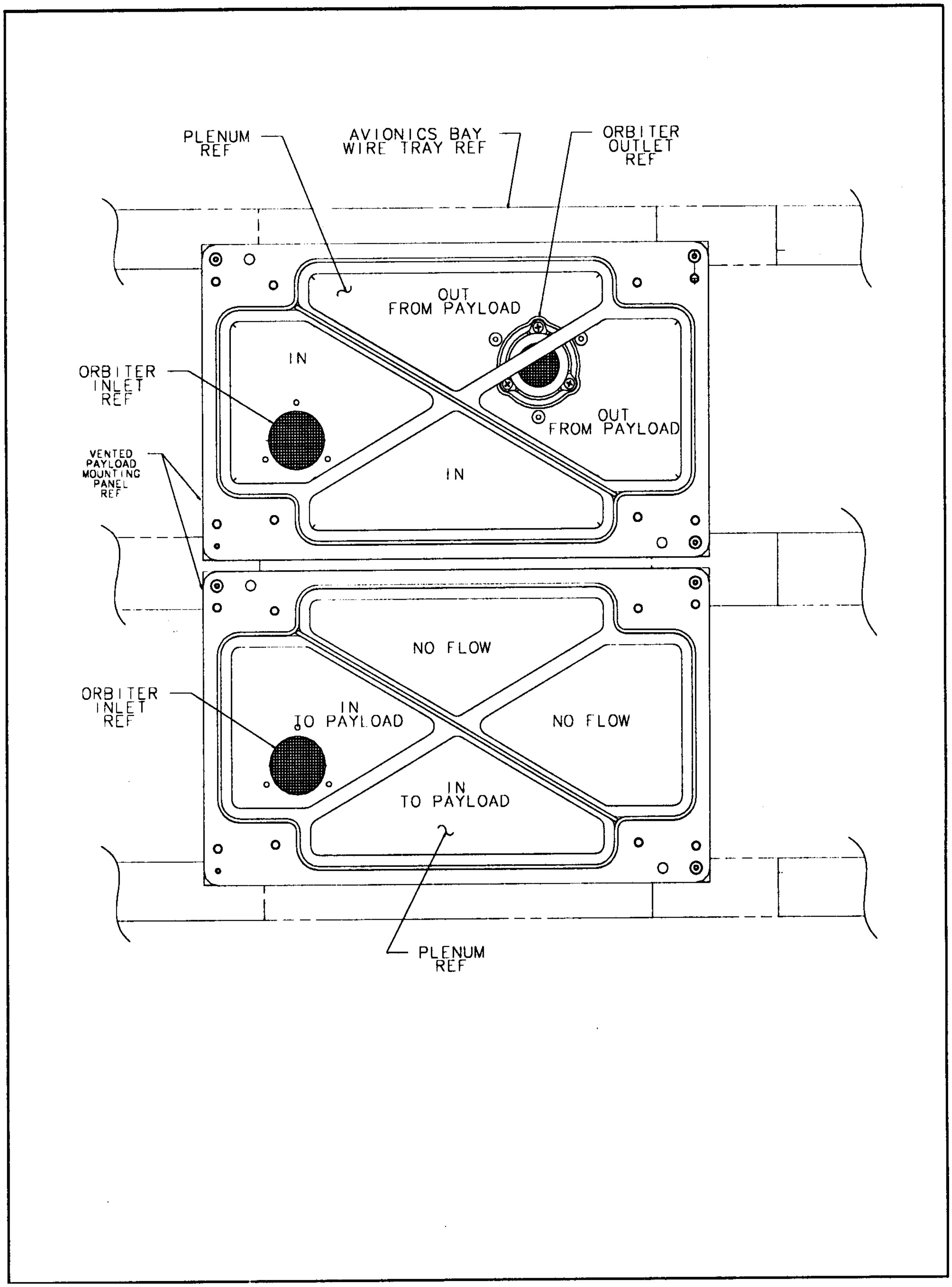


FIGURE 6.2.1.5.5.2-3
DOUBLE SIZE PAYLOAD AIR FLOW FUNCTIONAL INTERFACE - TOP OUTLET /BOTTOM AND TOP INLET (NO MINIMUM 0.75 INCH RECIRCULATION GAP)

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7.0 Electrical Power Interfaces

7.1 Electrical Energy

7.1.1 Baseline Energy Allocation

The payload is required to minimize electrical power requirements. Those payloads which have DC power requirements greater than 130 W may limit the number of manifest possibilities. Total power (including middeck, AFD and Cargo bay payloads) shall not exceed the Orbiter capabilities as defined in ICD-2-19001 and NSTS 21000-IDD-ISS. Total Prelaunch, Ascent, Descent, and Post-landing power usage is limited by thermal constraints (see paragraph 6.2.1.1). The length of the power feeder cable for a particular payload cannot be determined until the time it is manifested on a mission and the middeck configuration is determined. The mission unique Crew Compartment Configuration Drawing (CCCD) will define the power feeder cable length and routing for each middeck payload.

7.2 DC Power Characteristics

Total Pre-launch, Ascent, Descent, and Post-landing DC power capability shall be as shown in Table 7.2-1, but is also limited by thermal constraints (see paragraph 6.2.1.1). Maximum continuous power that could be available during ascent and descent is 400 W. A maximum of 1800 W DC is available continuously on-orbit with the restrictions imposed by paragraph 6.2.1.1. A reduction of power is required during ascent and descent due to the dedicated use of the ceiling outlets MO52J, MO30F and portions of ML85E (Middeck Utility Panel (MUP)) by the crew suits. Power panel MO63P availability shall be as shown in Table 7.2-2.

7.2.1 Middeck Power and Voltage

7.2.1.1 10 Amp Middeck Power and Voltage

Orbiter main DC electrical power is available to payloads via the MUP (ML85E), middeck ceiling outlet panels MO13Q, MO30F, MO52J, and MO63P. No power shall be available during ascent/descent from ceiling outlet panels MO52J, MO30F and portions of the MUP. Minimum interface voltage levels (maximum is 32.0 VDC) as measured at the payload end of SSP-provided DC cables are shown in Figures 7.2.1.1-1, 7.2.1.1-2 and 7.2.1.1-3.

7.2.1.2 15 Amp Middeck Power and Voltage

Orbiter main DC electrical power is also available to payloads via the MO63P 15 Amp outlets J2 and J5. Minimum interface voltage levels (maximum is 32.0 VDC) as measured at the payload end of the SSP provided DC power cables are shown in Figure 7.2.1.2-1. J2 is only available when J3 or J4 (10 amp) outlets are not used and vice versa. Also, J5 is only available when J6 (10 amp) outlet is not used and vice versa.

7.2.1.3 20 Amp Middeck Power and Voltage
Orbiter main DC electrical power is also available to payloads via the ML85E (MUP) 20 Amp outlets J11 and J21. Minimum interface voltage levels (maximum is 32.0 VDC) as measured at the payload end of the SSP provided DC power cables are shown in Figure 7.2.1.3-1. The 20 amp ML85E (MUP) outlets are only available when the associated 10 amp circuits are not used.

7.2.1.4 Overload Protection
Circuit protection for each middeck ceiling outlet is provided by a 10 amp circuit breaker (derated to 9.5 amps) which in some cases shall also protect aft flight deck utility outlets. Circuit protection for panel MO63P outlets is provided by 10 amp and 15 amp circuit breakers (derated respectively to 9.5 an 14.25 amps). Circuit protection for ML85E (MUP) outlets is provided by 10 amp and 20 amp circuit breakers (derated respectively to 9.5 and 19.0 amps). Refer to Figure 7.2.1.4-1 for each utility power distribution system.

7.2.1.5 Current Limiting
Payload electrical power distribution circuitry shall be designed such that electrical faults do not damage Orbiter wiring nor present a hazard to the Orbiter or crew. Circuit protection devices shall be incorporated into the payload design when payload power distribution wiring is routed within a crew volume.

Orbiter electrical wiring insulation is rated at 200 degree Centigrade. Cargo element circuit protection design shall comply with NASA electrical design criteria for cargo element circuit protection as defined in NSTS 18798.

TABLE 7.2-1
MIDDECK PAYLOAD DC ALLOCATION

MISSION PHASE	ALLOCATION (WATTS)	PHASE ALLOCATION ASSUMPTIONS
PRE-LAUNCH	400	
ASCENT	400	CAPABILITY FROM L-5 HOURS UNTIL OMS-2 BURN + 30 MINUTES. REDUCTION IN MAXIMUM CAPABILITY ACCOUNTS FOR CREW SUIT REQUIREMENTS
ON-ORBIT	1800	CAPABILITY UNTIL DE-ORBIT PREP OPERATIONS AT TD-3 HOURS
DESCENT	400	CAPABILITY FROM TD-3 HOURS UNTIL TD+1 HOURS. REDUCTION IN MAXIMUM CAPABILITY ACCOUNTS FOR CREW SUIT REQUIREMENTS.
POST-LANDING	400	

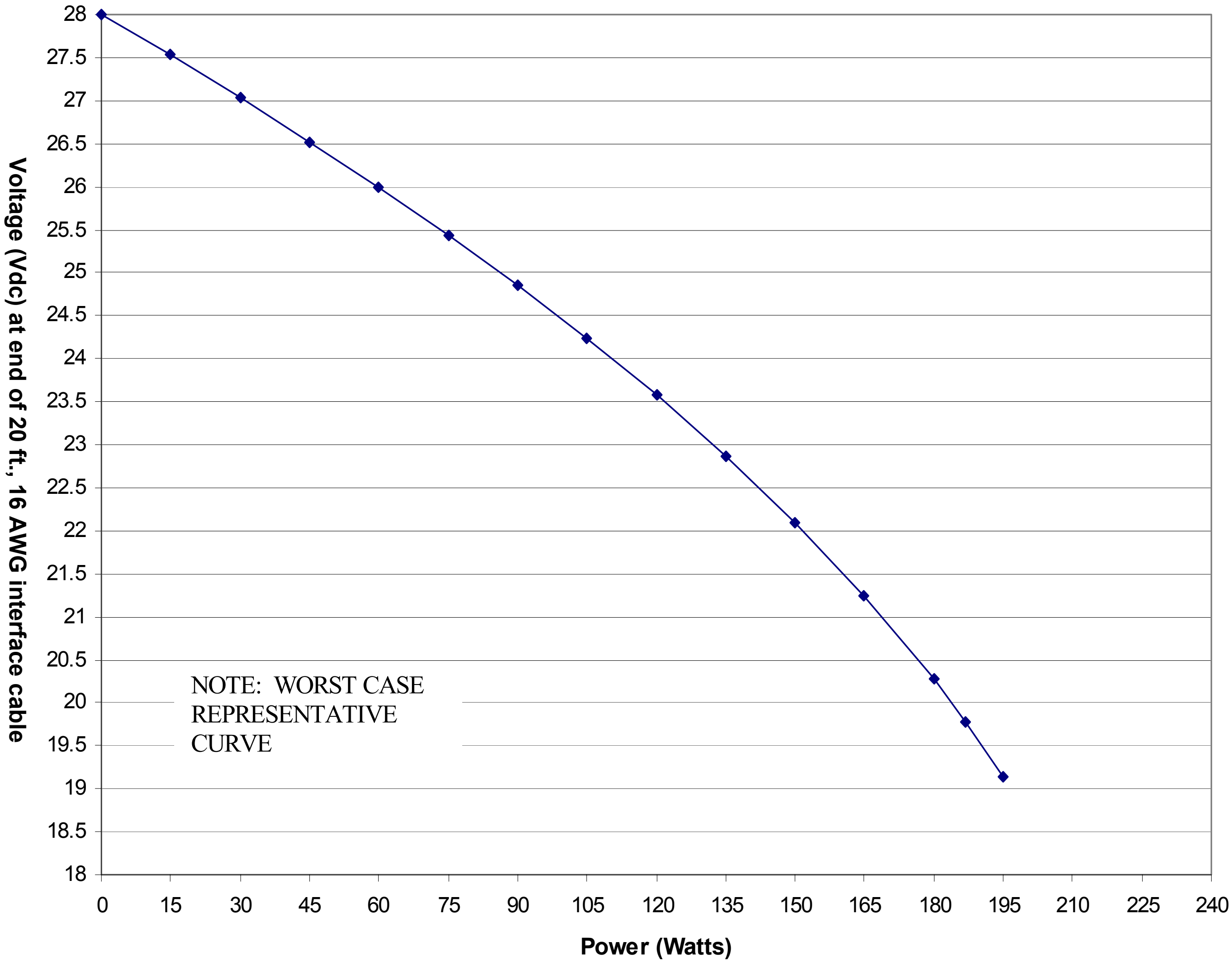


FIGURE 7.2.1.1-1 CEILING DC OUTLET CHARACTERISTICS

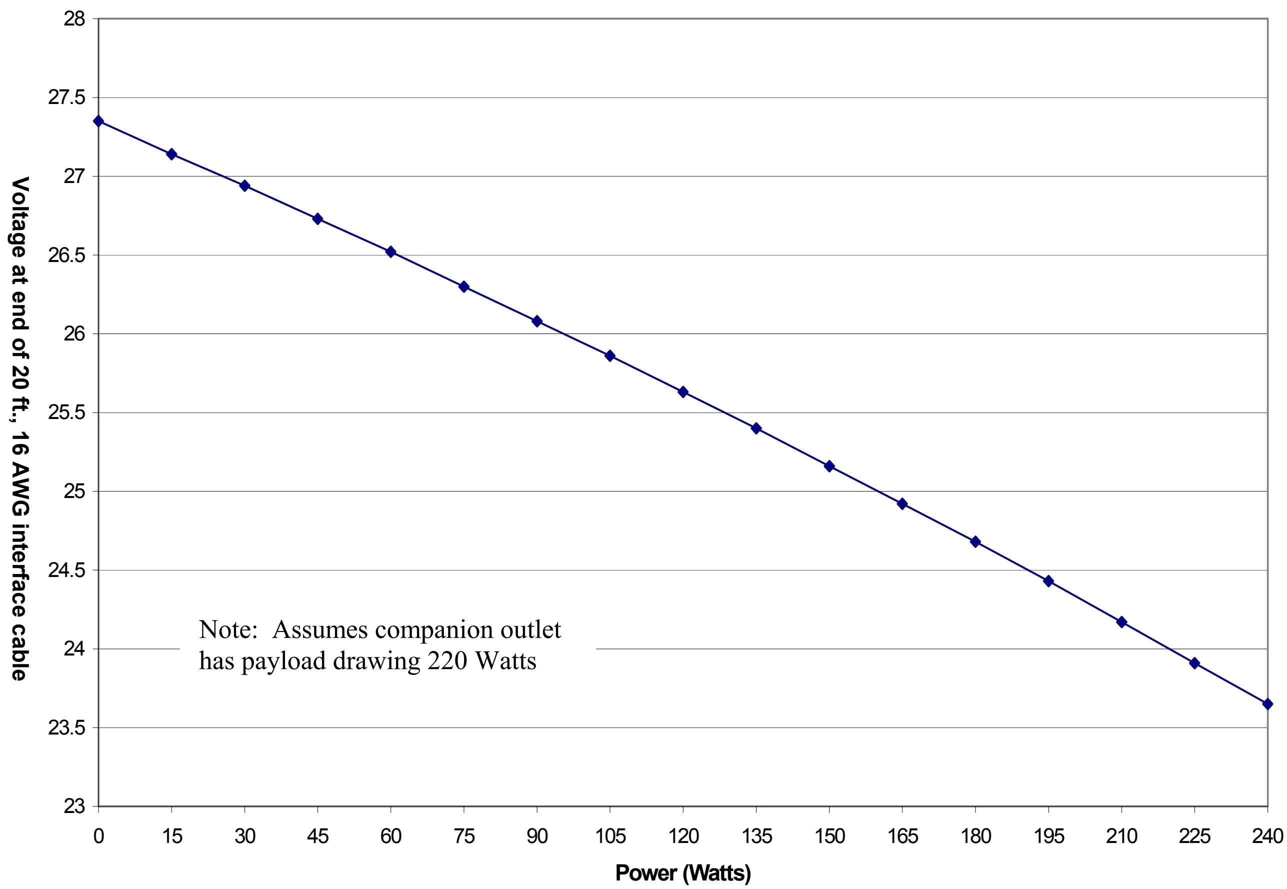


FIGURE 7.2.1.1-2 10 AMP ML85E (MUP) OUTLET CHARACTERISTICS

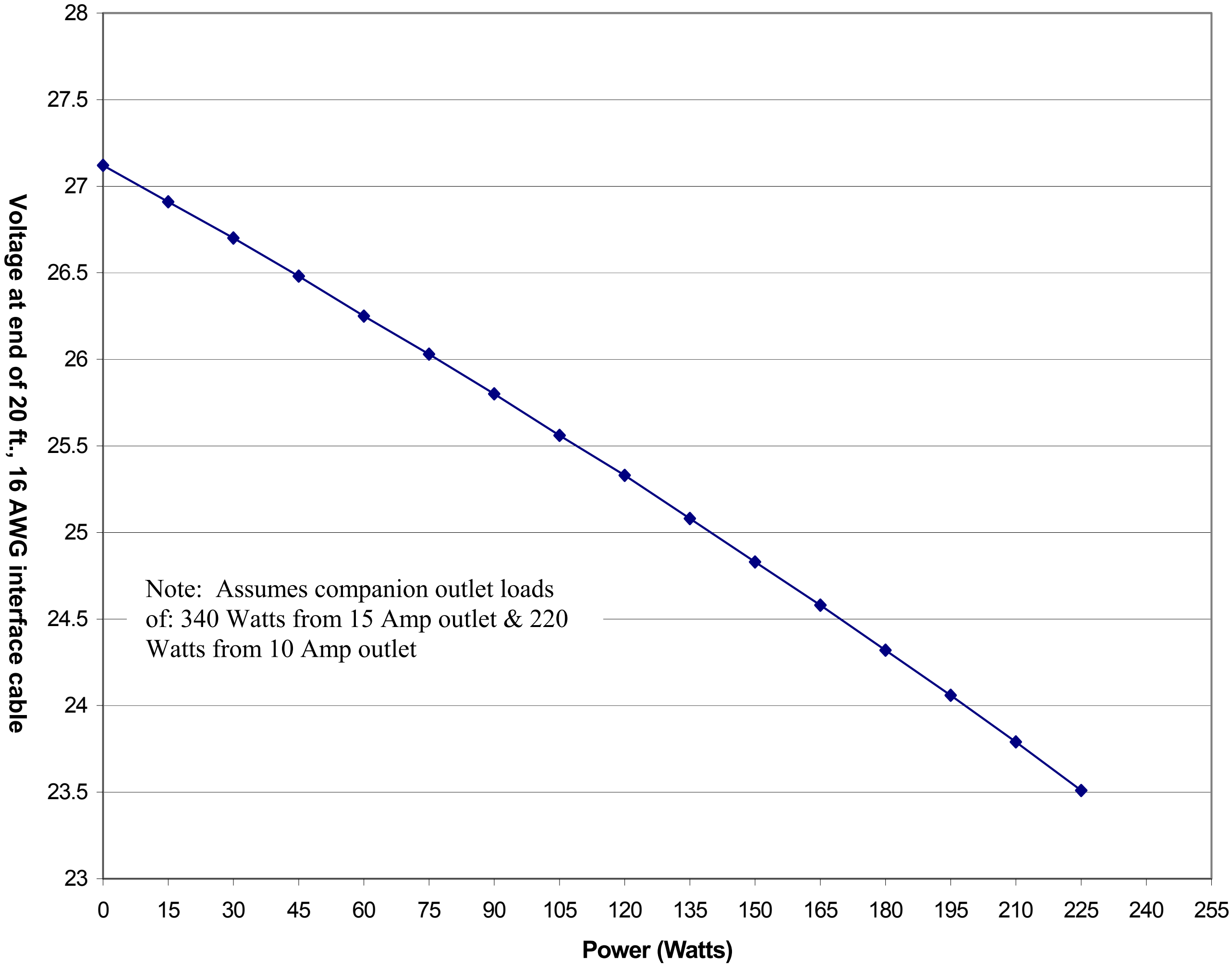


FIGURE 7.2.1.1-3 10 AMP MO63P OUTLET CHARACTERISTICS

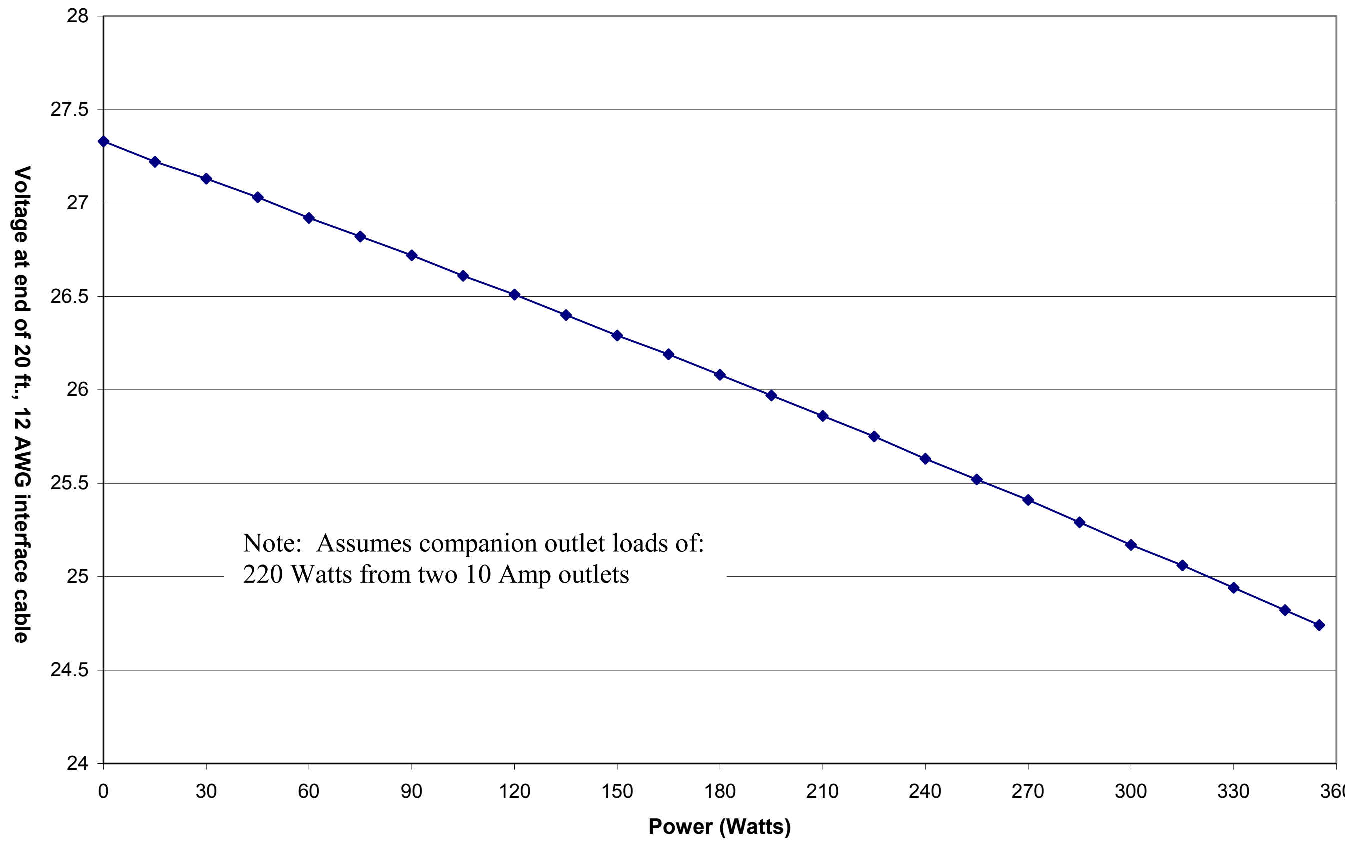


FIGURE 7.2.1.2-1 15 AMP MO63P OUTLET CHARACTERISTICS

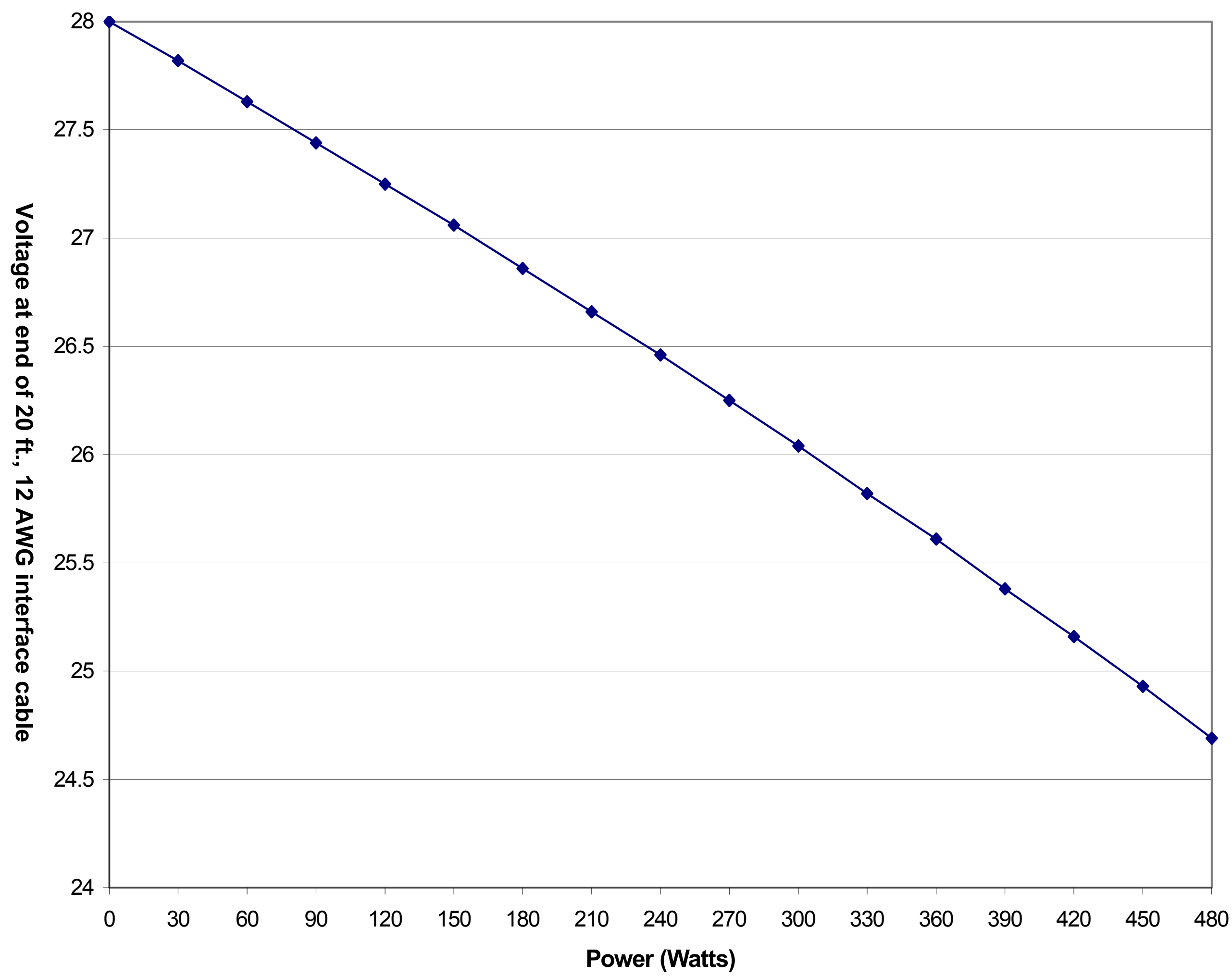


FIGURE 7.2.1.3-1 20 AMP ML85E (MUP) OUTLET CHARACTERISTICS

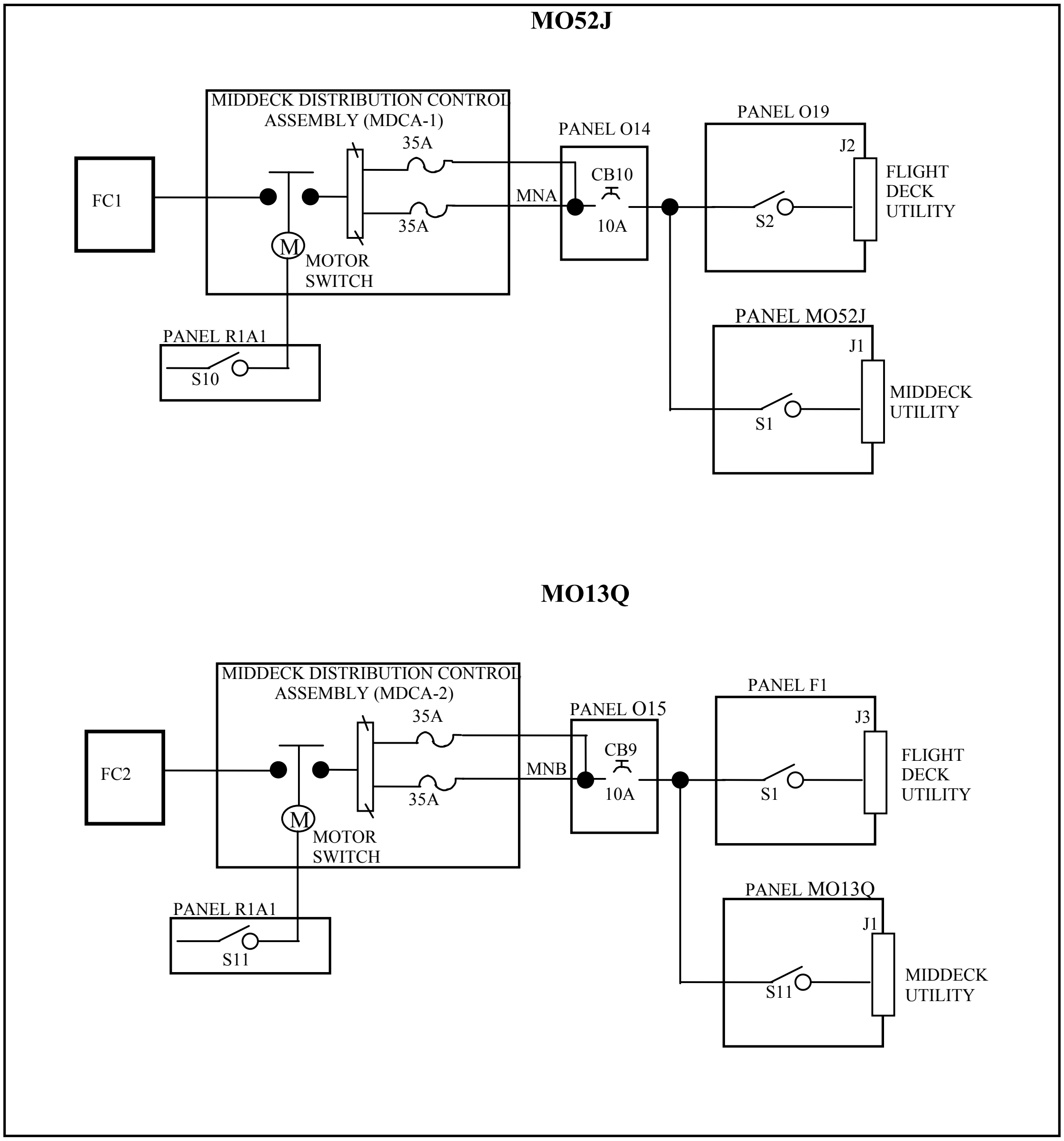


FIGURE 7.2.1.4-1 MIDDECK POWER DISTRIBUTION (MO52J AND MO13Q)
(SHEET 1 OF 4)

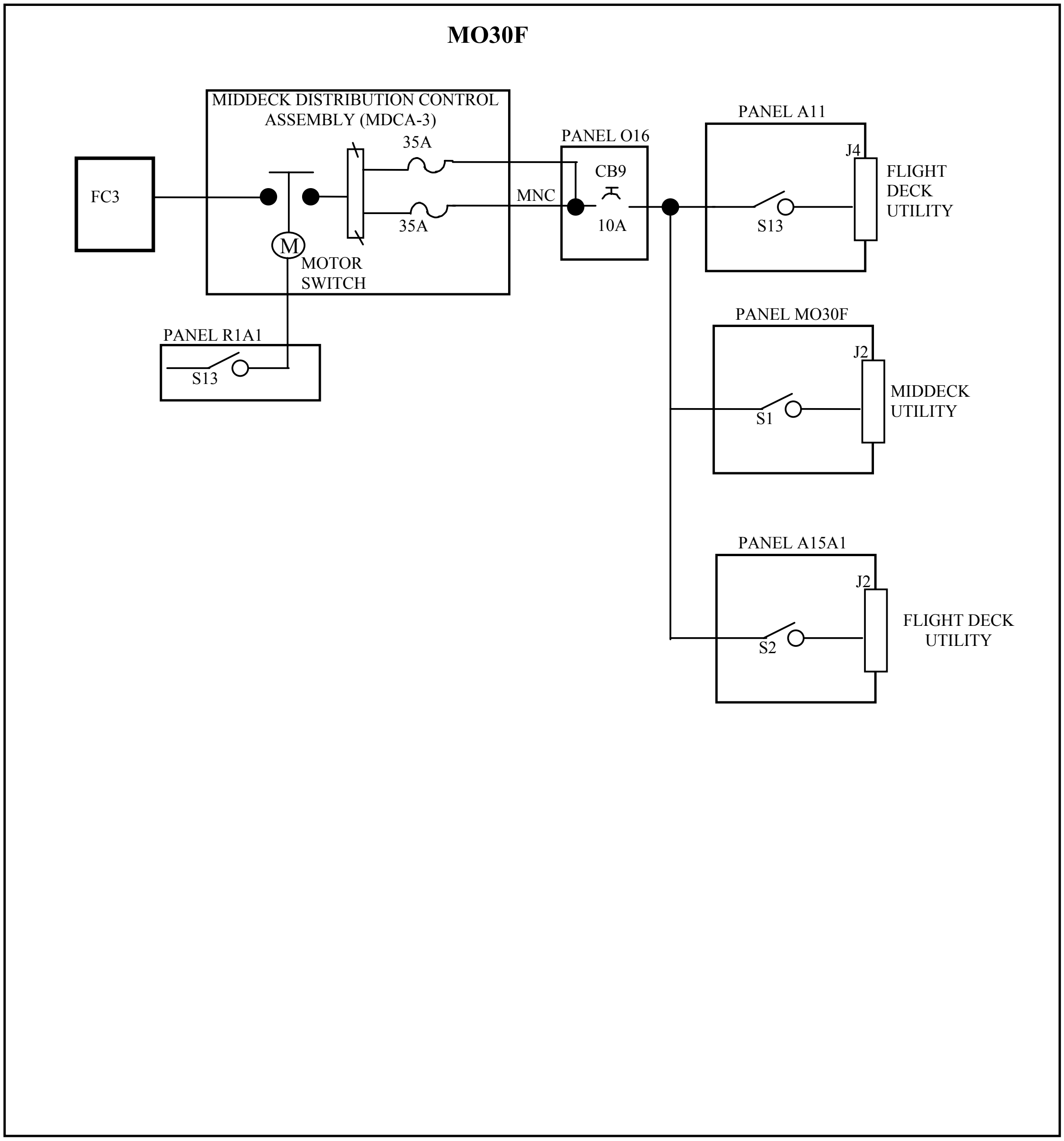
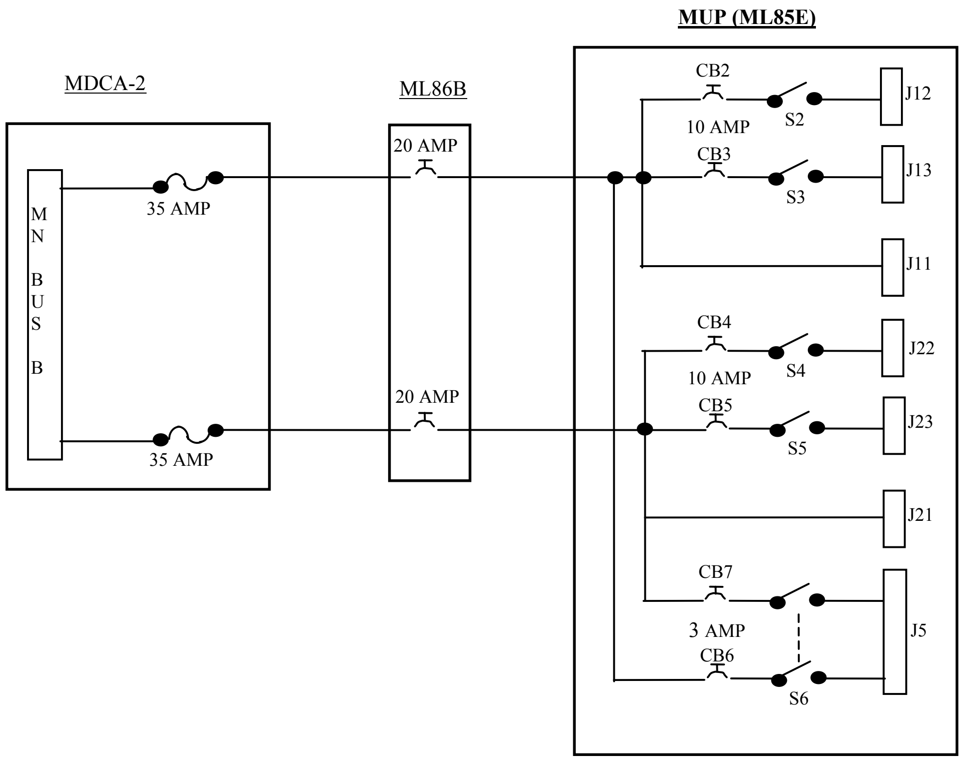


FIGURE 7.2.1.4-1 MIDDECK POWER DISTRIBUTION (MO30F)
(SHEET 2 OF 4)



NOTE: OUTLETS J11 AND J21 ARE ONLY AVAILABLE WHEN ASSOCIATED 10 AMP OUTLETS ARE NOT USED (J12 & J13, J22 & J23). J5 OUTLET RESERVED FOR MAR COOLING PUMP.

FIGURE 7.2.1.4-1 MIDDECK POWER DISTRIBUTION (ML85E (MUP))
(SHEET 3 OF 4)

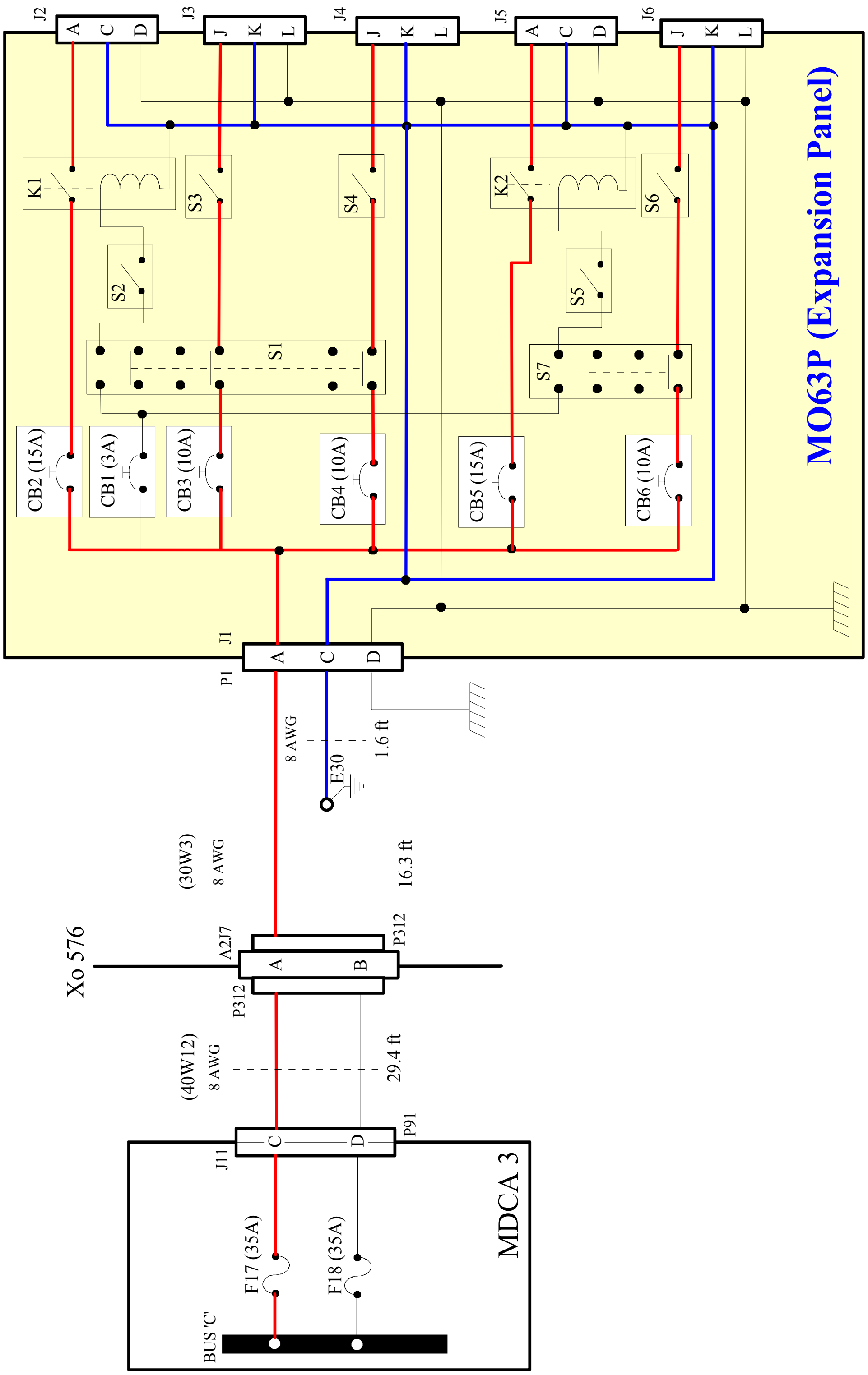


FIGURE 7.2.1.4-1 MO63P POWER PANEL
(SHEET 4 OF 4)

7.2.2 Ripple and Transient Spike (Repetitive) Limits

Ripple and transient spike limits for electrical power provided by the Orbiter at the indicated interfaces shall not exceed the voltage values specified in the following subparagraphs:

a. In-flight DC power bus ripple at the interface shall not exceed:

1. 0.9 volts peak to peak narrowband (30 Hz to 7 kHz) falling 10 dB per decade to 0.28 volts peak-to- peak at 70 kHz, thereafter remaining constant to 250 kHz.

   On orbit, during the Orbiter hydraulic circulation pump start up (300 milliseconds) a sawtooth ripple voltage of 4 volts peak-to-peak amplitude will appear on the 28 volt DC power bus at a frequency of 500 to 700 Hz.

2. The momentary coincidence of 2 or more signals at any one frequency shall not exceed the envelope defined as 1.6 volts peak-to-peak (30 Hz to 7 kHz), falling 10 dB per decade to 0.5 volts peak-to-peak at 70 kHz, thereafter remaining constant to 250 kHz.

b. In-flight DC Power Transient Spikes (Repetitive).

1. In-flight DC power transient spikes appear at the payload interface as measured differential mode (line to line). A typical positive transient is shown in Figure 7.2.2-1. A typical negative transient is shown in Figure 7.2.2-2.

c. Ground DC Power.

1. The narrowband ripple voltage at the interface shall not exceed an envelope with the limits 1.2 volts peak-to-peak (30 Hz to 7 kHz), falling log-linear to 0.28 volts peak-to-peak at 70 kHz, thereafter remaining constant to 250 kHz.

2. The momentary coincidence of two or more signals at any one frequency shall not exceed an envelope with limits 2.0 volts peak-to-peak (30 Hz to 7 kHz), falling log-linear to 0.5 volts peak-to-peak at 70 kHz, thereafter remaining constant to 250 kHz.

3. Ground power transients on the Orbiter DC power buses appear at the payload interface as measured differential mode (line to line). A typical positive transient is shown in Figure 7.2.2-1. A typical negative transient is shown in Figure 7.2.2-2.

4. When the Orbiter is on ground power, hydraulic circulation pump start-up will produce voltage transients on the DC bus connected to the pump and all sub-buses for that bus. The oscillations have a base frequency between 500 and 700

Hertz with a duration of approximately 250 to 300 milliseconds and an amplitude of 14 volts. Only one pump motor shall be turned on at a time. Hydraulic pump operations is required at the commencement of cryo loading.

7.2.2.1 Susceptibility Testing

7.2.2.1.1 Methodology and Recommended Testing

It is recommended that the techniques and/or test methods of SL-E-0002 be followed when required to demonstrate compatibility with the STS DC power bus environments. The recommended limits and test methods to demonstrate compatibility with the environment are those of CS101 (from 30 Hz and extended to 250 kHz) for power bus ripple and CS106 for power bus transients. For positive transients shown in Figure 7.2.2-1, measurements shall be made into a 50-Ohm source. The test methods of SL-E-0002 for Hydraulic Circulation Pump Transients on the Aft Power Busses shall also apply to Middeck busses however, the test limits shall be 6 volts peak to peak.

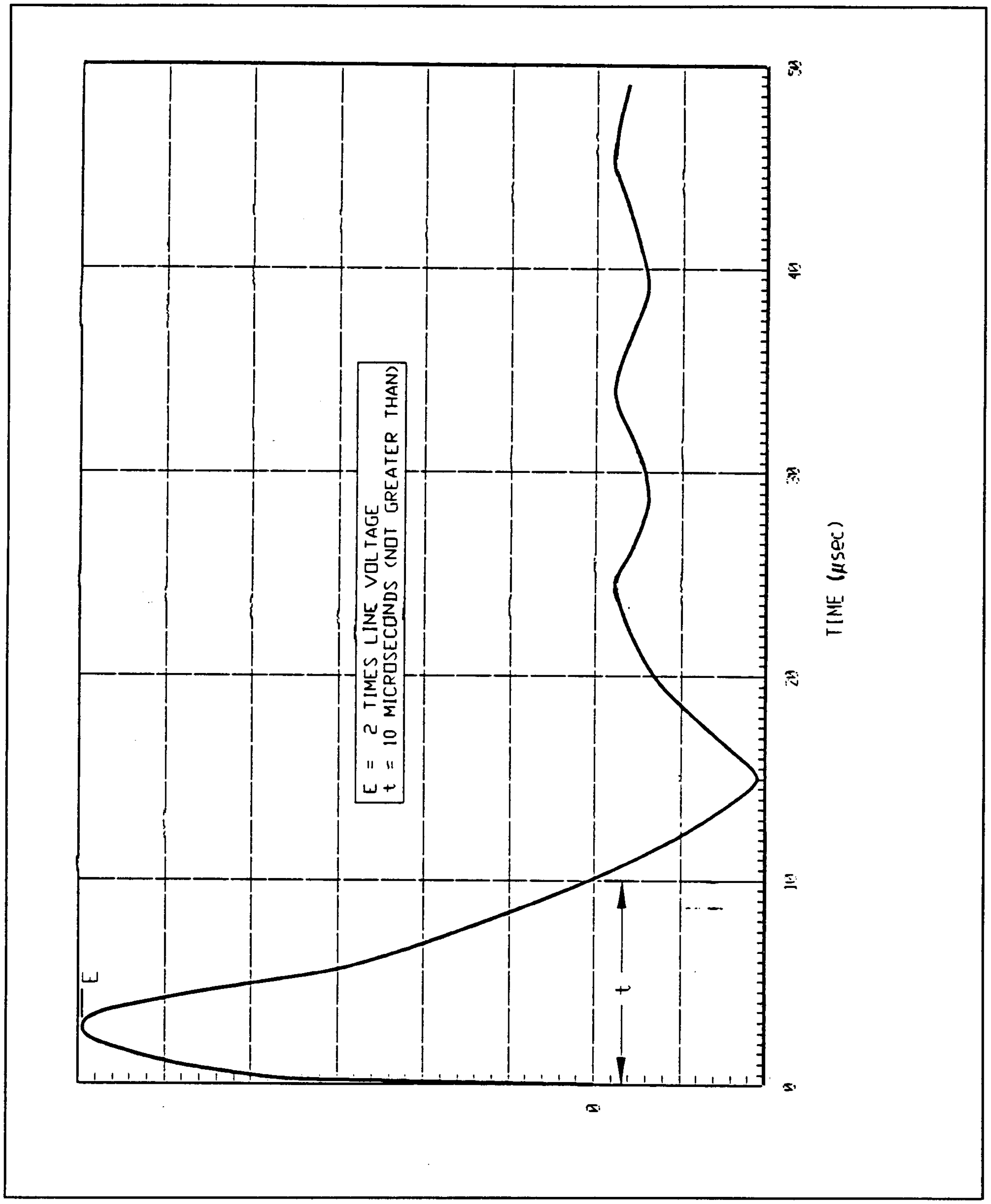


FIGURE 7.2.2-1 IN-FLIGHT AND GROUND DC POWER POSITIVE TRANSIENTS (MEASURED LINE-TO-LINE) AT ALL CARGO ELEMENT DC POWER INTERFACES

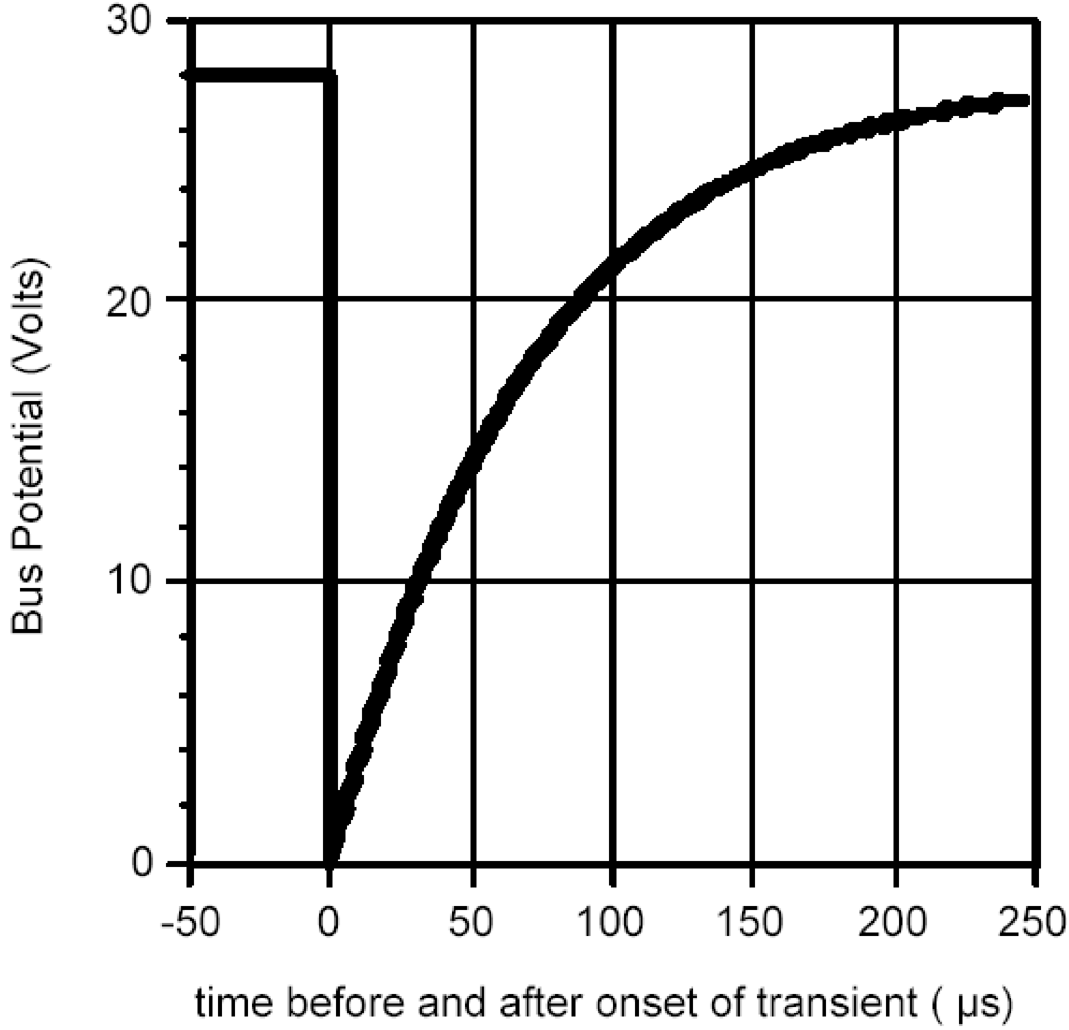


FIGURE 7.2.2-2 IN FLIGHT AND GROUND DC POWER NEGATIVE TRANSIENTS AT ALL CARGO ELEMENT DC POWER INTERFACES

7.3 AC Power Characteristics

7.3.1 Middeck Power and Voltage

Orbiter AC power is available as an optional service to payloads via outlet panels M013Q and MUP (refer to Figure 9.1-1) . AC power is not available during pre-launch and ascent/descent mission phases. The AC power available from any panel shall be limited to 300 volt amps (VA). AC loads greater than 100 VA must be balanced three phase loads.

7.3.1.1 Overload Protection

Circuit protection for the middeck ceiling outlets and MUP is provided by 3 amp, per phase, circuit breakers (derated 2,85 amps). The circuit breakers for the middeck ceiling outlets shall also protect the aft flight deck utility outlets. Refer to figure 7.3.1.1-1 for each utility power distribution system.

7.3.1.2 Voltage Characteristics

Voltage characteristics on each AC power bus shall be as specified below:

Type:	AC, 3- phase, 4- wire, wye.
Voltage:	System : 115 volts RMS Steady0state: 115 ±5 volts RMS Modulation: 3.5 volts maximum when measured as the peak-to-valley difference between the maximum and minimum voltages reached over a period of at least one second. Transient limits: 115 ±15 volts RMS - with 5 to 10 msec recovery to steady-state limits. Recovery to steady-steady limits. Spikes: -600 volts to +600 volts (refer to paragraph 7.3.1.3)
Frequency:	Limits: 400 ±7 Modulation: ±1 Hz
Waveform:	Sine with crest factor of 1.41 + 0.15 Total harmonic: 5 percent of fundamental Individual harmonic: 4 percent of the fundamental RMS when measured with a harmonic analyzer.
Phase:	Sequence: A-B-C Displacement: 120 ± 2 °

Power Factor:	Equipment shall present as near unity power factor as practicable. The fully loaded equipment loads shall present a power factor on the worst phase within the limits defined in Figure 7.3.1.2-1.

In addition, the average Orbiter Inverter efficiency is 76.5 percent. Inverter losses in supplying AC power to the cargo shall be included in calculations of Cargo changeable energy.

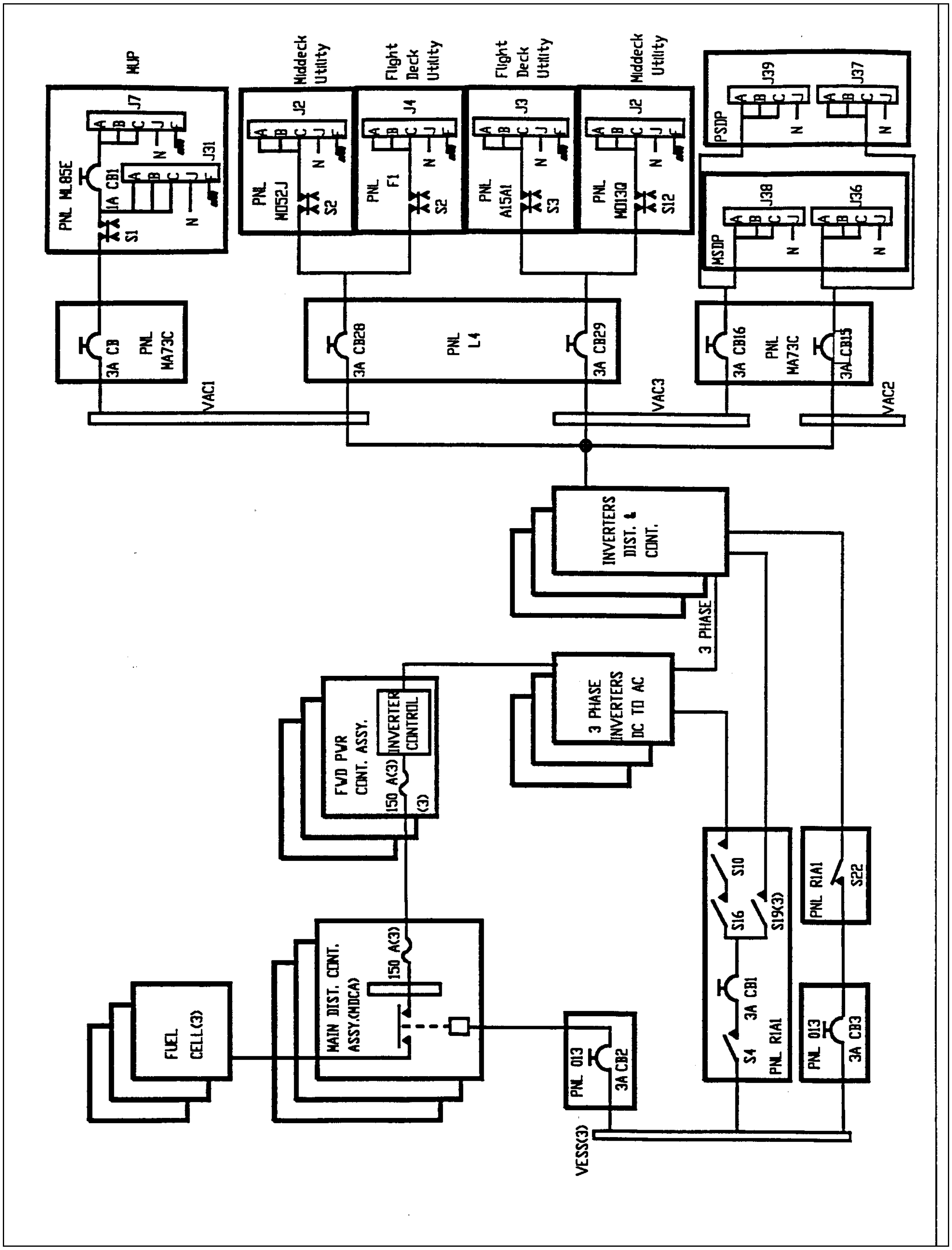


FIGURE 7.3.1.1-1 AC POWER DISTRIBUTION (MIDDECK AND AFD)

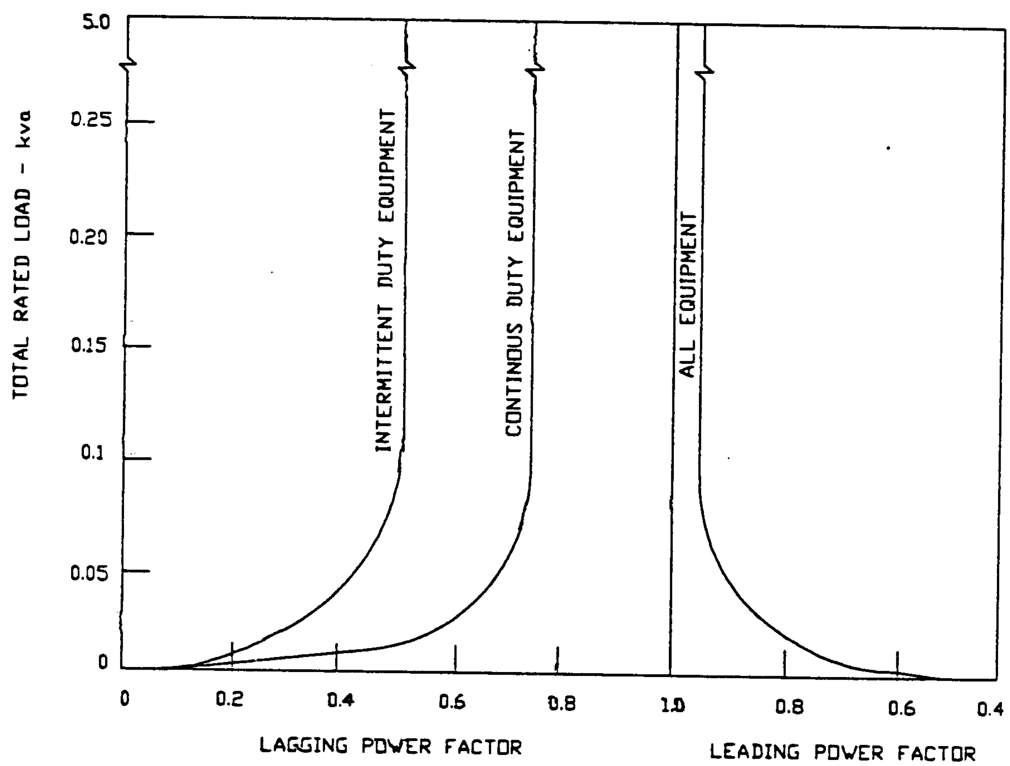


FIGURE 7.3.1.2-1 POWER FACTOR LIMITS FOR UTILIZATION EQUIPMENT

7.3.1.3 AC Power Ripple and Transients
AC power bus ripple shall be limited to 1.5 volts RMS from 30 Hz to 1.5 kHz falling to 0.6 volts RMS at 50 kHz, thereafter, remaining constant to 250 kHz, except that the ripple shall not exceed 4 percent RMS of the AC line voltage at inverter harmonic frequencies. With the AC neutral line grounded to Orbiter structure, the transient spikes measured on the three phases shall not exceed the levels defined in Figure 7.3.1.3-1 for AC system operation. The impedance into which the spikes are generated shall be 50 ohms minimum for significant frequency components of the spikes. Figure 7.3.1.3-1 is not intended to represent actual spikes, but rather to define stress levels for design purposes.

Shuttle produced transients on the AC power busses, of less than one millisecond duration, are not controlled. Therefore, the use of electronic loads on the orbiter AC power busses is strongly discouraged. Payloads shall not use AC powered electronic loads to control safety critical functions.

7.3.1.4 Susceptibility

7.3.1.4.1 Methodology and Recommended Testing
It is recommended that the techniques and/or test methods of SL-E-0002 be followed when required to demonstrate compatibility with the STS AC power bus environments. The recommended test method to demonstrate compatibility with the ripple environment is CS101, steady state susceptibility (30 Hz and extended to 250 kHz).

7.4 Limitation on Middeck Payload Utilization of Electrical Power

7.4.1 Power Loss
Loss of Orbiter supplied power to the Middeck payload element during on-orbit operation shall require manual reconfiguration of Orbiter power to restore power to the Middeck payload elements. The power shall normally be restored within 15 minutes of the Middeck payload element power loss detection.

7.4.2 Emergency Operational Modes
For emergency operational modes, the payloads shall be able to sustain a safe condition with permanent loss of Orbiter power.

7.4.3 On-Orbit Transfer
Payloads requiring on-orbit transfer shall be designed to withstand up to 30 minutes without Orbiter supplied power.

7.4.4 Payload Element Activation/Deactivation and Isolation.
The Payload shall provide means for its power activation/deactivation via crew control.

7.5 Electrical Connectors

7.5.1 Electrical Connector Deadfacing

All power shall be removed when mating or demating electrical connectors.

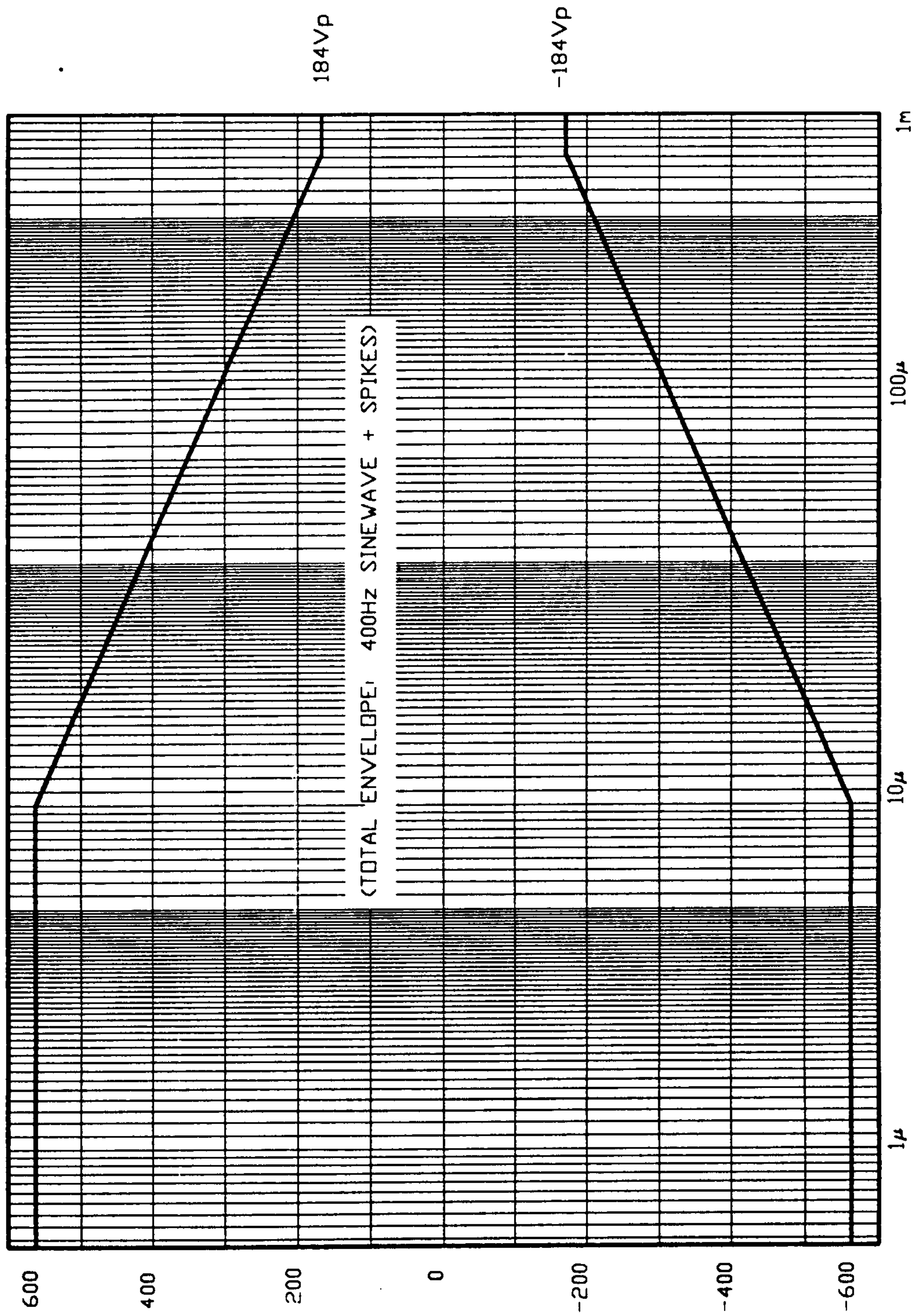


FIGURE 7.3.1.3-1 ENVELOPE OF SHUTTLE-PRODUCED SPIKES ON THE AC POWER BUS

8.0 Electromagnetic Compatibility (EMC)

Sections 8.0 through 8.5.4 define Orbiter produced electromagnetic environments as well as limitations of Payload produced electromagnetic environments. The recommended test methodologies may be found in SL-E-0002, SSP 30238 and/or NSTS 07636, for example.

8.1 Circuit EMEC Classifications

Circuit EMEC Classifications are as defined as Table 8.1-1. As a design goal, orbiter to payload wiring shall meet the requirements of Table 8.1-2, or utilize equivalent shielding.

8.2 Shuttle-Produced Interference Environment

8.2.1 Conducted Interference

(See paragraphs 7.2.2 and 7.3.1.3).

8.2.2.1 Orbiter Produced WCCS Radiated Electrical Fields

The wireless Crew Communication System (WCCS) is used on STS flight and is primarily located in the Orbiter flight deck and middeck. WCCS operational frequencies are between 338.0 MHz in the crew compartment. The maximum radiated field intensity for the WCCS is 1.0 volt per meter at 1.0 meter away from the source.

8.2.2 Radiated Interference

The shuttle produced radiated fields environment shall be limited as follows:

a. Electrical fields are defined in Figures 8.2.2-1 and 8.2.2-2 for unintentional emissions, and Figure 8.2.2-3 for intentional emissions.

   The generated AC magnetic fields shall be limited to less than 140 dB above 1 picotesla (30 Hz to 2 KHz) falling 40 dB per decade to 50 KHz.

   These levels shall be considered when evaluating the possibility of operating radio frequency receiving equipment or electronic field sensing equipment.

b. The lightning produced magnetic fields in the Crew Compartment for vehicles inflight shall be limited to a peak level of 3 amperes/meter; for vehicles on the ground protected by facility or other structures the peak level shall be limited to 5 amperes/meter; and for vehicles on the ground not protected by facility or other structures the peak level shall be limited to 10 amperes/meter. The rise to peak value is 2 microseconds and the fall to zero value is 100 microseconds. The payload shall be designed so that a failure due to lightning strike shall not propagate to the Shuttle.

c. The design of the Orbiter shall preclude any electrostatic discharges.

TABLE 8.1-1 CIRCUIT EMEC CLASSIFICATIONS

Frequency or Rise/Fall Time	Source Impedance (ohms)	Load Impedance (ohms)	Voltage	Circuit Class	Wire Type	Shield Grounding
Analog Alternating or Direct Current	< 100	100-600k 0-200 0-200	>100 mV to ≤ 6V > 6V to ≤ 40V > 40V	ML HO EO	TWS TW TW	SPG** NONE NONE
	≤ 2.5K	100-600k > 600k	≤ 100mv	ML	TWS TWS+	SPG SPG
	< 100	≥ 200 ≥ 200 ≥ 200	> 100mV to ≤ 6V > 6V to ≤ 40V > 40V	ML HO EO	TWS TW TW	SPG NONE NONE
≤ 50 kHz or Rise & Fall Time >10 µs	< 100	≥ 10k 0-200 0-200	≤ 6V > 6V to ≤ 40V > 40V	ML HO EO	TWS TW TW	SPG** NONE NONE
	≤ 2.5K	100-600k > 600k	≤ 100mV	ML	TWS TWS+	SPG SPG
	≥ 200	> 200	> 100mV to ≤ 6V > 6V to ≤ 40V > 40V	ML HO EO	TWS TW TW	SPG NONE NONE
>50 kHz and ≤1.024 MHz or Rise & Fall Time ≤ 10 µs	ALL	ALL	≤ 100mV > 100mV to ≤ 6V	RF RF	TWS*+ TWS*	MPG MPG
		< 1000 ≥ 1000	> 6V	RF	TWS* TWS+	MPG MPG
≥1.024 MHz	ALL	ALL	ALL	RF	COAX	MPG
Video	ALL	ALL	ALL	RF	TWS*	MPG

NOTE:
This table does not describe those wire types that are permitted to use structure for the circuit return.
* If the capacitance per foot is critical, controlled impedance wiring should be used.
** If the circuit is balanced by transformer, differential, or optical isolation, the shield shall be multipoint grounded to structure.
\+ TWDS may be utilized as required.

<u>Symbols Used</u>:

SPG	Single Point Ground	<	Less than
MPG	Multiple Point Ground	≤	Less than or equal to
TW	Twisted	>	Greater than
TWS	Twisted Shielded	≥	Greater than or equal to
TWDS	Twisted Double Shielded	kHz	kilohertz
EO	Extremely high voltage	mV	millivolts
HO	High voltage		
ML	Medium or Low voltage		
RF	Radio Frequency		

TABLE 8.1.2 CARGO EDGE-TO-EDGE BUNDLE SEPARATION REQUIREMENTS

Bundle	Routed Parallel to Bundle	Separation (in inches for parallel runs of D [feet])			
		$1 > D$	$1 \leq D < 3$	$3 \leq D < 5$	$D \geq 5$
ML	HO	0	1.0	2.0	4.0
	EO	0	1.5	3.0	6.0
	RF	0	2.5	5.0	10.0
HO	EO	0	0.5	1.0	2.0
	RF	0	1.5	3.0	6.0
EO	RF	0	1.0	2.0	4.0

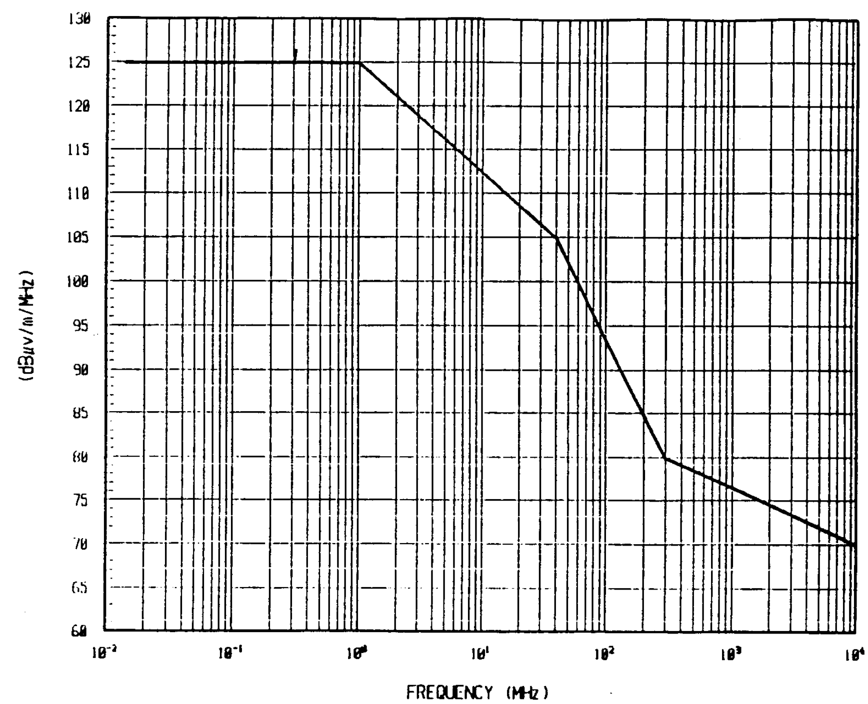


FIGURE 8.2.2-1 SHUTTLE-PRODUCED RADIATED NARROWBAND EMISSIONS, UNINTENTIONAL

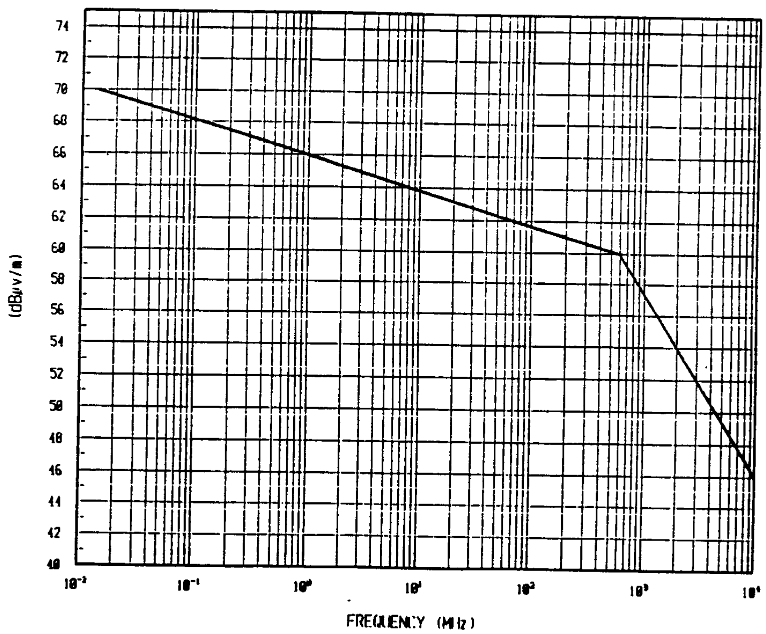


FIGURE 8.2.2-2 SHUTTLE-PRODUCED RADIATED NARROWBAND EMISSIONS, UNINTENTIONAL

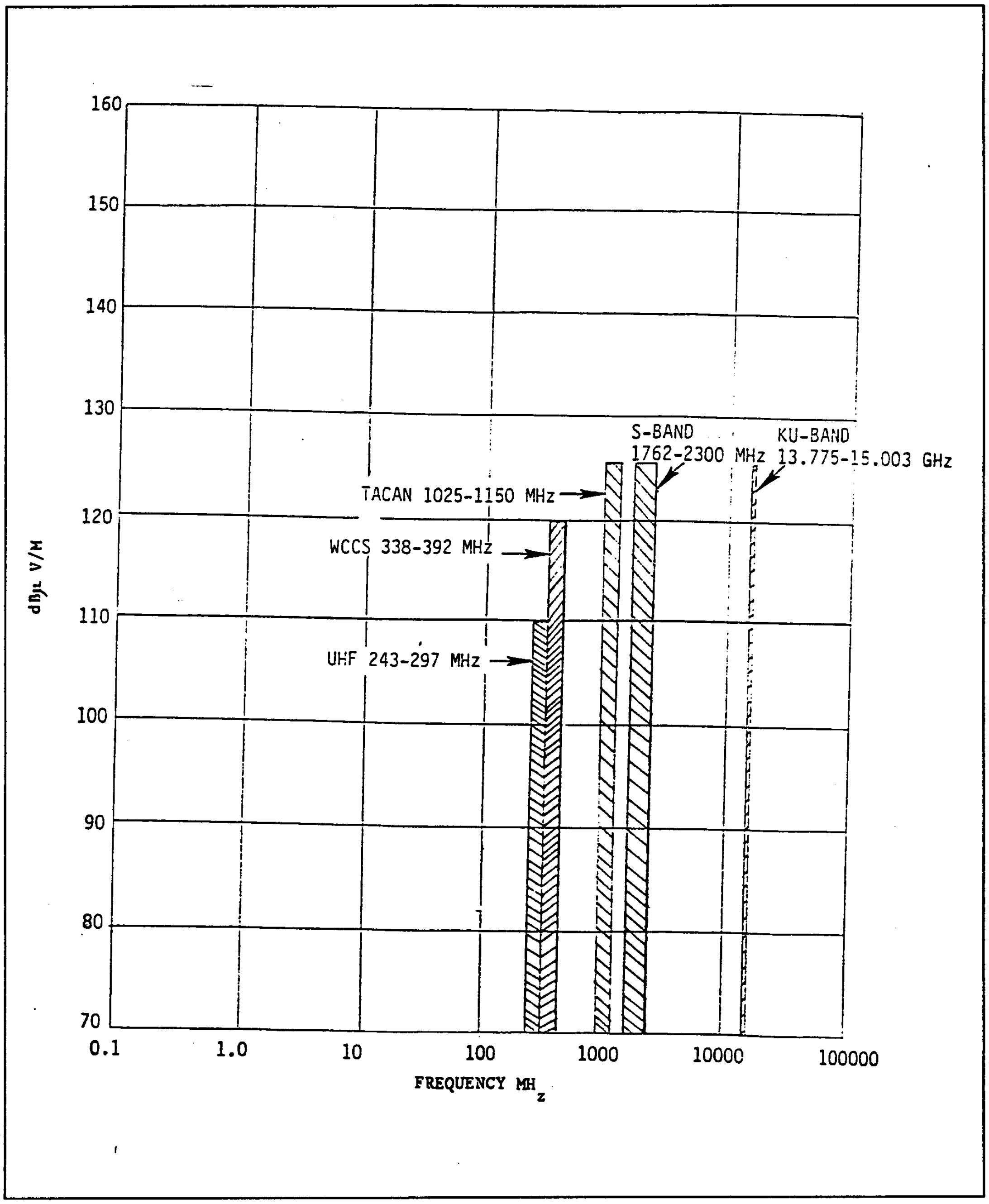


FIGURE 8.2.2-3 SHUTTLE-PRODUCED RADIATED NARROWBAND EMISSIONS, INTENTIONAL

8.3 Allowable Payload Produced Interference Environment

8.3.1 Conducted Noise

The Payload generated conducted emission limits, applicable to all DC power interfaces, shall be as follows:

a. DC Power

1. The power line conducted emissions in the frequency domain shall be limited to the levels indicated in Figure 8.3.1-1 and the steady state ripple voltage in the time domain shall not exceed 28.45 volts nor go below 27.55 volts, starting at approximately one second after the transient.

   The cargo-generated transients produced on DC power lines by switching or other operations shall not exceed the limits defined in Figure 8.3.1-2 when fed from a source impedance close to but not less than the values defined in Figure 8.3.1-4 and 8.3.1-5. (The use of a battery cart is preferable to regulated DC power supplies). Each non-overlapping transient is considered independent of prior or post transients.

b. AC Power

1. The AC power-line-conducted emissions of the Cargo AFD equipment shall not exceed the limits defined in Figure 8.3.1-1.

2. Shuttle produced transients on the AC power busses, of less than one millisecond duration, are not controlled. Therefore, the use of electronic loads on the orbiter AC power busses is strongly discouraged. Payloads shall not use AC powered electronic loads to control safety critical functions. All payloads operating on AC power shall comply with the requirements of Figure 8.3.1-3.

8.3.2 Payload Produced Radiated Fields

The payload produced radiated field shall be limited as follows:

a. Equipment located internal to the SSV shall meet the limit depicted in Figure 8.3.2-1. Equipment that meets all of the following criteria may use the limit depicted in Figure 8.3.2-2.

   1. The equipment is located internal to the SSV.
   2. The equipment is designated as Criticality 3 or non-critical allowing it to be turned off if interference arises from its operation.
   3. The equipment is not operated on the flight deck during launch and entry operational phases.
   4. The equipment is not permanently manifested.

b. The generated AC magnetic fields (applies at a distance of 7 cm from any payload equipment) shall not exceed 140 dB above 1 picotesla (30 Hz to 2 kHz) falling 40 dB per decade to 50 kHz. The generated DC magnetic fields shall not exceed 170 dBpT at 7 cm from the payload envelope. This limit applies to electromagnetic and permanent magnetic devices.

c. Electrostatic discharges shall not occur within the Orbiter other than those isolated from the gaseous environment (hydrogen-oxygen mixture) and shielded by the payload to satisfy the requirements of subparagraph “a” above.

d. Allowable levels of radiation from cabin payload or experiment transmitter system are shown in Figure 8.3.2-3. These limits apply at 1 meter from window mounted antennas. Other antenna mounting locations will be negotiated with the SSP.

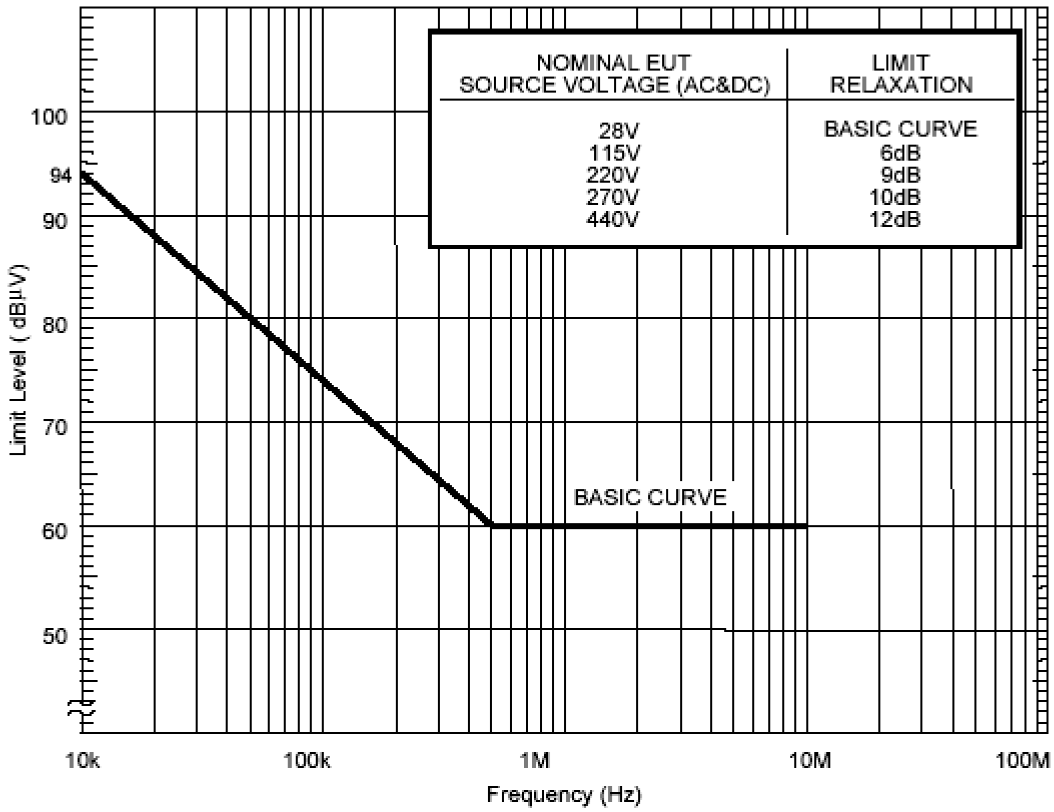


FIGURE 8.3.1-1 CARGO ALLOWABLE CONDUCTED EMISSIONS

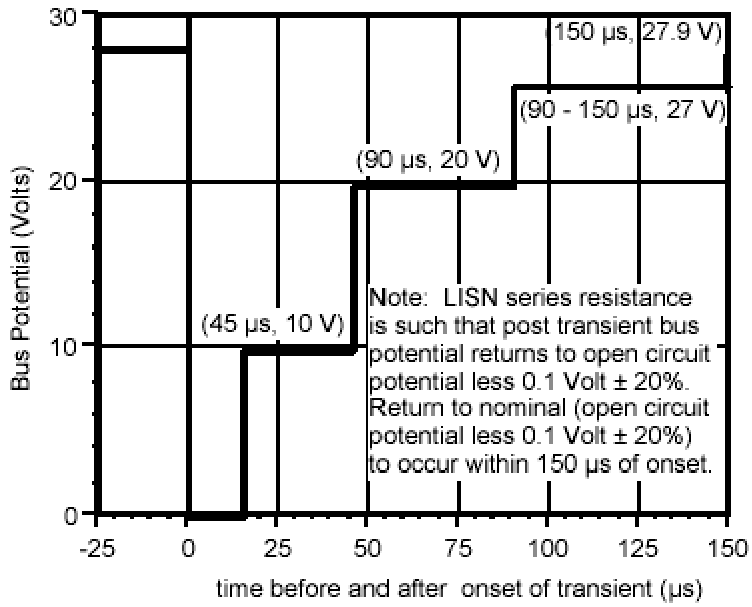


FIGURE 8.3.1-2 ALLOWABLE CARGO GENERATED DC POWER TRANSIENT LIMITS

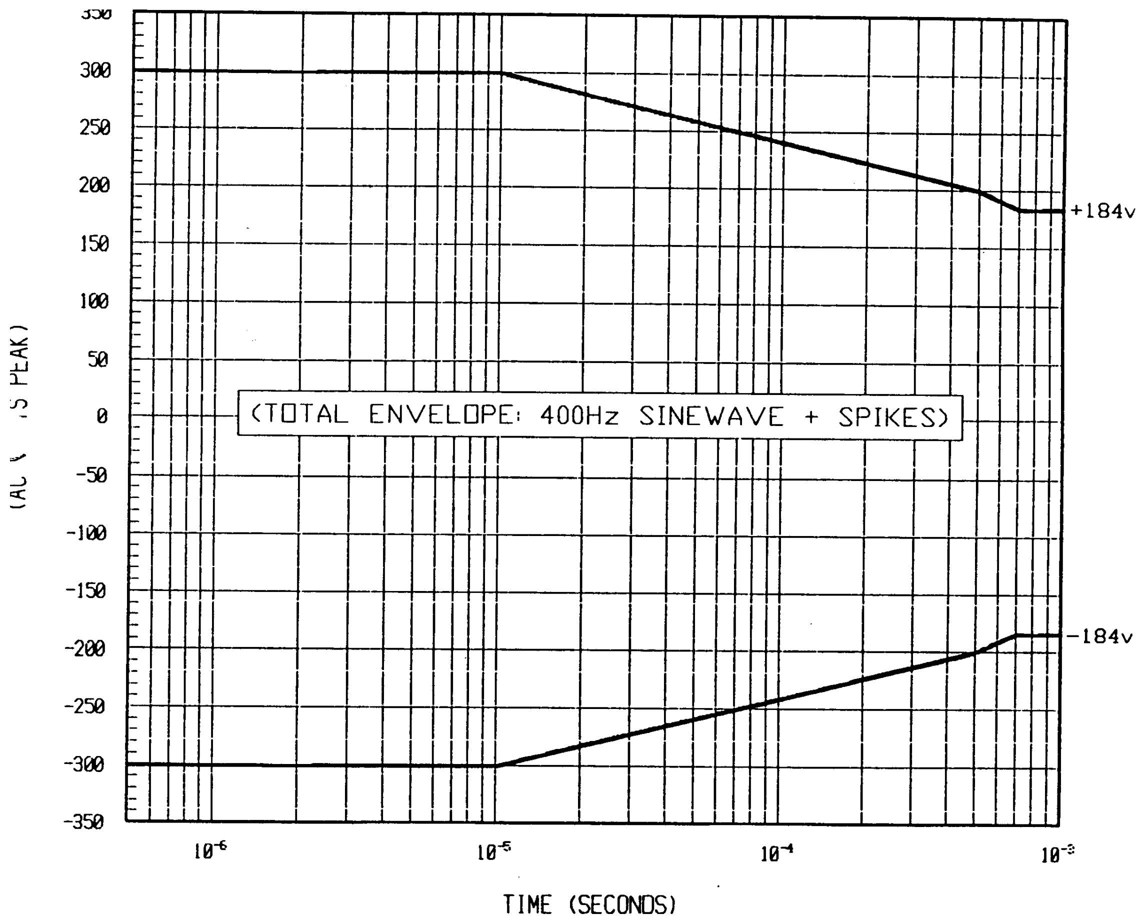
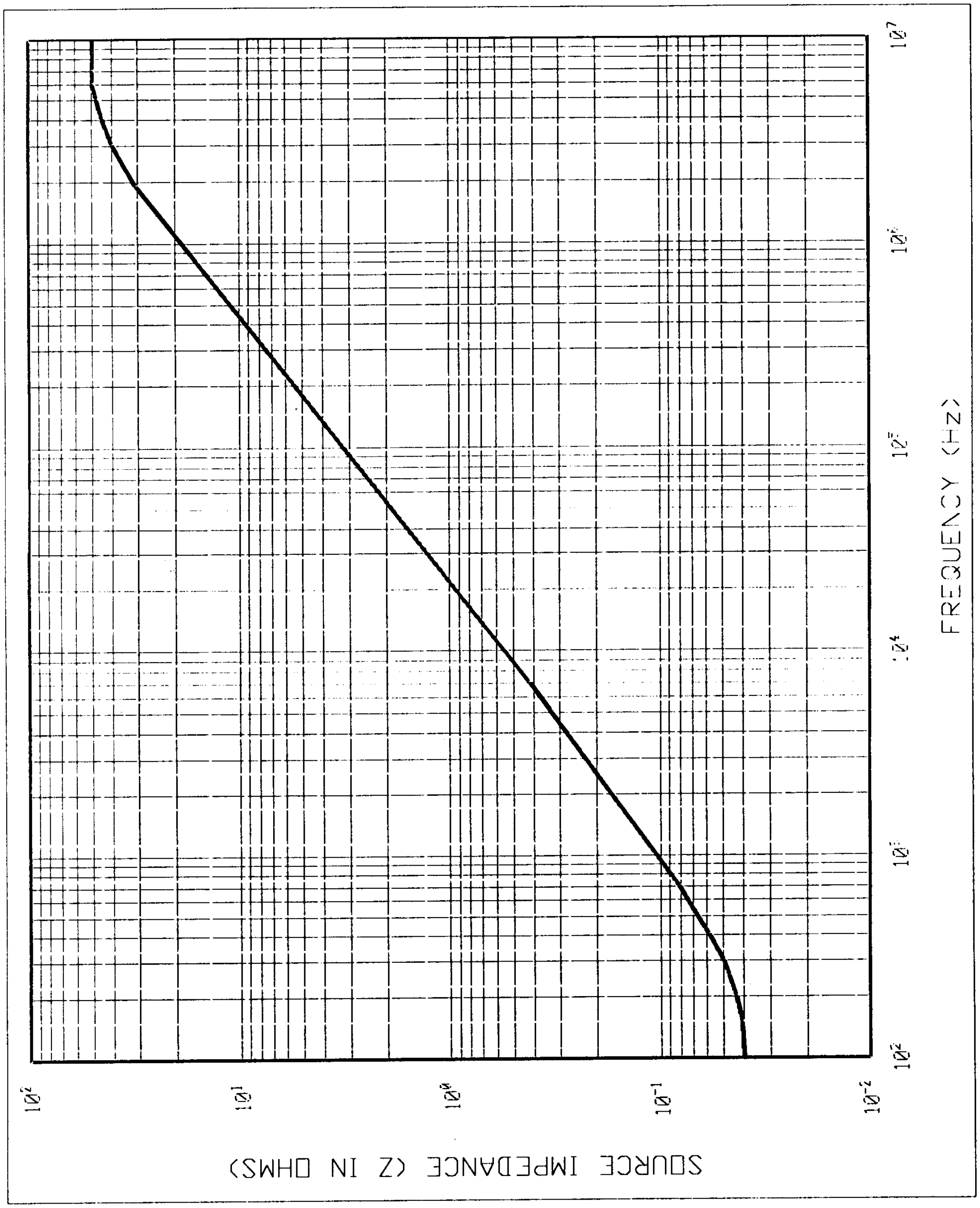


FIGURE 8.3.1-3 ENVELOPE OF CARGO ALLOWED SPIKES ON THE AC POWER BUS



FGURE 8.3.1-4 ORBITER DC POWER SOURCE IMPEDANCE
(IN-FLIGHT)

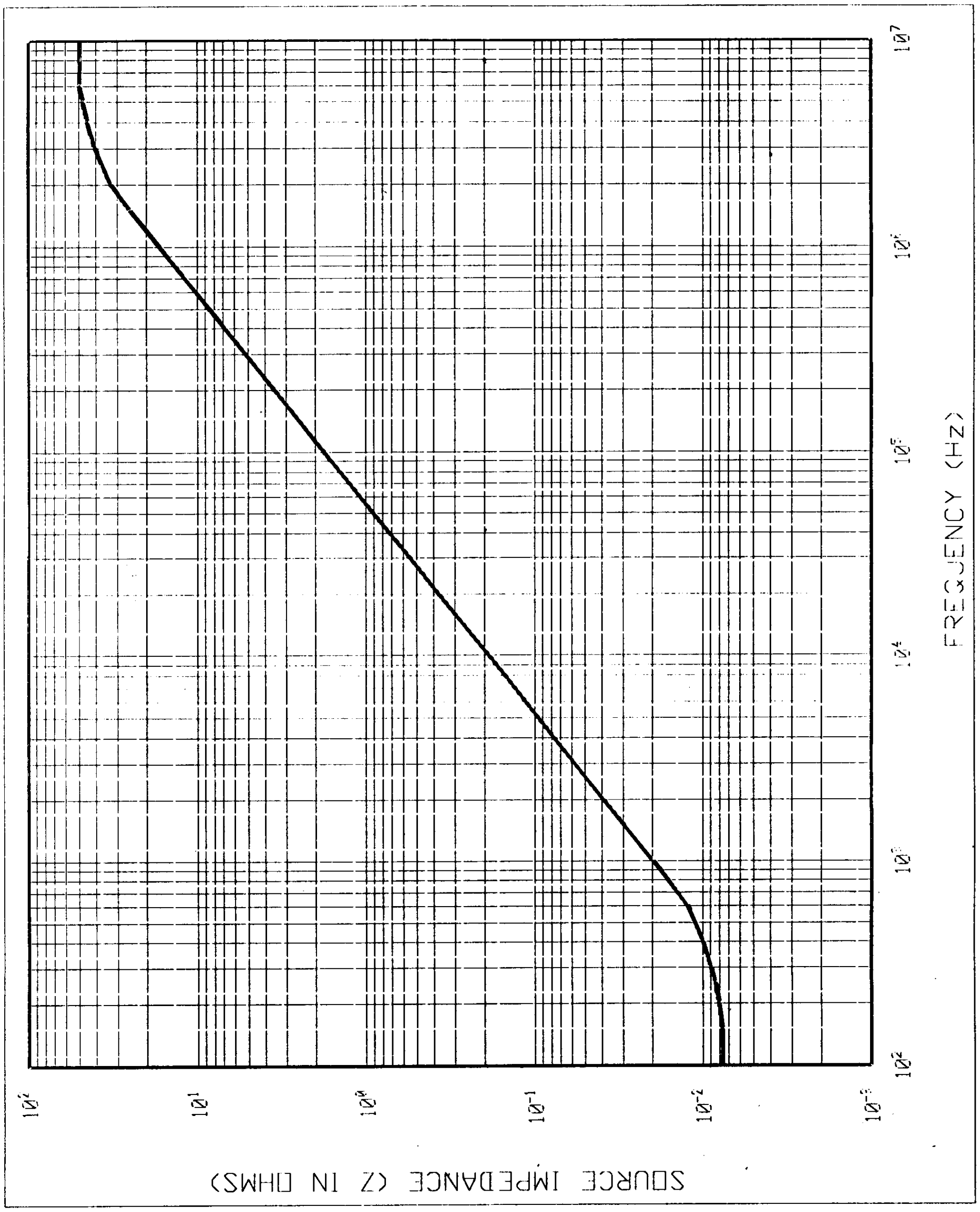


FIGURE 8.3.1-5 ORBITER DC POWER SOURCE IMPEDANCE (GROUND POWER)

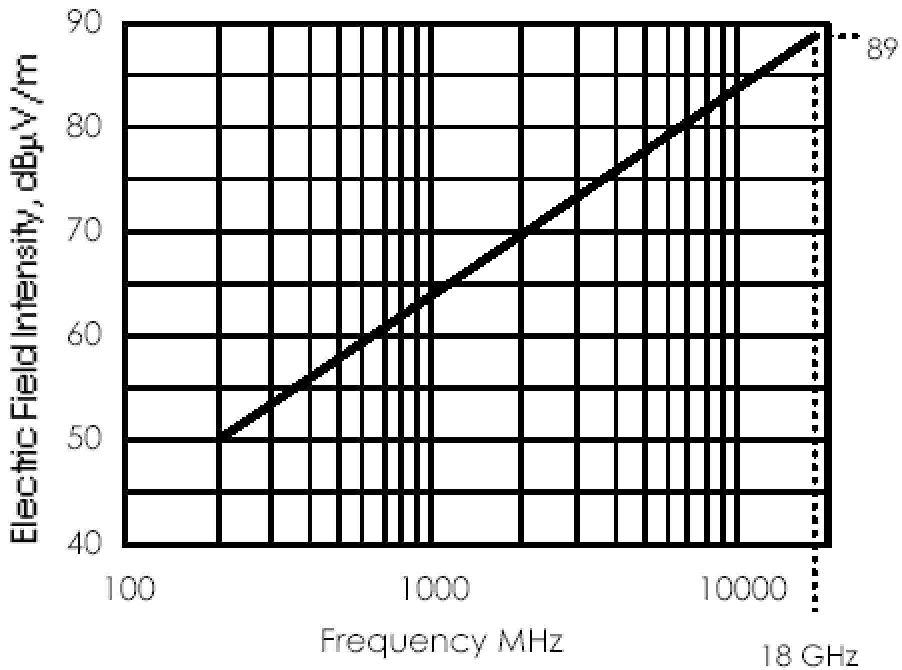


FIGURE 8.3.2-1 INTERNAL RADIATED EMISSION LIMITS

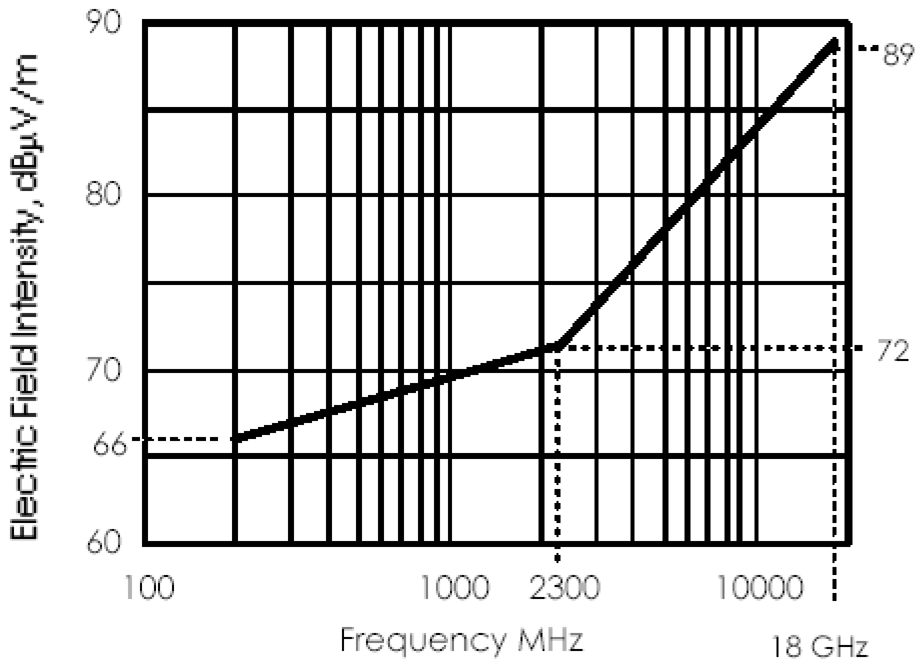


FIGURE 8.3.2-2 INTERNAL RADIATED EMISSION LIMITS THAT COMPLIES WITH ALL CRITERIA

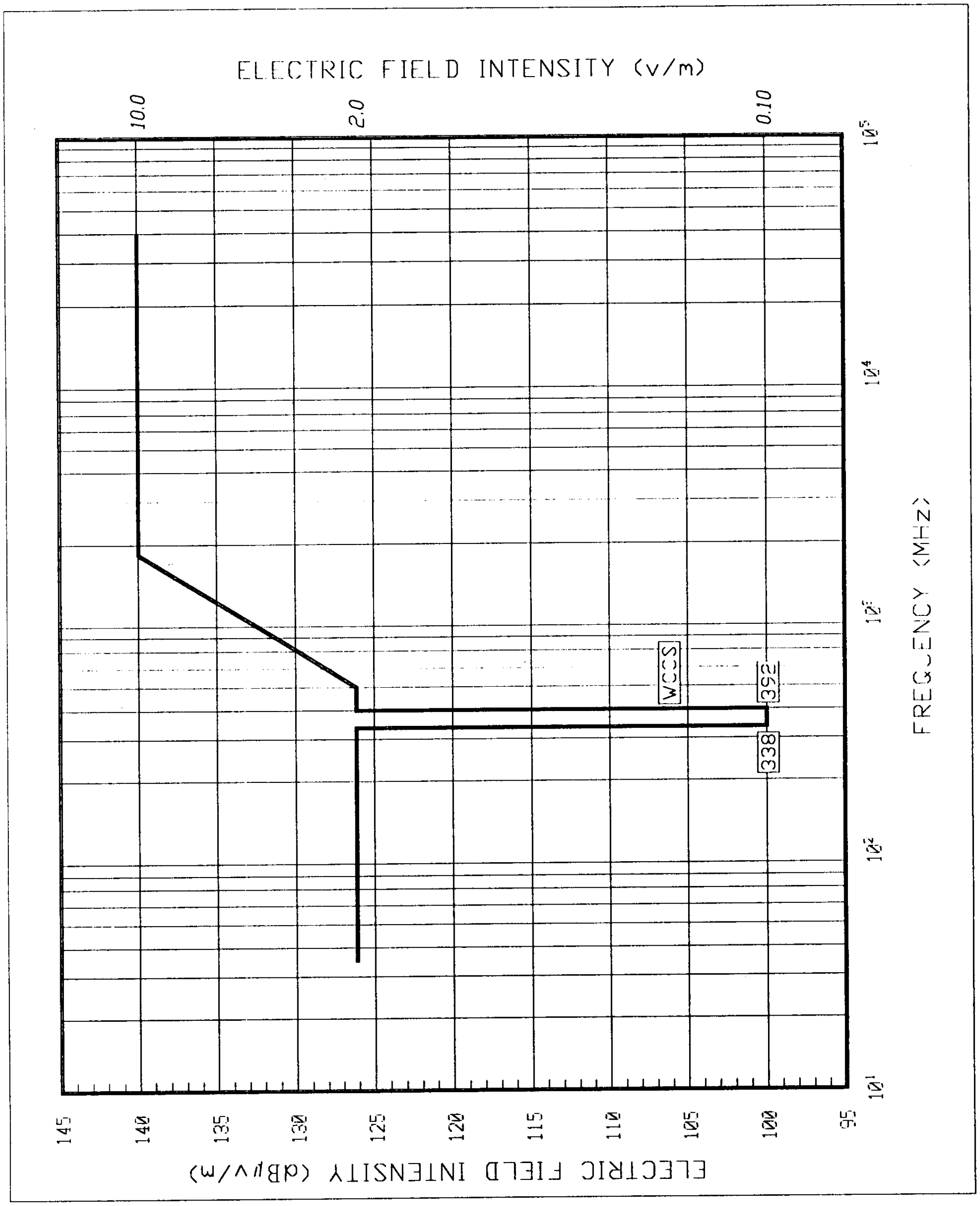


FIGURE 8.3.2-3 ALLOWABLE INTENTIONAL ELECTRIC FIELD STRENGTH IN THE CREW COMPARTMENT

8.4 Avionics Electrical Compatibility

8.4.1 Electrical Bonding

The Cargo -to -Orbiter electrical bonding interfaces shall be electrically bonded to provide homogeneous electrical characteristics. All electrical and mechanical elements shall be securely bonded to structure in compliance with NSTS 37330. All aluminum surfaces used for bonding shall be originally cleaned to bare metal then chemically filmed per MIL-C-5541, Class 3 (gold alodine 1200LN9368 or equivalent). Three (3) classes of bonds are applicable : Class C, R and S. These bond classes are defined in the following paragraphs:

1) Fault Current Bond - Class C:
   All Cargo elements using Orbiter power shall have mechanically secure electrical connections to the Orbiter structure capable of carrying the maximum return fault current (See paragraph 7.2.1.4).

2) RF Bond – Class R
   Cargo elements containing electrical circuits which generate radio frequencies or circuits which are susceptible to radio frequency interference may require a low impedance path to structure in order to comply with EMC requirements. The DC resistance of the Class R bond between the Orbiter interface and structure shall be less than 2.5 milliohms.

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 cargo element structure. The resistance of this connection shall be less than (1) ohm

8.4.1.1 Electrical Bonding of Equipment

Wire harness shields external to equipment, requiring grounding at the equipment shall have provisions for grounding the shields to the equipment through the harness connector backshell or for carrying single point grounded shields through the connector pins.

All equipment electrical bonds and their respective interfaces shall comply with NSTS 37330 and should be tested as delineated below.

8.4.1.1.1 Battery Powered Payloads

For installation into the Orbiter, there is no testing for battery powered payloads using Static Bond, Fault Bond or RF Bond.

8.4.1.1.2 Orbiter Powered Payloads

These are two types of testing required for Orbiter powered payloads.

1) Fault Current Bond Test (end-to-end)
   All Orbiter powered payloads requires a Class C type of bond. The payload structure to Orbiter structure bond continuity shall be less than or equal to 150 milliohms for payloads interfacing with the 10 amperes Orbiter utility outlets. For payloads interfacing with the 20 amperes outlets (e.g. MUP connectors J11 and J21), payload structure to Orbiter structure bond continuity shall be less than or equal to 75 milliohms.

2) RF Bond Test:
   Equipment which generate and/or susceptible to RF interference require a Class R type of bond. The metallic shells of all electrical connectors shall be electrically bonded to the equipment case or the bulk-head mount with a dc resistance of less than 2.5 milliohms. The dc resistance between the mated halves of the connectors shall not exceed 50 milliohms.

8..1.2 Electrical Bonding of Structure

8.4.1.2.1 Payload-to-Orbiter Main Bond

8.4.1.2.1.1 Primary Payload Connector Bond
The Primary connector bond is defined as the Orbiter-to -Payload power interface and shall be accomplished by a single ‘ 16 ‘ AWG wire in the primary power connector capable of carrying a maximum current of 20 amperes. For payloads with MUP connectors J11 and/or J21, the primary connector band shall be accomplished by a single 12 AWG wire in the primary power connector capable of carrying a maximum current of 33 amperes.

These bonds shall meet the appropriate bond class requirements of Paragraph 8.4.1 “Electrical Bonding” and shall have less than or equal to 0.25 milliohms at each junction of the fault bond interface.

8.4.1.2.1.2 Cargo-To-Orbit Bond Strap
The Cargo-to-Orbiter bond strap shall be STS provided (as an optional service) and shall be connected to the Orbiter structure and cargo ground stud provisions. This bond shall meet the requirements of Paragraph 8.4.1 “Electrical Bonding” and shall have less than or equal to 0.25 milliohms at each junction of the fault current interface.

8.4.1.2.1.3 Cargo-To-Orbiter Mated Surface Board
The maximum resistance between the mated surfaces of the bond connection (connector-to-mounting base, mounting base-to-Orbiter, or when applicable.

Mounting base-to-payload) shall be less than or equal to 2.5 milliohms at each junction of the fault current interface.

8.4.1.2.2 Payload-To-Orbiter and Fluid Line Bonding
All metallic pipes (hardlines) used to connect the Cargo environmental control system to the Orbiter, shall be Class -S electrically bonded per NSTS 37330.

8.4.1.2.3 Electrical Bonding For Static Protection
All Orbiter and Cargo interfaces shall comply with Paragraph 8.4.1 “Electrical Bonding”.

8.4.1.2.3.1 Static Electricity Protection
All payloads hardware elements shall comply with Class S bond requirements of NSTS 37330. All payload hardware elements also shall be designed to preclude the accumulation of an electrostatic charge on their surfaces. The specific requirements and methods employed shall be negotiated with STS.

8.4.2 Circuit Reference Symbols
The circuit Reference symbols for use on the Space Shuttle program shall be as illustrated and defined as follows:

* Structure reference- a connection to vehicle structure

** Primary power reference - a connection top the vehicle primary DC power return.

8.5 Power Circuit Isolation and Grounding

8.5.1 DC Power Ground Reference
Orbiter DC power supplied to a cargo element shall be structure referenced in the Orbiter and DC Isolated from structure ground at the cargo element by 1 megohm. The Orbiter primary DC power return system shall be 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 as shown in Figure 8.5.1-1

8.5.2 AC Power ground Reference
Orbiter AC power supplied to a cargo element shall be structure referenced in the Orbiter and DC isolated by 1 megohm in the cargo element from the other AC buses, DC primary power, signal/secondary power and structure references. The Orbiter AC neutral is a wire-return system grounded at a single point at Station Xo 576 for each AC bus, as showing Figure 8.5.1-1.
Structure and DC power returns by one megohm DC resistance in AFD cargo equipment.

8.5.4 Ground Support Equipment Isolation and Grounding
GSE interfacing with payloads shall have power returns isolated from payload structures by a minimum 1 megohm, except where balanced differential circuits are used. In case of balanced differential circuits, each side of the circuit shall be balanced to ground by no less than 400 ohms. Coax cables , with their inherent grounding of the signal return to structure, are permitted , provided their interface with other payload or systems does not propagate that ground to circuits which are already referenced to ground at some other point.

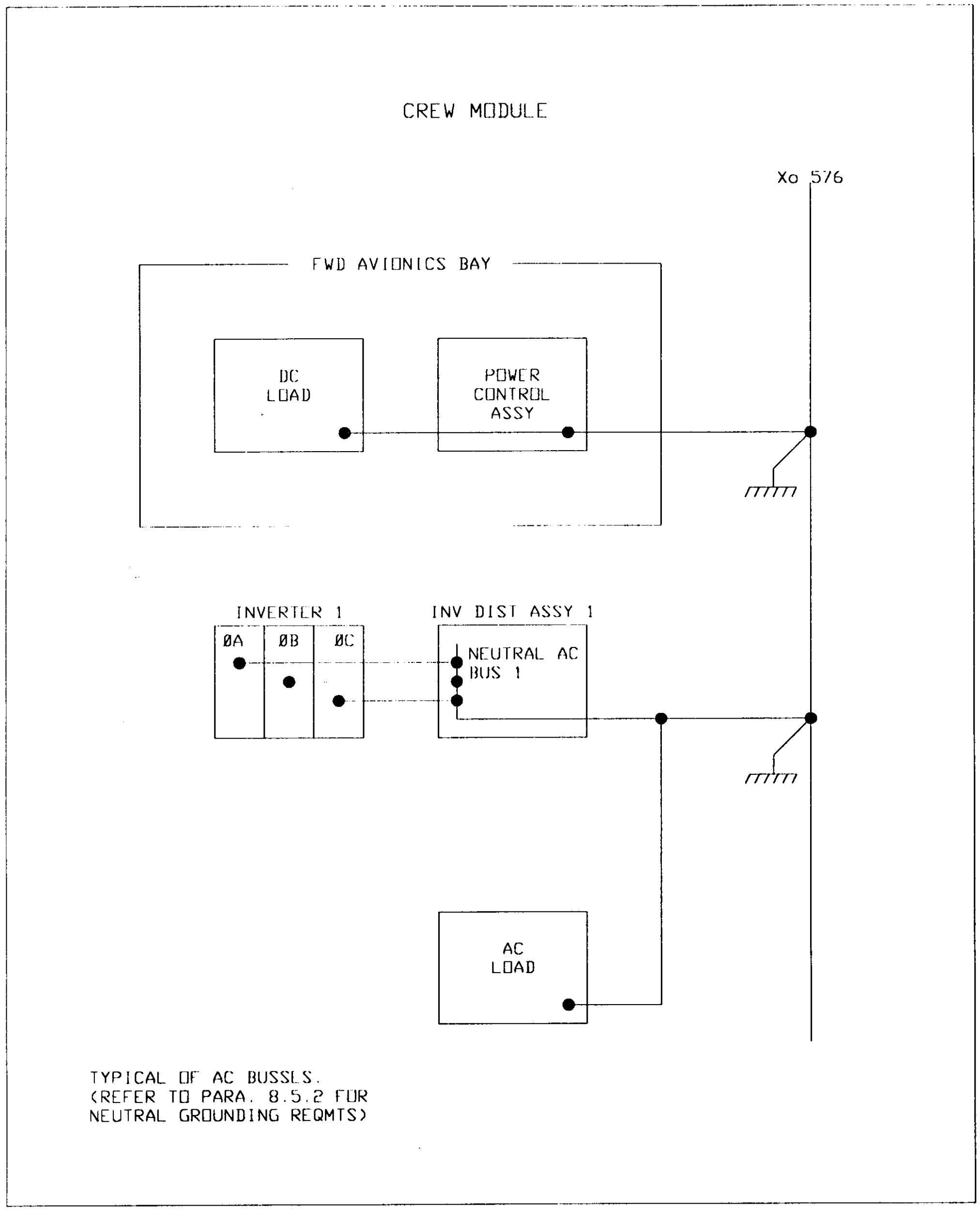


FIGURE 8.5.1-1 SHUTTLE PRIMARY POWER, DC AND AC, GROUNDING SYSTEM

9.0 Electrical Wiring Interface

9.1 General
Power provisions shall be available through panels MO30F, MO13Q, MO52J, MO63P and ML85E (MUP) at the locations as shown in Figure 9.1-1. Power cables shall be SSP-supplied and installed from the outlet locations to the payload interface.

9.1.1 Connector/Pin Interfaces
All interface connectors shall consist of pin contacts for interfacing. Table 9.1.1 lists the Orbiter and payload interface connectors allowing the use of standard SSP-supplied power cables.

TABLE 9.1.1 ORBITER AND PAYLOAD INTERFACE CONNECTORS

Source	Panel	SSP Panel Connector Designator	SSP Panel Receptacle Part Number	Payload Receptacle Part Number	Type	EMC Class
	MO13Q	J1	NBOE14-12SNT	NBOE14-12PNT2	DC	HO
	MO30F	J2	NBOE14-12SNT	NBOE14-12PNT2	DC	HO
	MO52J	J1	NBOE14-12SNT	NBOE14-12PNT2	DC	HO
	MO13Q	J2	NBOE12-10SNT	NBOE12-10PNT2	AC	EO
	MO52J	J2	NBOE12-10SNT	NBOE12-10PNT2	AC	EO
	MO63P	J3,J4,J6	NBOE14-12SNT	NBOE14-12PNT2	DC	HO
	MO63P	J2,J5	NBOE14-4SNT	NBOE14-4PNT	DC	HO
	ML85E (MUP)	J12,J13,J22,J23	NBOE14-12SNT	NBOE14-12PNT2	DC	HO
	ML85E (MUP)	J11	NBOE14-4SNT	NBOE14-4PNT	DC	HO
	ML85E (MUP)	J21	NBOE14-4SNT	NBOE14-4PNT	DC	HO
	ML85E (MUP)	J7, J31	NBOE12-10SNT	NBOE12-10PNT2	AC	EO

9.1.2 Approved Connectors for Middeck Payload Use

All Middeck payload element electrical connectors and connector contacts that interface with the orbiter shall be selected from the NASA specification, as applicable.

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9.2 Cable Schematics

Electrical power cables and interface pin/plug assignments for AC and DC services are shown in Figures 9.2-1, 9.2-2 and 9.2-3.

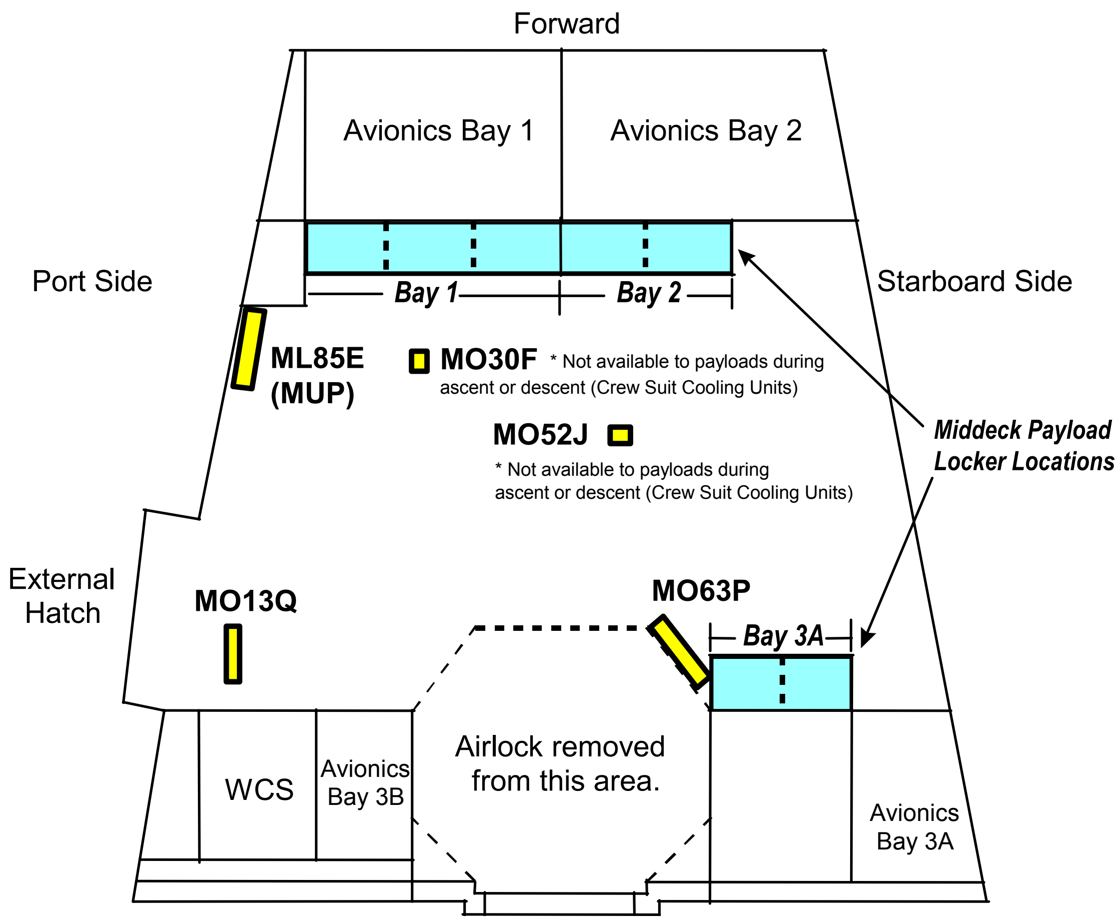

FIGURE 9.1-1 MIDDECK UTILITY POWER PROVISIONS
(SHEET 1 OF 5)

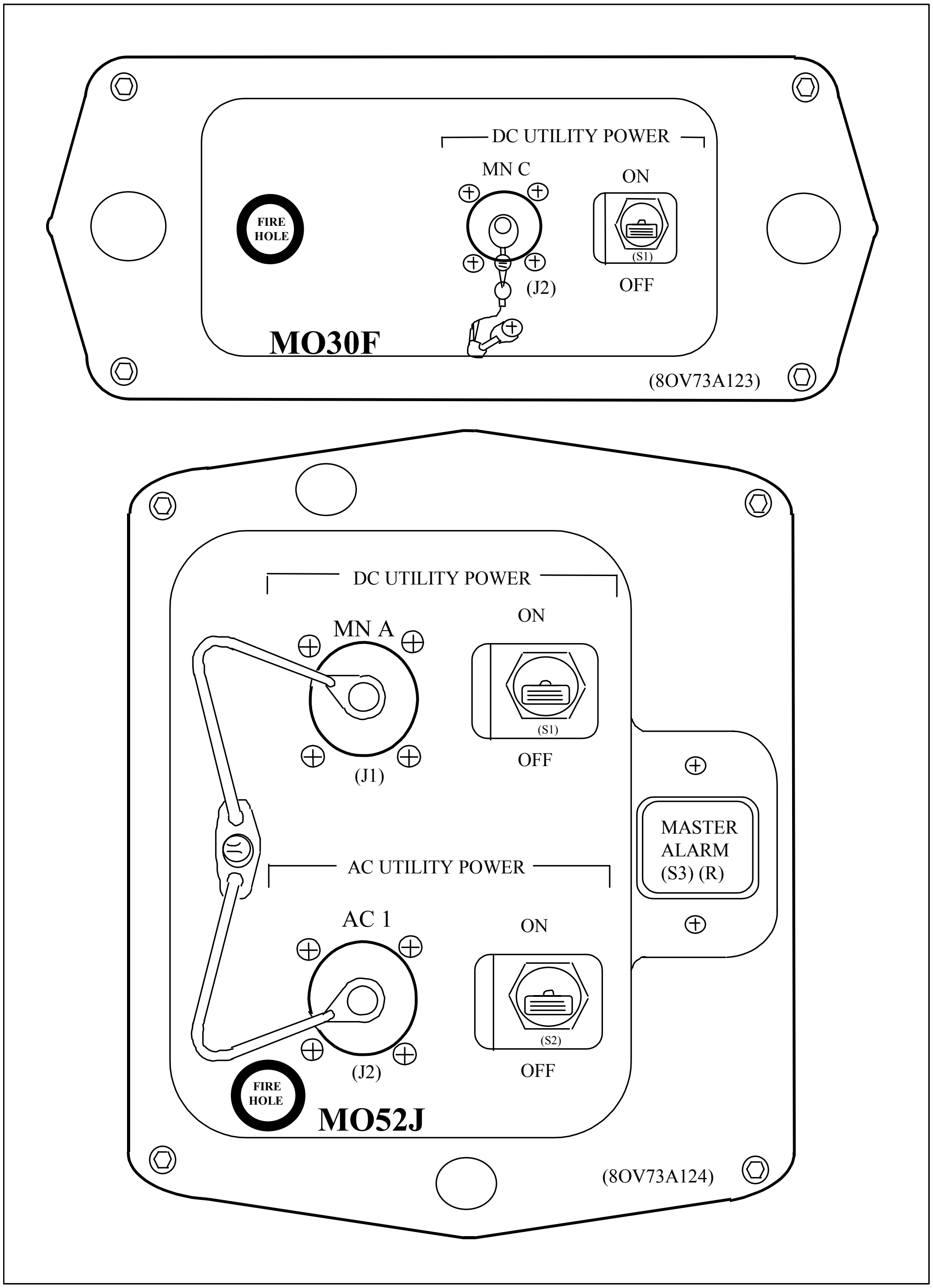

FIGURE 9.1-1 MIDDECK UTILITY POWER PROVISIONS
(SHEET 2 OF 5)

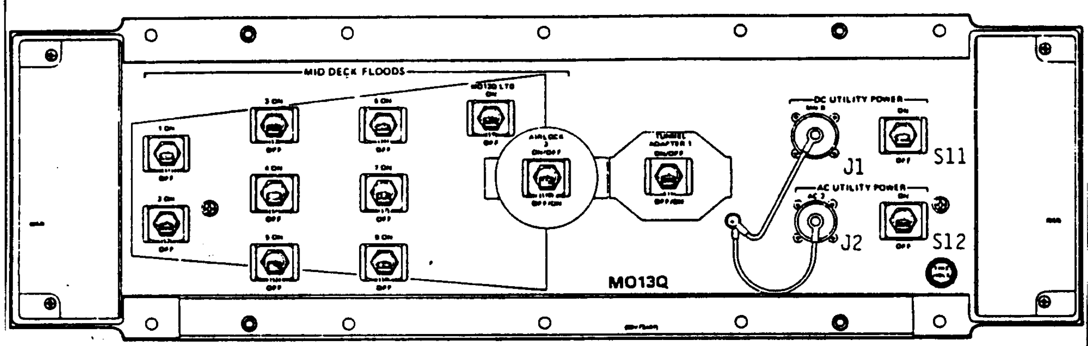

FIGURE 9.1-1 MIDDECK UTILITY POWER PROVISIONS
(SHEET 3 OF 5)

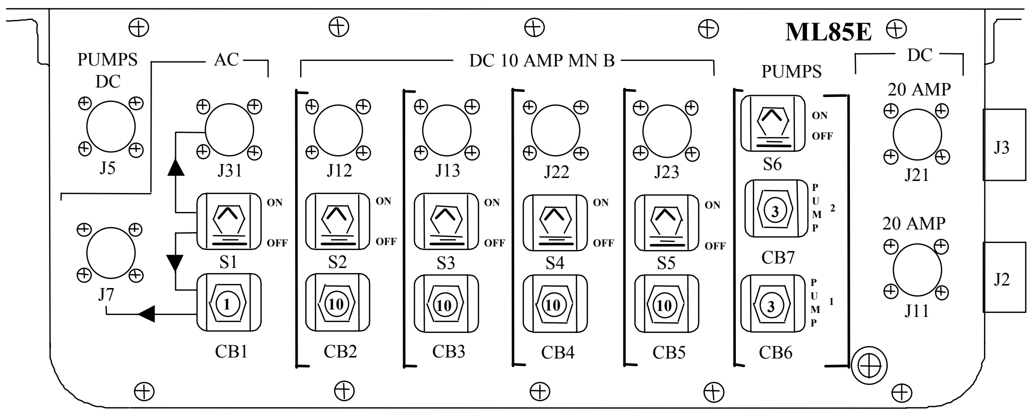

FIGURE 9.1-1 MIDDECK UTILITY POWER PROVISIONS
(SHEET 4 OF 5)

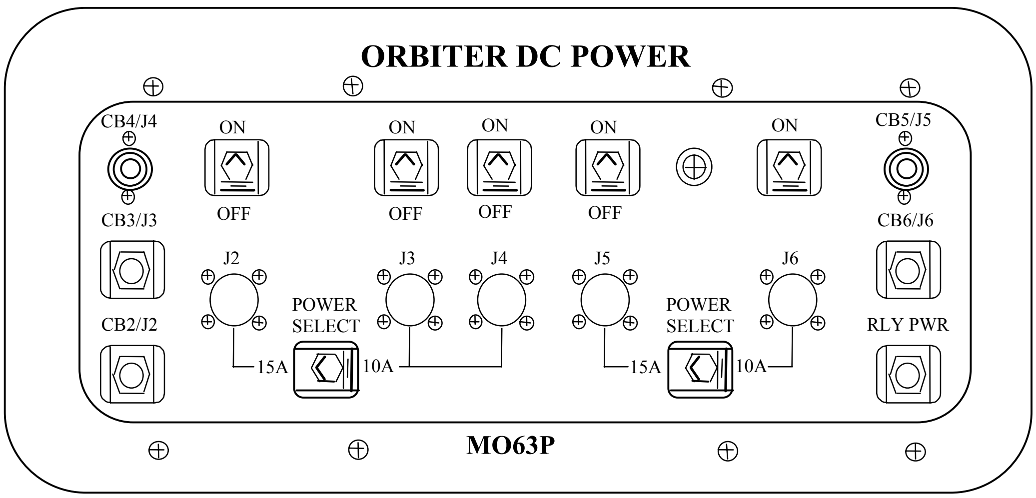

FIGURE 9.1-1 MIDDECK UTILITY POWER PROVISIONS
(SHEET 5 OF 5)

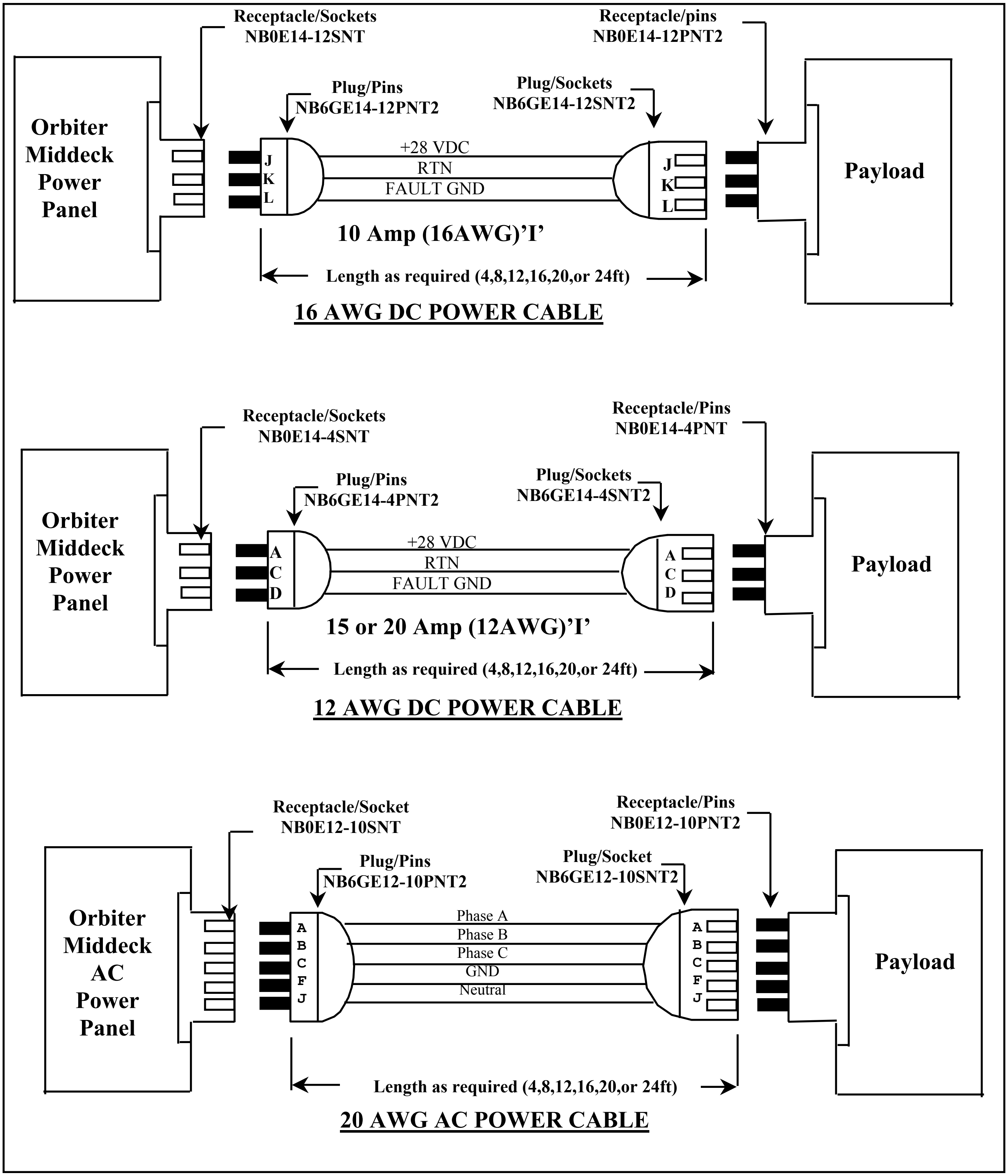
Receptacle/Sockets
NB0E14-12SNT
Receptacle/pins
NB0E14-12PNT2
Plug/Pins
NB6GE14-12PNT2
Plug/Sockets
NB6GE14-12SNT2
Orbiter
Middeck
Power
Panel
+28 VDC
RTN
FAULT GND
J
K
L
Payload
10 Amp (16AWG)'I'
Length as required (4,8,12,16,20,or 24ft)
16 AWG DC POWER CABLE
Receptacle/Sockets
NB0E14-4SNT
Receptacle/Pins
NB0E14-4PNT
Plug/Pins
NB6GE14-4PNT2
Plug/Sockets
NB6GE14-4SNT2
Orbiter
Middeck
Power
Panel
A
C
D
+28 VDC
RTN
FAULT GND
Payload
15 or 20 Amp (12AWG)'I'
Length as required (4,8,12,16,20,or 24ft)
12 AWG DC POWER CABLE
Receptacle/Socket
NB0E12-10SNT
Receptacle/Pins
NB0E12-10PNT2
Plug/Pins
NB6GE12-10PNT2
Plug/Socket
NB6GE12-10SNT2
Orbiter
Middeck
AC
Power
Panel
A
B
C
F
J
Phase A
Phase B
Phase C
GND
Neutral
Payload
Length as required (4,8,12,16,20,or 24ft)
20 AWG AC POWER CABLE

FIGURE 9.2-1

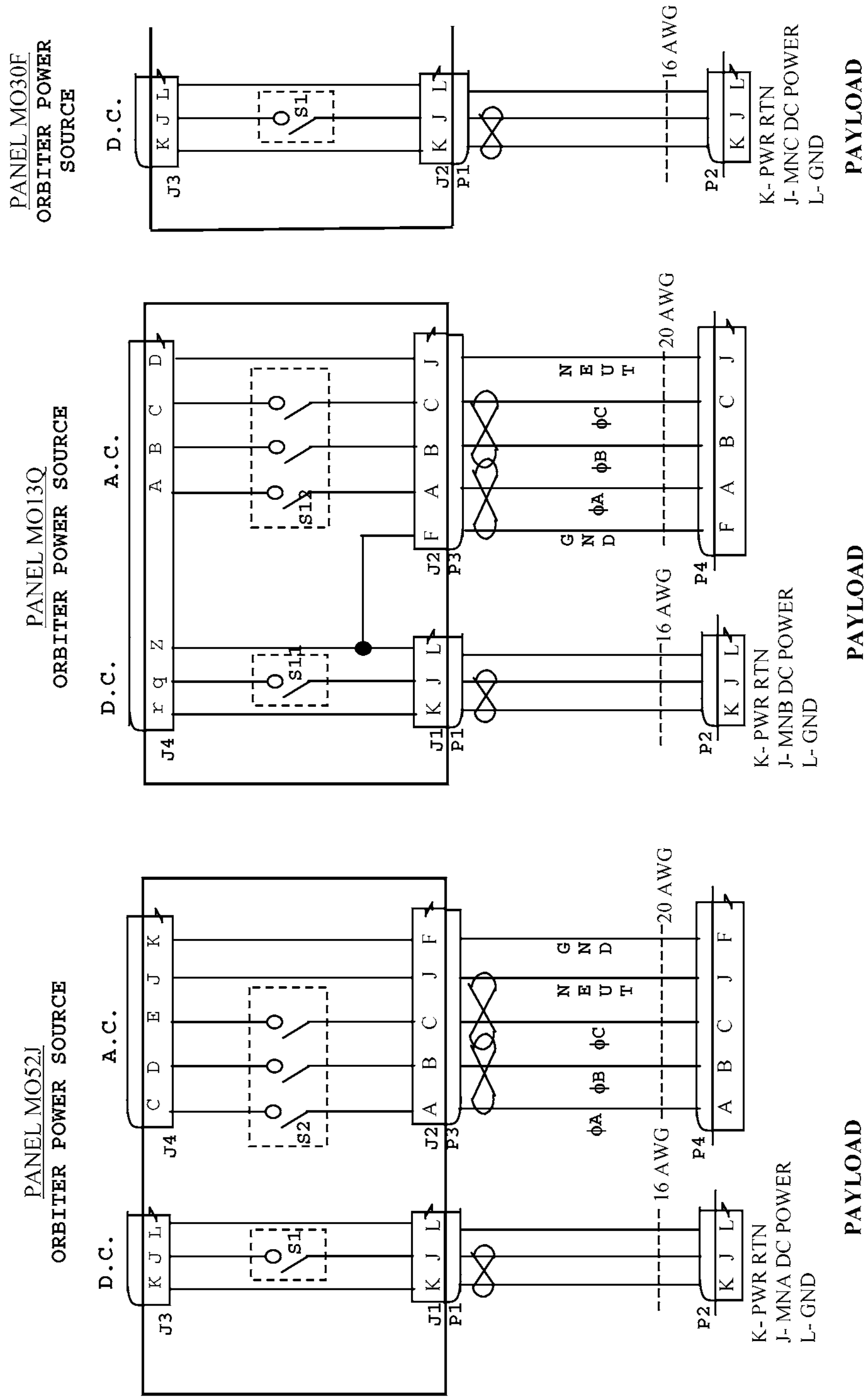

FIGURE 9.2-2 UTILITY OUTLET INTERFACE PIN/PLUG ASSIGNMENTS
(SHEET 1 OF 3)

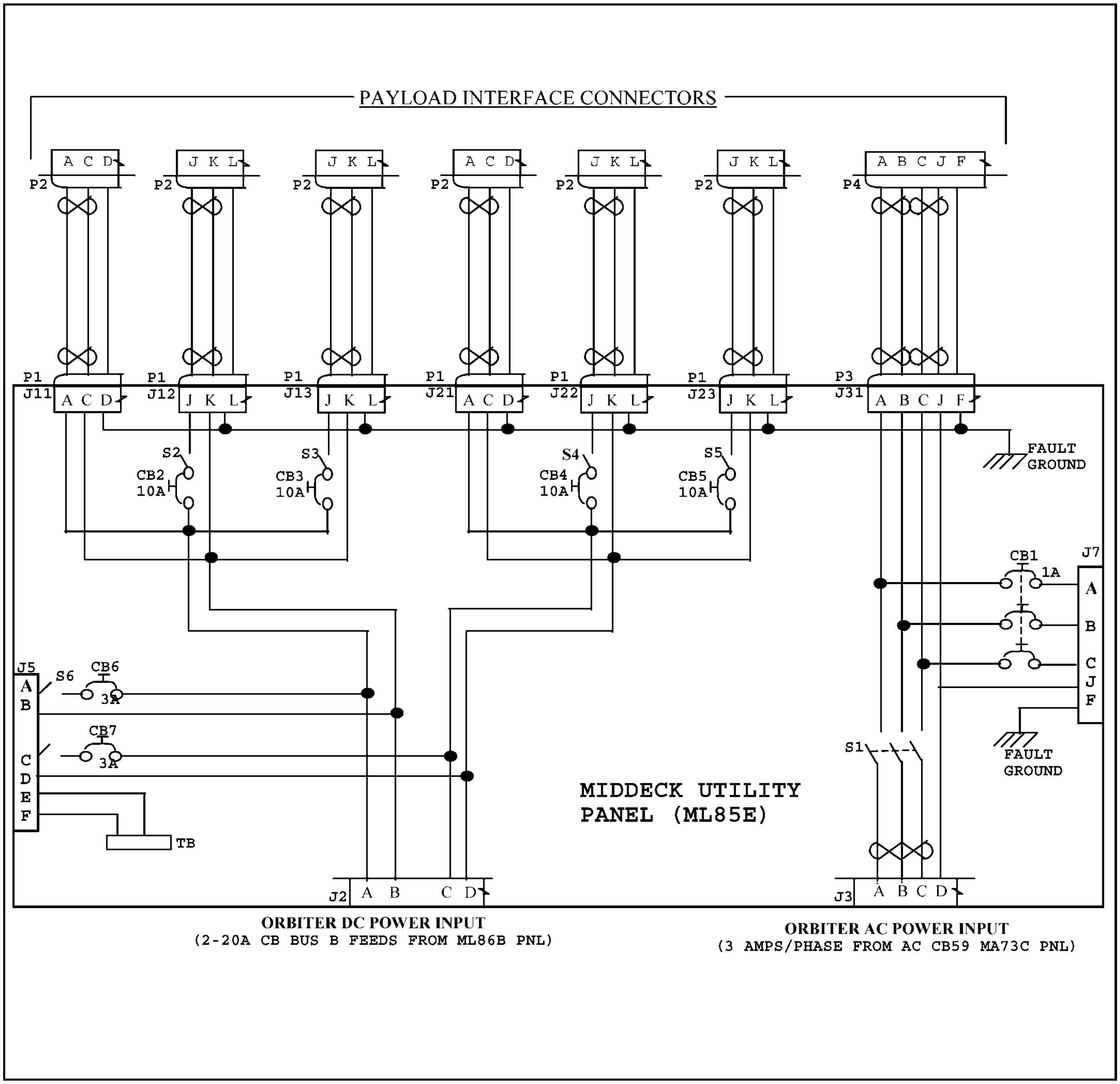

FIGURE 9.2-2 UTILITY OUTLET INTERFACE PIN/PLUG ASSIGNMENTS
(SHEET 2 OF 3)

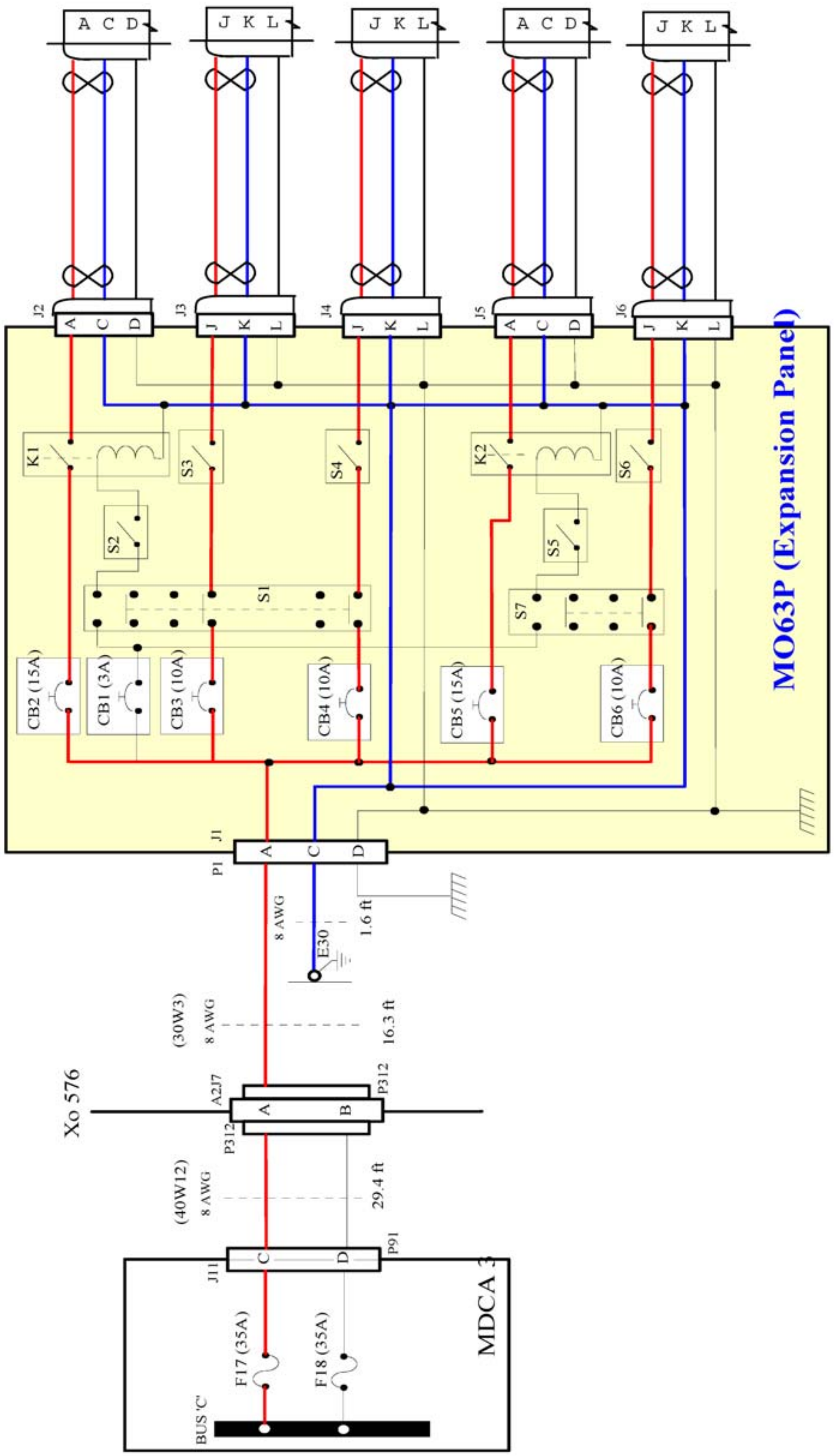

FIGURE 9.2-2 UTILITY OUTLET INTERFACE PIN/PLUG ASSIGNMENTS
(SHEET 3 OF 3)

10.0 Payload and General Support Computer (PGSC)

10.1 General

PGSC utilization, operations, and constraints are defined in NSTS 21000-IDD-760XD. Interfaces are defined below:

10.2 PGSC Electrical Power Characteristics

10.2.1 Payload Powered

The PGSC is powered through the payload as specified in Paragraph 5.4 of NSTS 21000-IDD-760XD. The power Table in the payload unique ICD shall include PGSC requirements.

10.2.2 Orbiter Powered

The PGSC may obtain electrical power through available Orbiter middeck outlets as specified in Paragraph 9.1 of this document. Electrical power requirements are specified in Paragraph 5.1 of NSTS 21000-IDD-760XD.

The PGSC will be powered from an AC power source when configured with an expansion chassis. If an expansion chassis is not used, power will be obtained from a DC power source. An SSP provided DC/DC power supply is required when a DC power source is used.

10.3 PGSC Interface Cables

10.3.1 Communication Cables

10.3.1.1 RS232C Cables

The RS232C cables, connectors, and pin functions are defined in paragraph 7.2.1 of NSTS 21000-IDD-760XD.

10.3.1.2 RS422A Cables

The RS422A cables, connectors, and pin functions are defined in Paragraph 7.2.2 of NSTS 21000-IDD-760XD.

10.3.2 Power Cables

Cables, connectors, and pin functions are defined in Paragraph 7.1 of NSTS 21000-IDD-760XD.