METRIC

DOD-STD-1788
15 May 1985

MILITARY STANDARD

AVIONICS INTERFACE DESIGN STANDARD

DISTRIBUTION STATEMENT A. Approved for public release; distribution is unlimited.

AREA GDRQ
AMSC F3537

DEPARTMENT OF DEFENSE

Washington, DC 20360

AVIONICS INTERFACE DESIGN STANDARD

DOD-STD-1788

1. This Department of Defense Standard is approved for use by all Departments and Agencies of the Department of Defense.

2. Beneficial comments (recommendations, additions, deletions) and any data which may be of use in improving this document should be addressed to: ASD/ENES, Wright-Patterson AFB, OH 45433-6503, by using the self-addressed Standardization Document Improvement Proposal (DD Form 1426) appearing at the end of this document or by letter.

FOREWORD

This standard contains requirements for the form factor, design, and environmental tolerance of avionic equipment and the control of the avionics environment in aircraft designed and developed under government contracts. The requirements of this standard are specifically oriented to improve the packaging efficiency, increase the reliability, enhance the maintainability, and reduce the life cycle cost of avionics subsystems. Standardization is also expected to yield reduced costs when major modifications are incorporated to increase mission capability and when standardized avionics functions are installed in more that one type aircraft. Acquisition costs are expected to be reduced when identical avionics functions, packaged in different configurations designed for specific type aircraft, are greatly reduced or eliminated entirely.

This standard defines the sizes, weights, and power levels of a range of avionics enclosures that are designed for rapid removal and replacement by flightline maintenance personnel. By virtue of the standard, a common function LRU will be applicable to all the aircraft types having that functional need. An initial installation complying with the standard is easily reconfigured to accomodate updated LRUs of greater capability and (possibly) smaller size at a later date, and to add new functional capabilities within the allocated avionics bay space.

This standard is appropriate for contractual application only in full-scale development and production phases of an acquisition program. During the concept exploration, and demonstration and validation phases, it shall be contractually applied only as a guide.

CONTENTS

CONTENTS - Continued

CONTENTS - Continued

FIGURES

TABLES

1. SCOPE

1.1 Scope. This standard defines the form factor, mounting, and cooling criteria to be used for military Line Replacement Units (LRUs) and the associated equipment rack. Specific dimensions and environmental characteristics govern the design of new and repackaged standard electronic equipment that is intended to be installed in the equipment bays of military aircraft.

1.2 Applicability. Application of this standard shall provide:

a. A system of standard avionics boxes.

b. A system of standard designs in racks or mounting bases.

c. A system for effective environmental control of the equipment.

d. A basis for allocating cooling capacity based on optimized LRU reliability and minimum life cycle costs.

e. A family of low-insertion force electrical connectors to provide the electrical interface between the avionics equipment and the aircraft wiring with growth adequate to meet all known future requirements, with keying to prevent inadvertent installation of the LRU in the wrong rack location.

2. APPLICABLE DOCUMENTS

2.1 Government documents

2.1.1 Specifications, standards, and handbooks. Unless otherwise specified, the following specifications, standards, and handbooks of the issue listed in that issue of the Department of Defense Index of Specifications and Standards (DoDISS) specified in the solicitation shall form a part of this standard to the extent specified herein.

SPECIFICATIONS

MILITARY

MIL-B-5087	Bonding, Electrical, and Lighting Protection, for Aerospace Systems
MIL-E-6051	Electromagnetic Compatibility Requirements, Systems
MIL-C-38999	Connectors, Electrical, Circular, Environment Resisting, General Specification for
DOD-C-83527	Connectors, Plug and Receptacle, Electrical, Rectangular, Multiple Insert Type, Rack to Panel, Environment Resisting 150°C Continuous Operating Temperature
MIL-F-85731	Fastener, Positive Locking, Electronic Equipment, General Specification For
MIL-E-87145	Environmental Control, Airborne

STANDARDS

MILITARY

MIL-STD-454	Standard General Requirements for Electronic Equipment
MIL-STD-461	Electromagnetic Emission and Susceptibility Requirements for the Control of Electromagnetic Interference
MIL-STD-462	Electromagnetic Interference Characteristics, Measurement of
MIL-STD-704	Aircraft Electric Power Characteristics
MIL-STD-810	Environmental Test Methods
MIL-STD-1472	Human Engineering Design Criteria for Military Systems, Equipment and Facilities
MIL-STD-1553	Aircraft Internal Time Division Command/Response Multiplex Data Bus
MS14108	Fastener, Positive Self Locking, Case Mounting, Electronic Equipment

(Copies of specifications, standards, handbooks, drawings, and publications required by manufacturers in connection with specific acquisition functions should be obtained from the contracting activity or as directed by the contracting officer.)

2.2 Other publications. The following document(s) form a part of this standard to the extent specified herein. The issues of the document(s) which are indicated as DoD adopted shall be the issue listed in the current DoDISS and the supplement thereto, if applicable.

ARINC Spec 404 Air Transport Equipment Cases and Racking

(Applications for copies should be addressed to Aeronautical Radio Inc., Attn: Document Section, 2551 Riva Road, Annapolis MD 21401.)

(Industry association specifications and standards are generally available for reference from libraries. They are also distributed among technical groups and using federal agencies.

2.3 Order of precedence. In the event of a conflict between the text of this standard and the references cited herein, the text of this standard shall take precedence.

3. DEFINITIONS

3.1 Definitions applicable to this standard are as specified herein.

3.1.1 Line replaceable unit (LRU). The basic Line Replaceable Units (LRUs), around which the entire packaging and installation concept is constructed, are of uniform length and height. The width shall be selected (or specified) from a range of modular sizes numbered 2 through 12. Any combination of LRUs installed side by side occupy shelf space equal to the sum of their size numbers multiplied by 33 millimeters. The individual LRU dimensions are given in 4.2.1.

3.1.2 The equipment rack and shelf. The designation "equipment rack" pertains to the structure on which a number of LRUs are installed. The equipment rack shall be designed so best use can be made of the available space, often resulting in more than one tier of equipment. The structure upon which any one tier of equipment is mounted is designated a shelf. Shelves provide the support points which mechanically locate the LRU. The rack electrically interfaces the LRU with the aircraft wiring and other LRUs, and interfaces the LRU with the equipment cooling system. An equipment rack may be open or partially enclosed, or it may be entirely enclosed to meet specific requirements.

3.1.3 LRU guides and holddowns. LRU guides and holddowns on the shelf are integrated into the design of a mounting base or tray to provide dimensional control between the LRU, the rack connector, and the cooling air interface. A mounting tray combines the functions of LRU guides, LRU supporting structure, structure for attaching holddown devices, and back panel structure for attaching and locating the connector and air inlet control devices.

3.1.4 Electrical interface. The electrical interface between the LRU and the aircraft wiring is provided by a rack to panel connector. The metal or structural component on which the rack half of the connector is mounted in the rack is designated as the backplate.

3.1.5 Electrical power supply. The characteristics of the electrical power supplied to the equipment racks are usually described/controlled by the airframe manufacturer's specification for the particular aircraft. MIL-STD-704 describes the limits of deviation of the power quality from nominal under steady-state, normal, abnormal, and emergency conditions of operation in the aircraft electrical system.

3.1.6 Cooling air ducts and plenums. Ducting and plenums are members built into or mounted on the rack or adjacent structures to direct the flow of cooling air to the LRU. Mating apertures in the LRU provide for passage of the cooling air through the LRU.

3.1.7 Electronic part. An electronic part, for the purpose of this document is defined as an item not subject to further disassembly which is utilized in the fabrication of avionic equipment. For example: resistors, capacitors, filters, circuit breakers, switches, connectors (electrical), relays, coils, transformers, piezoelectric crystals, electron tubes, transistors, diodes, microcircuits, waveguides, synchros, and resolvers.

3.1.8 Temperature-critical parts. Temperature-critical parts are electronic parts whose operating temperatures are most likely to approach their minimum or maximum allowable temperature and begin degradation of performance.

3.1.9 Thermal stabilization. A stabilized thermal condition has been attained when the indicated temperature of all temperature sensors internal to the test chamber (including the instrumented test unit electronic parts) have varied no more than 2°C over a continuous one-hour exposure period.

3.1.10 Maximum steady-state heat dissipation. Unless otherwise specified, the maximum steady-state heat dissipation is the condition wherein the equipment is operated at the maximum steady-state supply voltage level through the normal operational duty cycle which will yield the maximum heat dissipation.

3.1.11 Ambient temperature. Ambient temperature is the air temperature immediately surrounding the equipment.

3.1.12 Thermal design conditions. The thermal design conditions are the environmental and electrical operating modes to be used as the basic design conditions for the equipment.

3.1.13 Standard sea level pressure. Standard sea level ambient pressure for purposes of specification, test, and evaluation, is 101.3 kilopascals absolute. The local ambient pressure is acceptable provided it is stated in the test report.

3.1.14 Mating apertures. The openings in the rear panel of the LRU through which conditioned air is fed through or returned to regulate the operating temperature of the LRU interior and electronic parts.

3.1.15 Air transport racking (ATR). The term "ATR" is defined as the size of a line replaceable unit configured in accordance with ARINC Specification 404A. These standard sizes are used primarily for commercial avionics equipment, but are also used industry-wide as at typical form factor for avionics packaging.

3.2 The specified datum and dimension (DIM) definitions are applicable to the figures contained in this standard.

3.2.1	DATUM -A-	Reference vertical surface on inside of LRU rear panel used to locate electrical receptacle.
3.2.2	DATUM -B-	Reference bottom surface of LRU container.
3.2.3	DATUM -C-	Reference theoretical vertical center plans of LRU measured on the surface of DATUM -A-. Used to define locations of electrical connectors and alternate rear holddown. See figures 1 and 4.
3.2.4	DATUM -D-	Reserved for future use.
3.2.5	DATUM -E-	Reference vertical surface on front side of shelf or rack backplate used to locate electrical plugs, cooling air seals and alternate rear holddown pins.
3.2.6	DATUM -F-	Reference vertical surface on LRU front panel used to locate holddown hooks, handles, etc.
3.2.7	DATUM -G-	Reference vertical center line plane of tray extending forward normal to DATUM -E-. Used as LRU vertical reference and to locate other rack and tray surfaces.
3.2.8	DATUM -K-	Defines horizontal surface of tray or rack to support LRU.
3.2.9	DIM J	Standardized width dimensions between holddown hooks.

3.2.10 DIM P Standadized dimensions between holddown pin for LRU sizes 4 through 12.

3.2.11 DIM T Standardized width dimensions of rack or tray including tolerance to accomodate installation of standardized LRUs of various sizes.

3.2.12 DIM W Standardized front width dimensions for LRU sizes 2 through 12.

3.2.13 DIM Y Standardized vertical dimension between bottom of rack and connector centerline.

4. DETAILED REQUIREMENTS

4.1 Program plans. Program plans (see 6.3) shall be prepared, used and maintained.

4.2 Line replaceable unit (LRU). The internal configuration of the LRUs shall be the responsibility of the equipment developing agency. However, the specific limits of interfaces which are required for physical interchange-ability, discussed in the following sections, shall be observed in each LRU design. The weights and cooling air consumptions of LRUs which comply with this standard shall be limited in proportion to the unit's size (width of rack occupied). This standard establishes the loading and cooling air supply requirement per unit length of shelf space in the avionics bay. The approxi-mately maximum values are 100 kg per meter and 4 kW per meter.

4.2.1 Form factor and case dimensions. The LRU is a right parallelpiped. The height and length dimensions shall be fixed. Variations in LRU sizes shall be accounted for by modular increments in case width. The smallest LRU shall be designated "Size 2," and all others shall be designated "Size n," where "n" is the number of modular units that would occupy the same shelf width as the case in question. The dimensions associated with each case size shall be as shown on figure 1 and in table I. Variations in length, as provided in table I, shall be permitted only with the approval of the government procuring activity.

4.2.1.1 LRU holddowns. The LRU shall have MIL-F-85731-11 and MIL-F-85731-12 fasteners installed, as shown on figure 2, or structurally and mechanically equivalent devices. For LRUs sizes 2, 3, 4, and 5, which have been mounted on the side, provisions shall be made for the optional attachment of MIL-F-85731-11 and MIl-F-85731-12 fasteners or structurally and mechanically equivalent devices on the lefthand 200 mm edge of the front panel. The LRU shall be capable of withstanding the following:

a. The compressive forces exerted between the holddown hooks on the front of the box and the connector on the rear of the box.

b. The vertical forces resulting from the downward component of the holddown devices, installed as shown on figure 3, in addition to the specified flight loads (see 4.3.6.2).

c. The tensile forces resulting from pulling the LRU out of its mating connector. The maximum values of the compressive and tensile forces shall be as shown in table II.

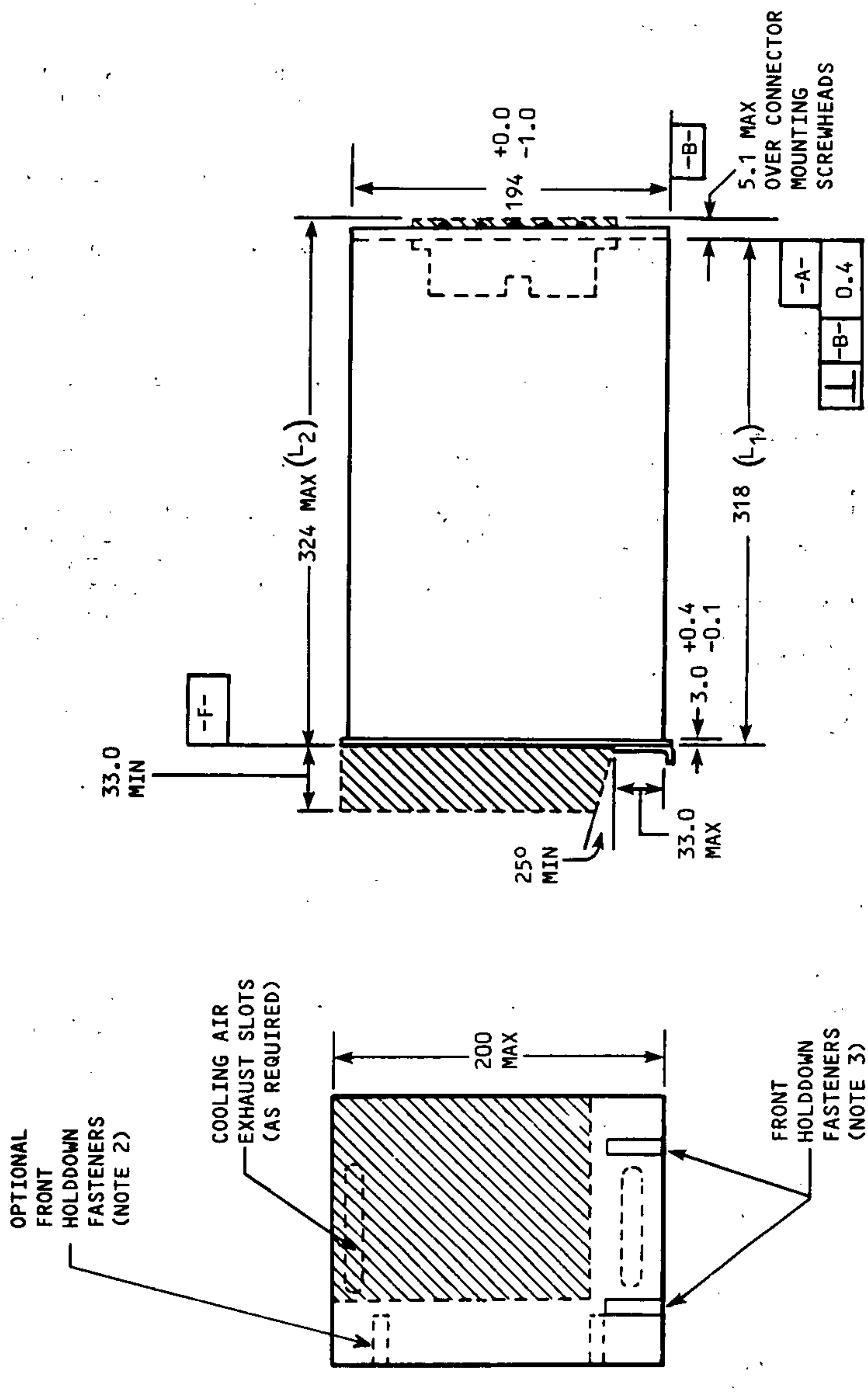


FIGURE 1A. FRONT VIEW.

FIGURE 1B. SIDE VIEW.

FIGURE 1. Standard LRU case.

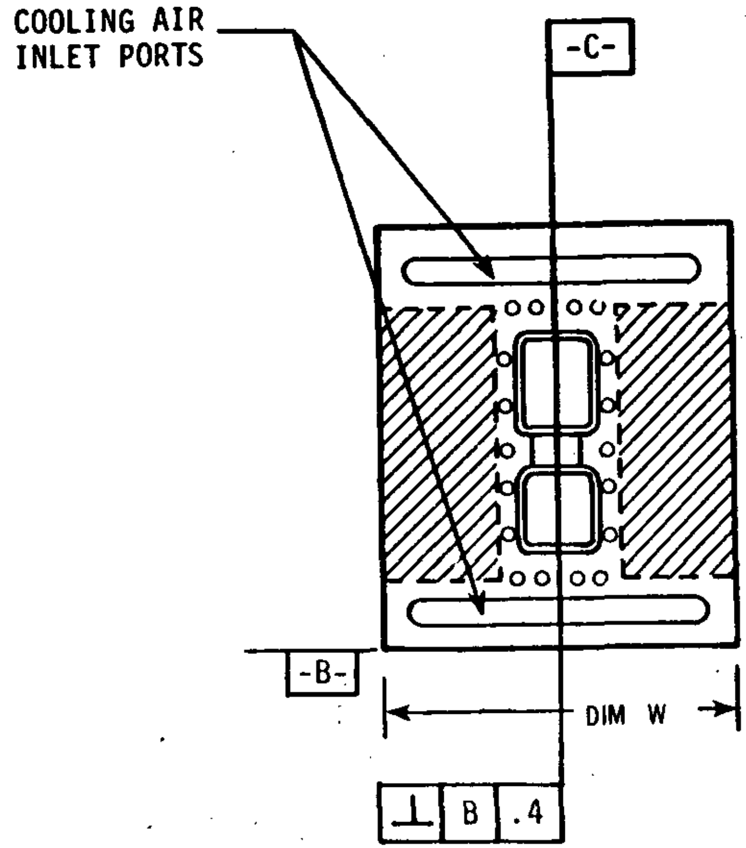


FIGURE IC. BACK VIEW.

LRU SIZE	2	3	4	5	6	7	8	9	10	11	12
DIM W	57.2	90.4	124	157.2	190.5	223.3	256.3	289.3	322.3	355.3	388.4

NOTES:
1. Dimensions are in millimeters. Unless otherwise specified, the tolerance is ±1.0 mm.
2. Optional front holddown fasteners are for LRU sizes 2 through 5 only.
3. Front holddown fasteners shall be in accordance with MIL-F-85731, or structurally and mechanically equivalent devices.

FIGURE 1. Standard LRU case. - Continued

TABLE I. Standard LRU dimensions.

LRU SIZE	WIDTH (W) mm +0.5	WIDTH (W) inches +0.02	HEIGHT (H) mm +0.0, -1.0	HEIGHT (H) inches +0.0, -0.04	LENGTH mm	LENGTH inches
12	388.4	15.29	↑	↑	↑	↑
11	355.3	13.99				
10	322.3	12.69				
9	289.3	11.39				
8	256.3	10.09				
7	223.3	8.79	194	7.64	L_1 318 ±1.0	12.52 ±0.04
6	190.5	7.50				
5	157.2	6.19				
4	124.0	4.88			L_2 324 MAX	12.76
3	90.4	3.56				
2	57.2	2.25	↓	↓	↓	↓

NOTES:
1. The LRU sizes listed above are derived from the short Air Transport Racking (ATR) boxes which have been the airline industry standard for black box design. The correlation between the LRU sizes of this standard and certain ATR sizes are given below:

a. The LRU height is the maximum allowed
b. The length is approximately equivalent to ATR short
c. The LRU width equivalencies are:

Size 12	1-1/2 ATR (Approximately)
Size 8	1 ATR (Approximately)
Size 6	3/4 ATR
Size 4	1/2 ATR
Size 3	3/8 ATR
Size 2	1/4 ATR

2. When a deviation to the standard lengths is unavoidable, the following values shall be used:

ALTERNATES (L_1):

496 ±1.0 mm (19.53 ±0.04 in)
192 ±1.0 mm (7.56 ±0.04 in)

ALTERNATES (L_2):

502 mm (19.76 in) MAX (REF)
198 mm (7.78 in) MAX (REF)

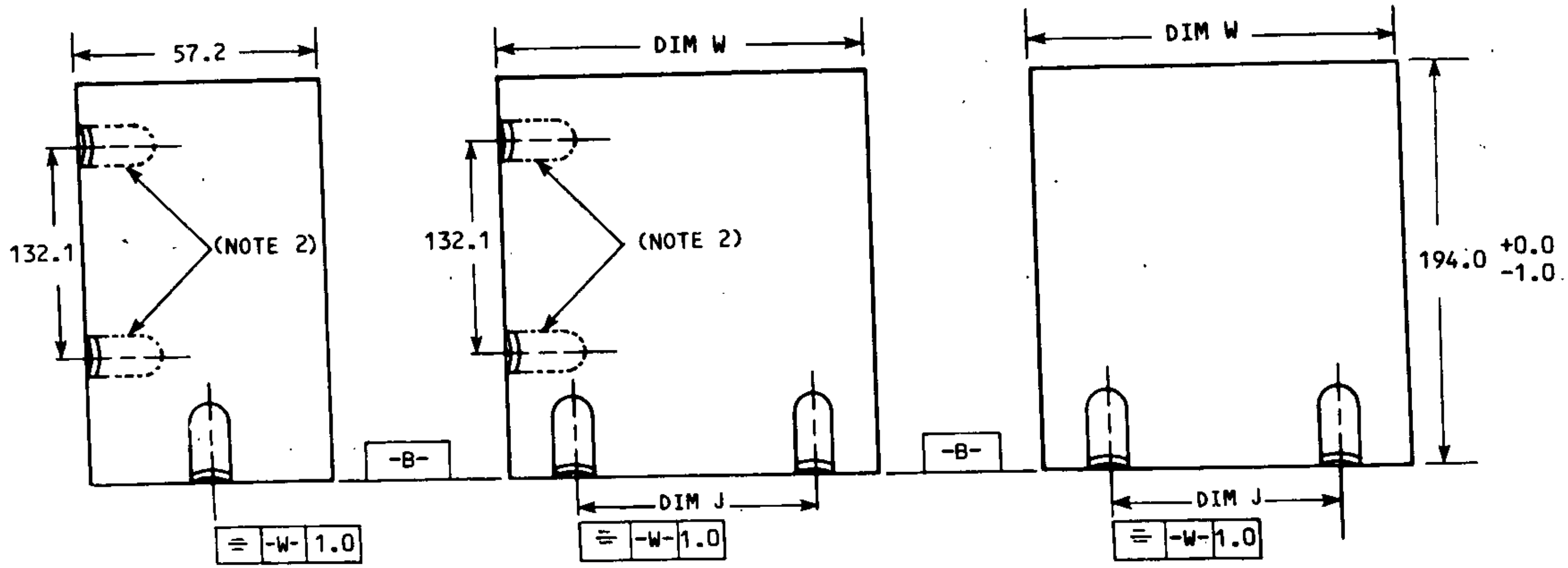


FIGURE 2A. Vertical (One Holddown) or Side Mounted (Three Holddowns)--Size 2 Only.

FIGURE 2B. Vertical (Two Holddowns) or Side Mounted (Four Holddowns)--Sizes 3, 4 and 5 Only.

FIGURE 2C. Vertical Mounted (Two Holddowns) --Size 6 and Larger.

FIGURE 2. LRU holddown mechanism.

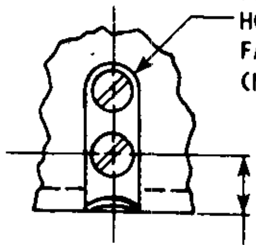


FIGURE 2D. Front Holdown Detail.

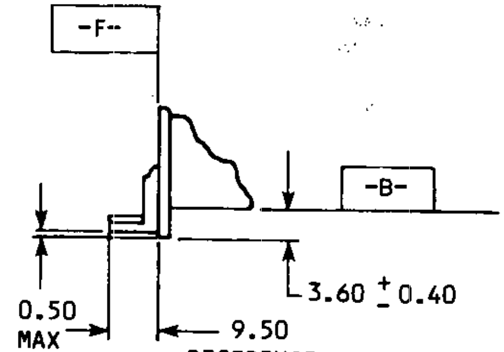


FIGURE 2E. Side View Detail.

LRU SIZE	3	4	5	6	7	8	9	10	11	12
DIM J ± 0.5 mm	66.0	66.0	99.1	132.1	165.1	198.1	231.1	264.2	297.2	330.2
DIM W ± 0.5 mm	90.4	124	157.2	190.5	223.3	265.3	289.3	322.3	355.3	388.4

NOTES:
1. Dimensions are in millimeters. Unless otherwise specified, the tolerance is ±1.0 mm.
2. Optional front holddown fasteners are for LRU sizes 2 through 5 only.
3. Front holddown fasteners shall be in accordance with MIL-F-85731, or structurally and mechanically equivalent devices.

FIGURE 2. <u>LRU holddown mechanism</u>. - Continued

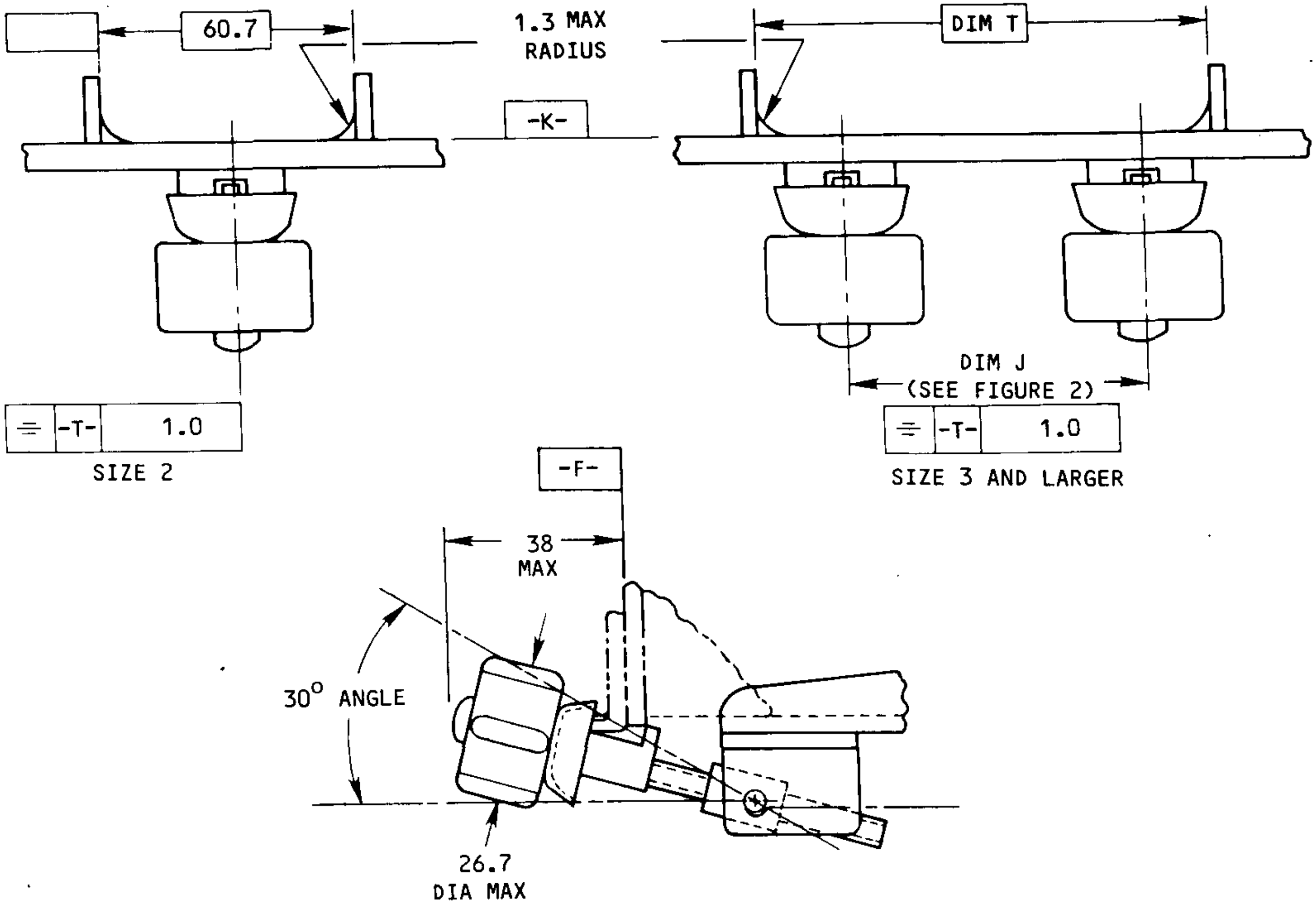


FIGURE 3. LRU/rack holddown mechanism.

LRU UNIT SIZE	3	4	5	6	7	8	9	10	11	12
DIM T ± 0.3 mm	93.7	127.3	160.3	193.3	226.3	259.3	292.4	325.4	358.4	391.4

NOTES:
1. Dimensions are in millimeters. Unless otherwise specified, the tolerance is ±1.0 mm.
2. Any combination of the pivot location and shaft length of the holddown that will provide a θ of $30^{\circ} \pm 5^{\circ}$, when the LRU connector is completely engaged with the backplate connector, is satisfactory.

FIGURE 3. LRU/rack holddown mechanism. - Continued

TABLE II. Maximum values of compressive and tensile forces.

LRU Size	Maximum axial force to be applied by holddown or other insertion device
12 to 3	1800 Newtons (312 lbs) (Equally divided between two hooks)
2	900 Newtons (156 lbs)

4.2.1.2 Front panel protrusions. All protrusions, such as handles, controls, displays and connectors, shall lie within the outline envelope shown shaded on figure 1.

4.2.1.2.1 Each LRU shall be provided with handle(s) or other suitable means for grasping, handling, and carrying. Handling provisions shall be located to allow for hand access as if maintainer(s) were reaching through an opening the same size as the LRU front view.

4.2.1.2.2 All controls, displays, test connectors and panel nomenclature shall comply with the design criteria of MIL-STD-1472 with regard to dimensions, locations and spacing.

4.2.1.3 Rear panel. The primary purpose of the back of the LRU shall be for connecting to the cooling air supply and mounting the electrical connector. Any other use shall not interfere with the interfacing of the LRU with the rack. Connector-mounting screw heads shall lie within the limits shown on figure 1.

4.2.1.3.1 The connector position on an LRU shall be as specified on figure 4. The rear mounting surface shall have a maximum thickness of 2.5 mm in the connector mounting area, ZONE "A". Projections on the LRU backplate surface are permitted provided there is no interference with the rack backplate, as provided by the dimensioning and tolerancing specified on figure 1.

4.2.1.4 Maximum weight. Maximum weight limits shall be as shown in table III to enable adequate strucutral design of racks and shelves which must carry the loads. In no case shall a unit having a weight of more than the amount given in table III be installed. Each LRU weighing 5 kg or more shall be prominently labeled on the front of the box with the weight. Each LRU weighing over 20 kg shall be prominently labeled on the front of the box with a two-man lift warning, and shall be subject to approval by the procuring activity.

4.2.2 Cooling. When the LRU heat dissipation exceeds the values given in table IV, column 3, "Without Cooling Air," the active cooling medium shall be forced air (as defined in 4.5.3) moving through passages in the LRU. In all cases, the LRU designer shall make efficient use of the cooling air supplied to the unit. Cooling by air impinging directly on electronic components shall not be permitted. Particular attention shall be directed to avoiding air leaks that allow coolant to bypass heat transfer surfaces. The maximum power dissipation for LRUs with cooling shall be as defined in table IV, column 2.

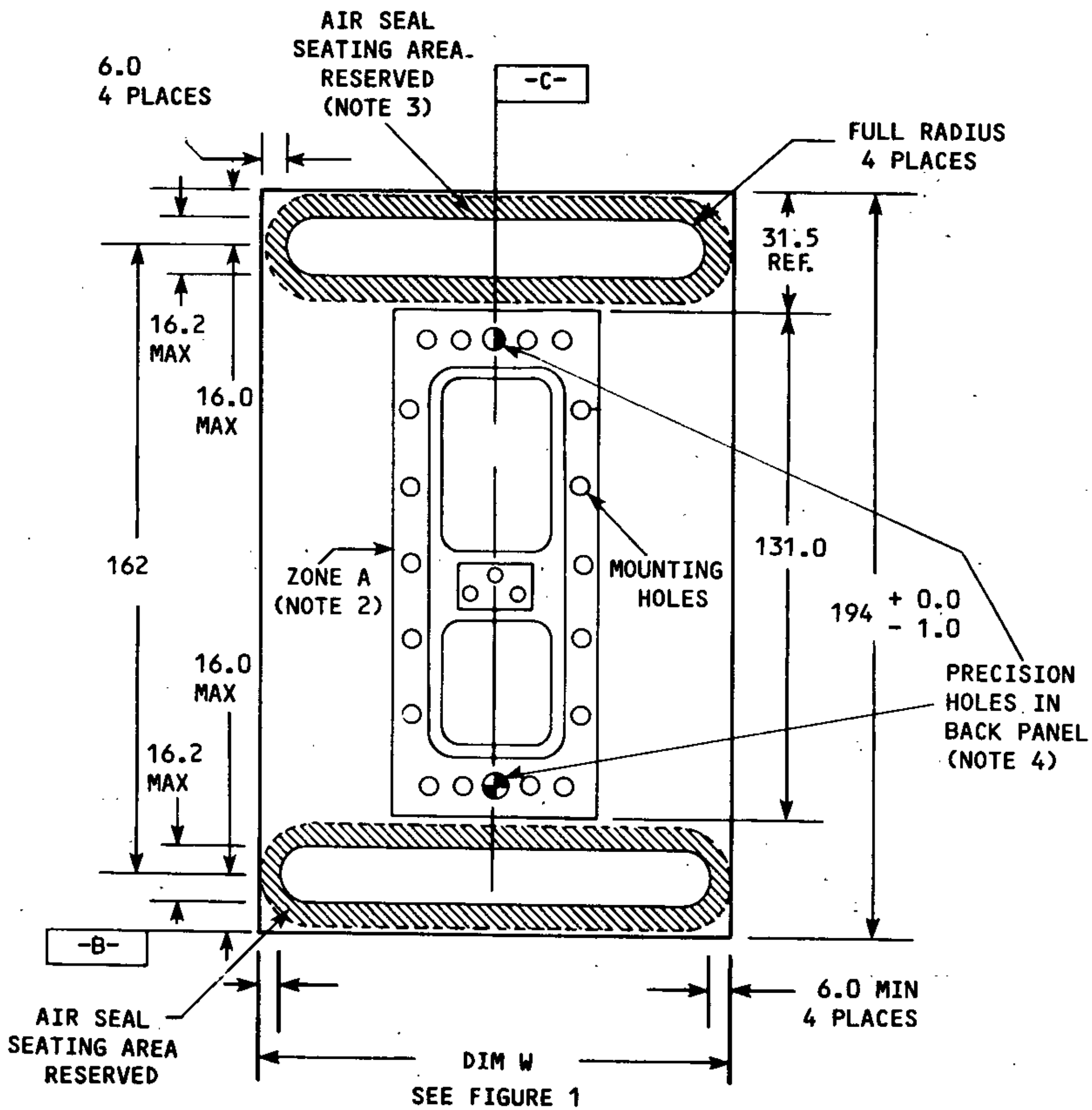
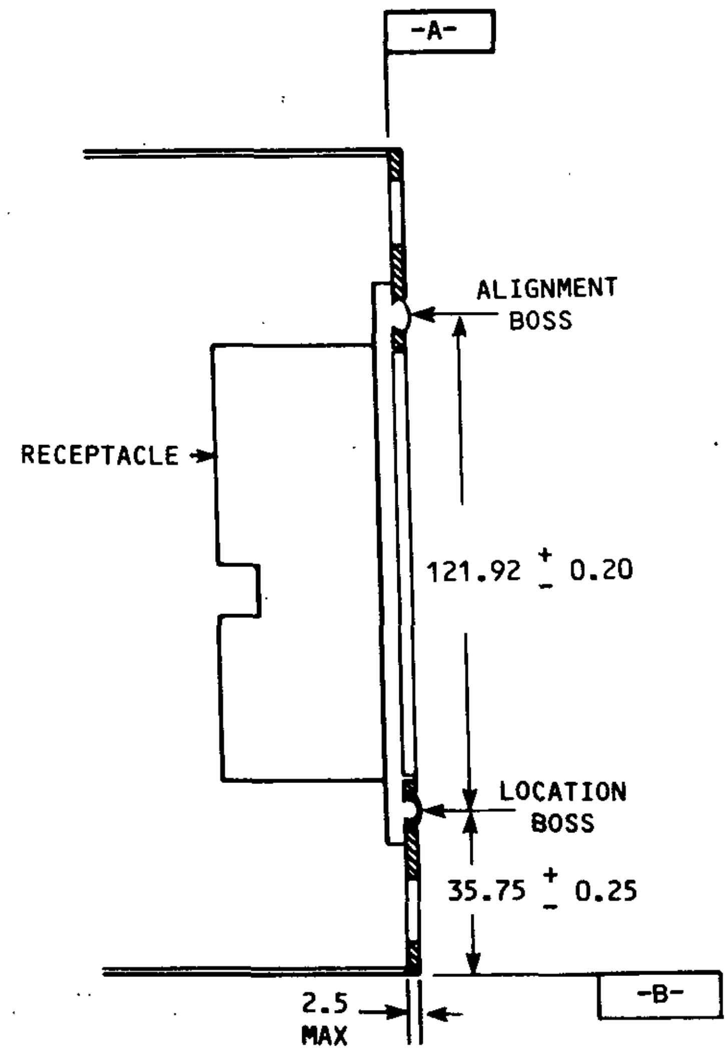


FIGURE 4. LRU, location of connector and cooling air aperatures.



NOTES:

1. Dimensions are in millimeters. Unless otherwise specified, the tolerance is ±1.0 mm.
2. Zone A is the area reserved for the connector location, and varies with the connector type.
3. The air seal seating area is reserved. There shall be no projection within this area.
4. The precision holes in the LRU back panel shall be drilled to fit the connector bosses, (See DoD-C-83527).

FIGURE 4. LRU, location of connection and cooling air aperatures. - Continued

TABLE III. LRU maximum weight.

LRU Size	Maximum Permissible Weight	
	Kilograms	Pounds
12 to 8	27.5	60.5
7	24.0	52.8
6	20.5	45.1
5	17.0	37.4
4	13.5	29.7
3	10.0	22.0
2	6.5	14.3

TABLE IV. Maximum LRU thermal dissipation.

LRU Size	Maximum Permissible Power Dissipation (Watts)	
	With Cooling Air	Without Cooling Air 1/
12	1500	35
11	1375	32
10	1250	30
9	1125	27
8	1000	25
7	875	22
6	750	20
5	625	17
4	500	15
3	375	12
2	250	10

1/ Equipment mounted in avionics racking, in accordance with this standard, but not requiring forced air cooling. Units not requiring forced air cooling shall pass the appraisal test in accordance with 4.5.5, with no air provided to the unit.

4.2.2.1 Cooling air inlet and outlet locations. The cooling air shall enter the equipment through the rear surface only. The exhaust cooling air shall exit via ports in the front face of the LRU (see figures 1, 4, 5 and 6).

4.2.2.1.1 When closed loop air cooling systems are employed for the entire avionics equipment rack, consideration shall be given to using the upper rear port for the air inlet and the lower rear port for exhaust, with no ports in the front face of the LRU. The closed loop configuration shall be subject to the approval of the procuring activity.

4.2.2.2 Cooling air interface. The interface with the avionics cooling system shall be designed to minimize leakage through both external and internal LRU interface. The interface with the aircraft environmental control system shall be via apertures in the LRU in accordance with the details shown in figure 4. The quantity and condition of cooling air flow through the unit shall be as defined in 4.5.2. The static air pressure drop (ΣP_S) through the LRU shall not exceed 51 mm water gauge at the design flow rate for inlet conditions of $+27^{o}C$.

4.2.2.2.1 Thermal design, thermal management, and documentation shall be in accordance with 4.2.7. The results of that design shall be proven in accordance with the evaluation tests outlined in section 5.2.2. See sections 4.5.3.3 and 5.2.2.1 for cooling pressure drop. The methods used to manage heat flow within the unit and to prevent temperature buildup at the power dissipating elements are not controlled by this standard.

4.2.2.3 Power dissipation. The power dissipated by each LRU shall be held to the minimum value consistent with its specified operational performance. The normal maximum steady-state heat dissipation of each LRU shall not exceed the values shown in table IV for forced air cooled and ambient cooled equipment. These limits are consistent with the forced air cooling concepts of this standard, but may require the use of advanced heat transfer techniques such as heat pipes, wedge circuit card clamps, and compact heat exchanger elements.

4.2.2.3.1 LRUs necessarily exceeding the power dissipation limits of table IV shall comply with all of the sections and paragraphs of this standard except that the cooling provisions shall be in accordance with the individual equipment design specification. The thermal design requirement shall be in accordance with 4.2.7, and its documentation shall include full details of the required cooling interface.

4.2.2.4 LRU cooling evaluation. Each LRU design shall be evaluated by the thermal appraisal test per paragraph 4.5.5, to demonstrate the unit's capability to perform and survive under the conditions set forth in this standard.

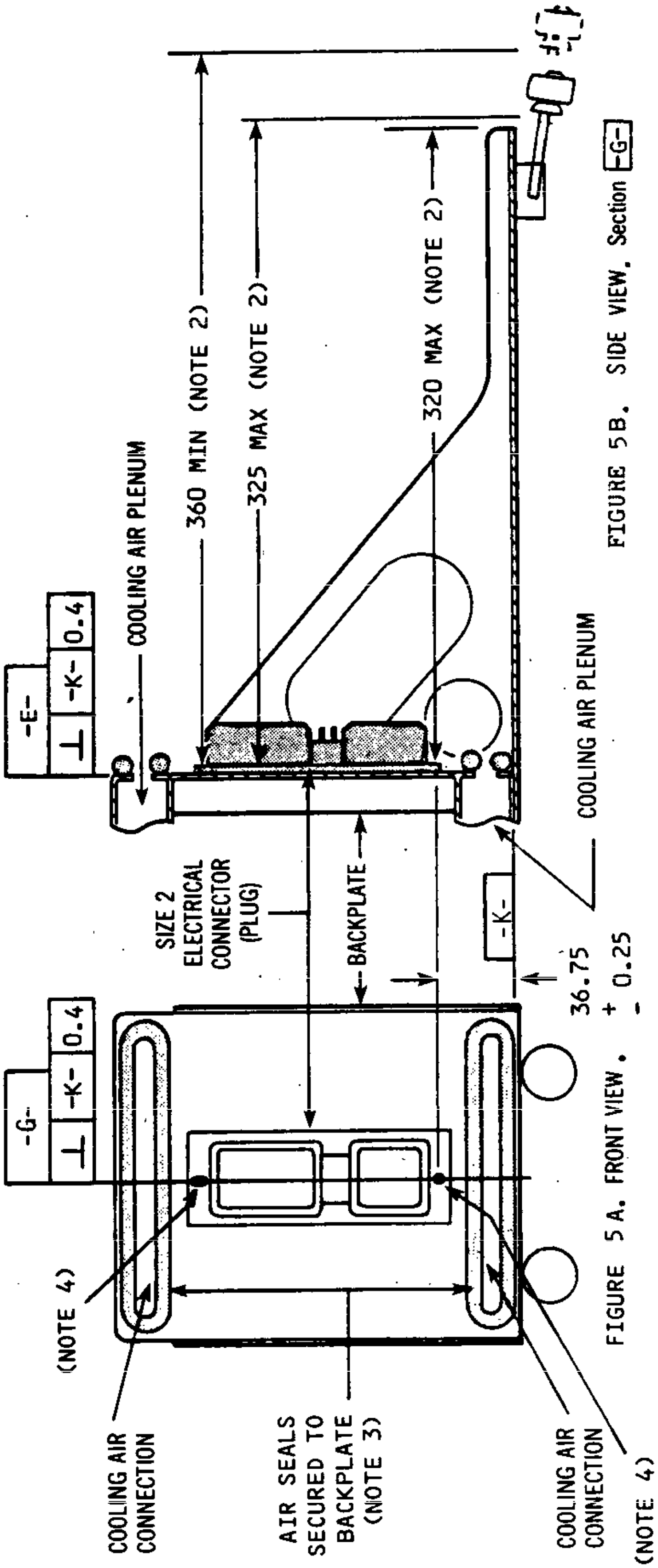


FIGURE 5. Rack datums, connector, and cooling air interface.

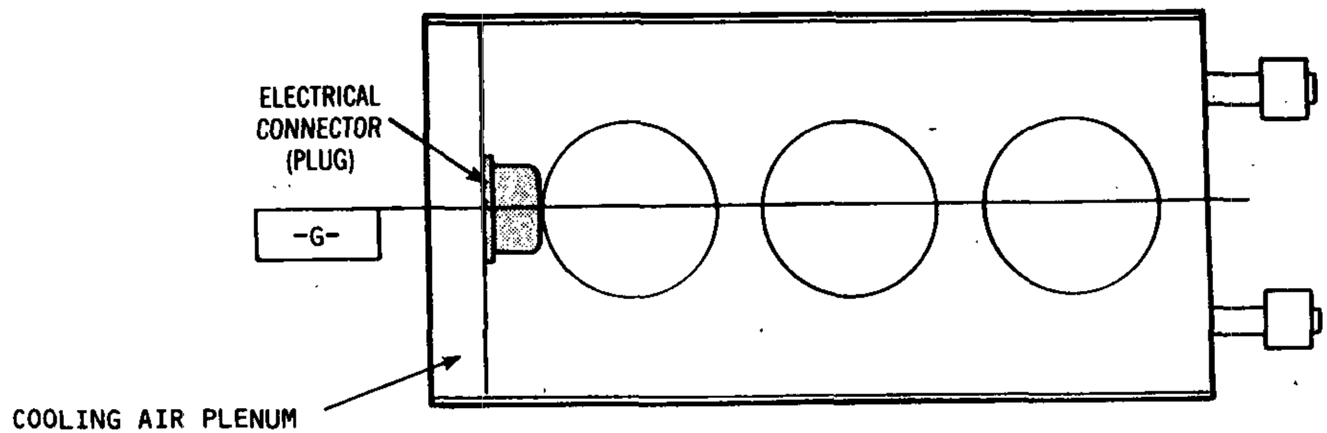


FIGURE 5C. TOP VIEW.

NOTES:
1. Dimensions are in millimeters. Unless otherwise specified, the tolerance is ±1.0 mm.
2. These dimensions apply from the front plane of the connector flange, whether the connector is mounted on the front (as shown), or on the rear of the rack backplate.
3. Air seals shall be attached to the front surface of the backplate only.
4. The oval and round slot receptacles are detailed on figure 4.

FIGURE 5. Rack datums, connector, and cooling air interface. - Continued

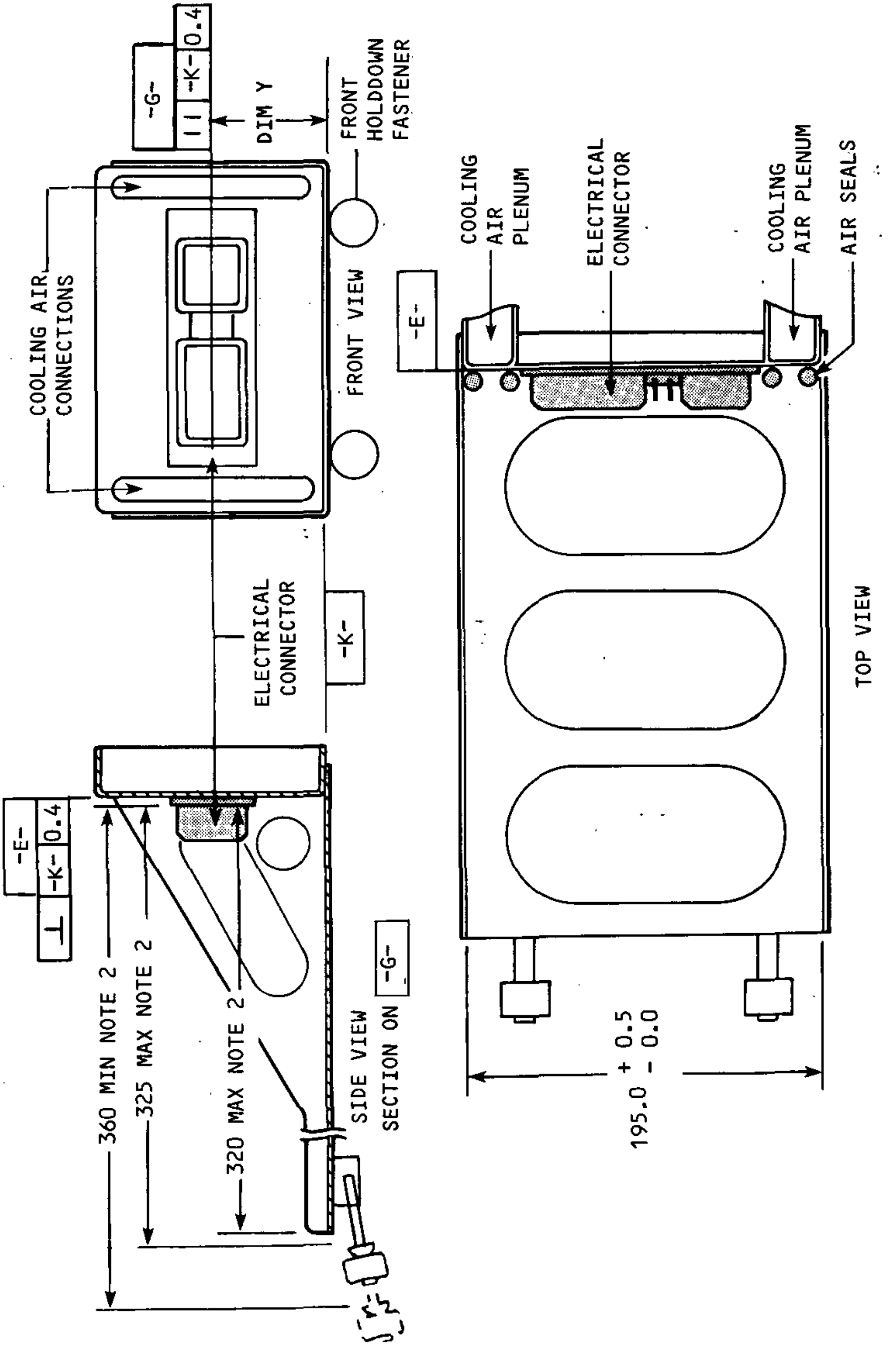


FIGURE 6. Typical low-profile tray.

LRU SIZE		2	3	4	5
DIM Y	MIN.	29.1	45.7	62.5	79.1
mm	MAX.	29.6	46.2	63.0	79.6

NOTES:

1. Dimensions are in millimeters. Unless otherwise specified, the tolerance is ±1.0 mm.
2. These dimensions apply from the front plane of the connector flange, whether the connector is mounted on the front (as shown), or on the rear of the rack backplate.

FIGURE 6. <u>Typical low-profile tray</u>. - Continued

4.2.3 Moisture pockets. Pockets, wells, traps, and the like, in which water or condensation could collect when the equipment is in the normal position, shall be avoided where practicable. Where moisture pockets are unavoidable and the equipment is not sealed, provision shall be made for drainage of such pockets. Dessicants or moisture absorbent materials shall not be used.

4.2.4 Emergency operations. The LRU shall be designed for the following conditions.

4.2.4.1 Loss of cooling air supply. The LRU shall not be damaged nor exceed the maximum electronic part temperatures for a period of 5 minutes. The type of operation and performance shall be as defined in the detailed equipment specification.

4.2.4.2 Emergency ram-air cooling. The LRU shall meet specified performance during and after exposure to the operating conditions shown on figures 7, curve B, with the ram-air cooling flow rate as shown on figure 8, curve B, for a period of 30 minutes.

4.2.5 Electromagnetic compatibility-LRU. Each LRU shall be designed to minimize electromagnetic interference (EMI) and shall comply with the EMI limits of MIL-STD-461 for class A-1-b vehicles (manned aircraft).

4.2.6 LRU service conditions (environmental). Each LRU shall be capable of operating with no degradation in performance under each of the service conditions specified herein.

4.2.6.1 Equipment bay ambient temperature. Equipment bay ambient temperatures shall be as follows:

a. Nonoperating Survival Temperature shall be -57°C to +95°C.

NOTE: These are the lowest and highest ground temperatures expected to be experienced by equipment during aircraft storage, or exposure to climatic extremes with power off.

b. Short Term Operating Temperature, 30 Minutes Duration, shall be -54°C to +95°C.

c. Low and High Operating Temperature, Ground or Flight, Continuous, shall be -54°C to +71°C.

d. Temperature Shock shall be temperature changes between -57°C and +95°C, at rates up to ±1°C per second.

4.2.6.2 Altitude. The altitude, operating and nonoperating, shall be sea level to 70,000 feet, at rates of change up to 13 millimeters of mercury per second.

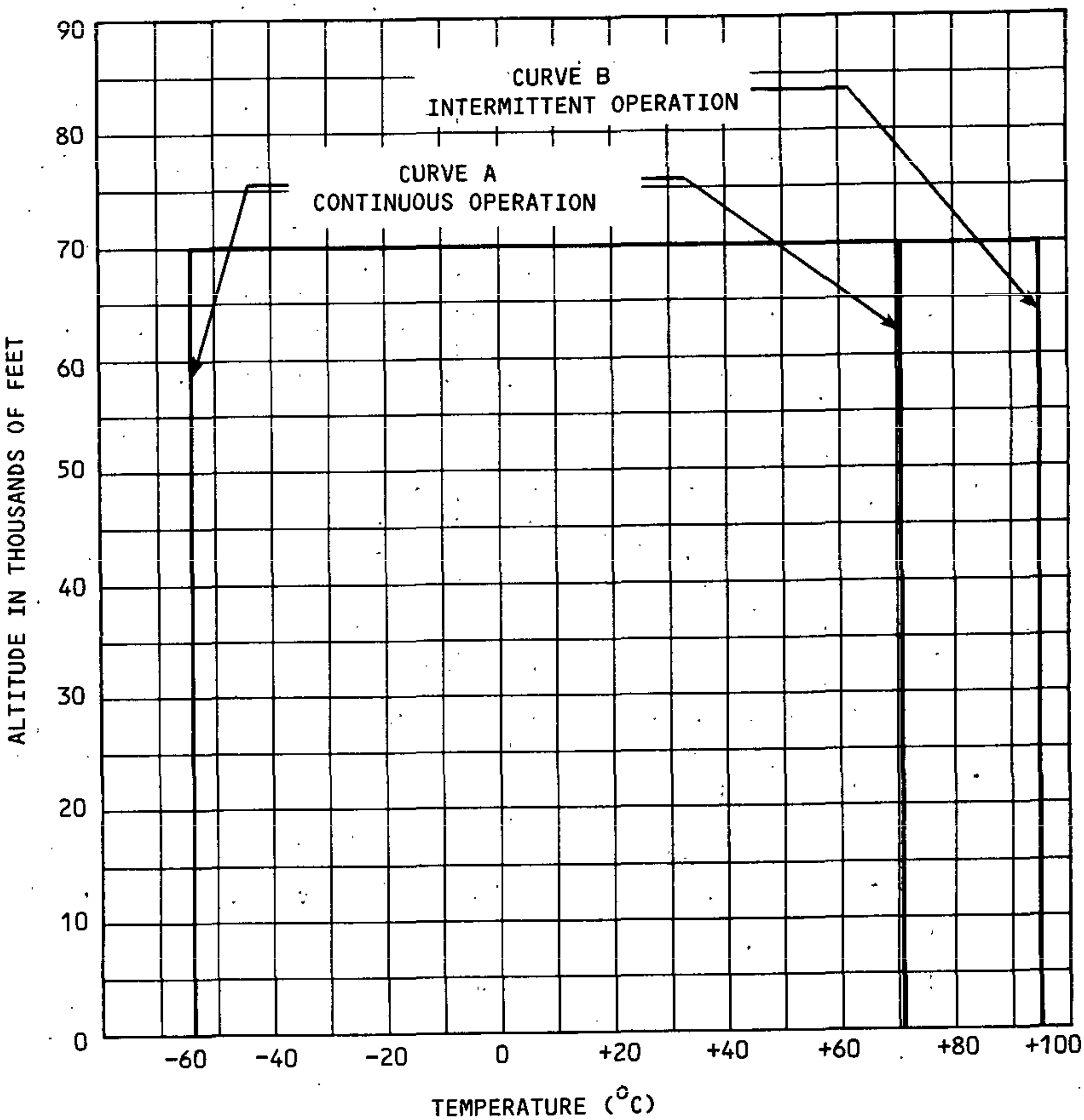


FIGURE 7a. Forced air cooled equipment.

FIGURE 7. Temperature/altitude environment.

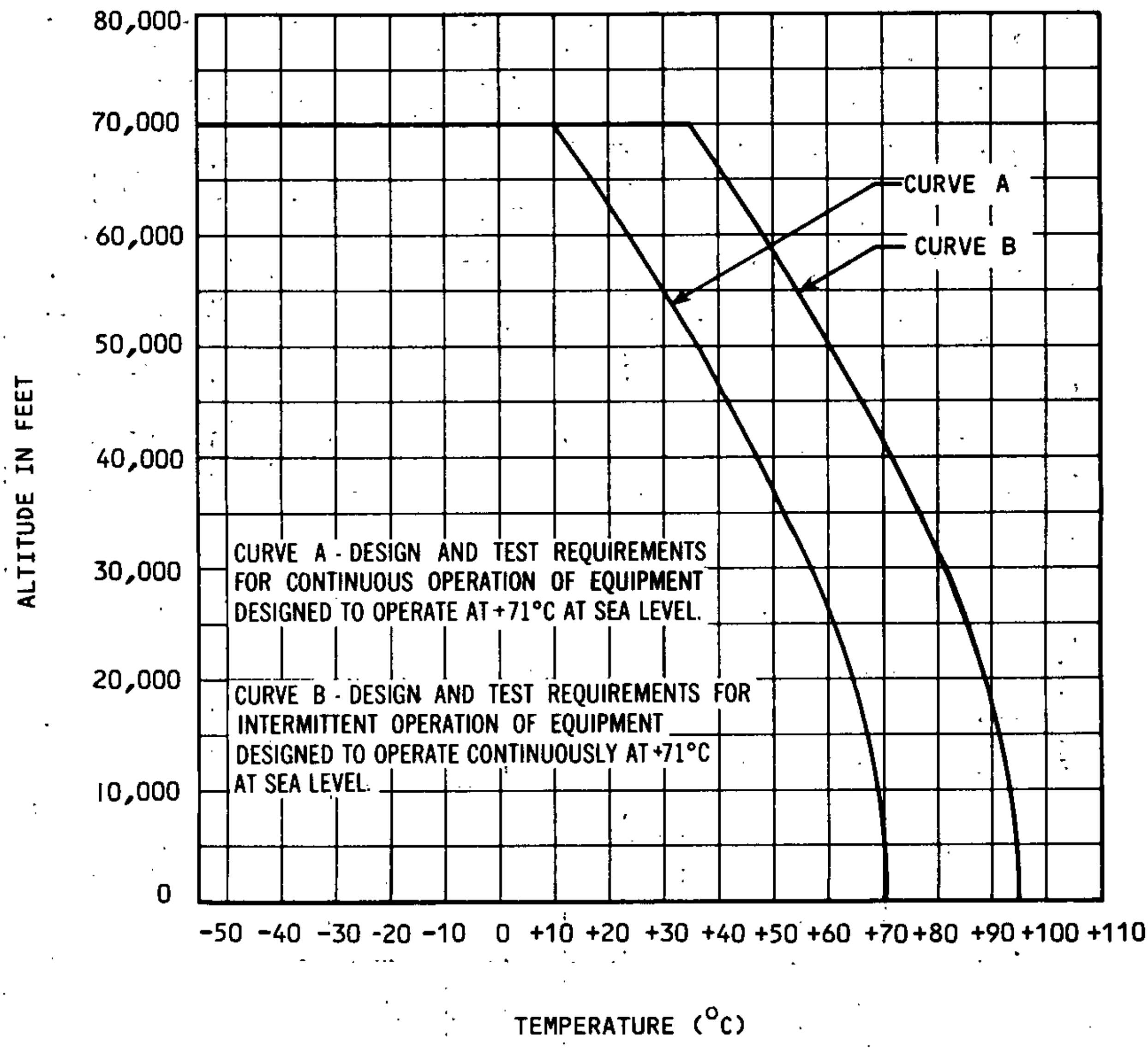


FIGURE 7b. Non-forced air cooled equipment.

FIGURE 7. Temperature/altitude environment. - Continued

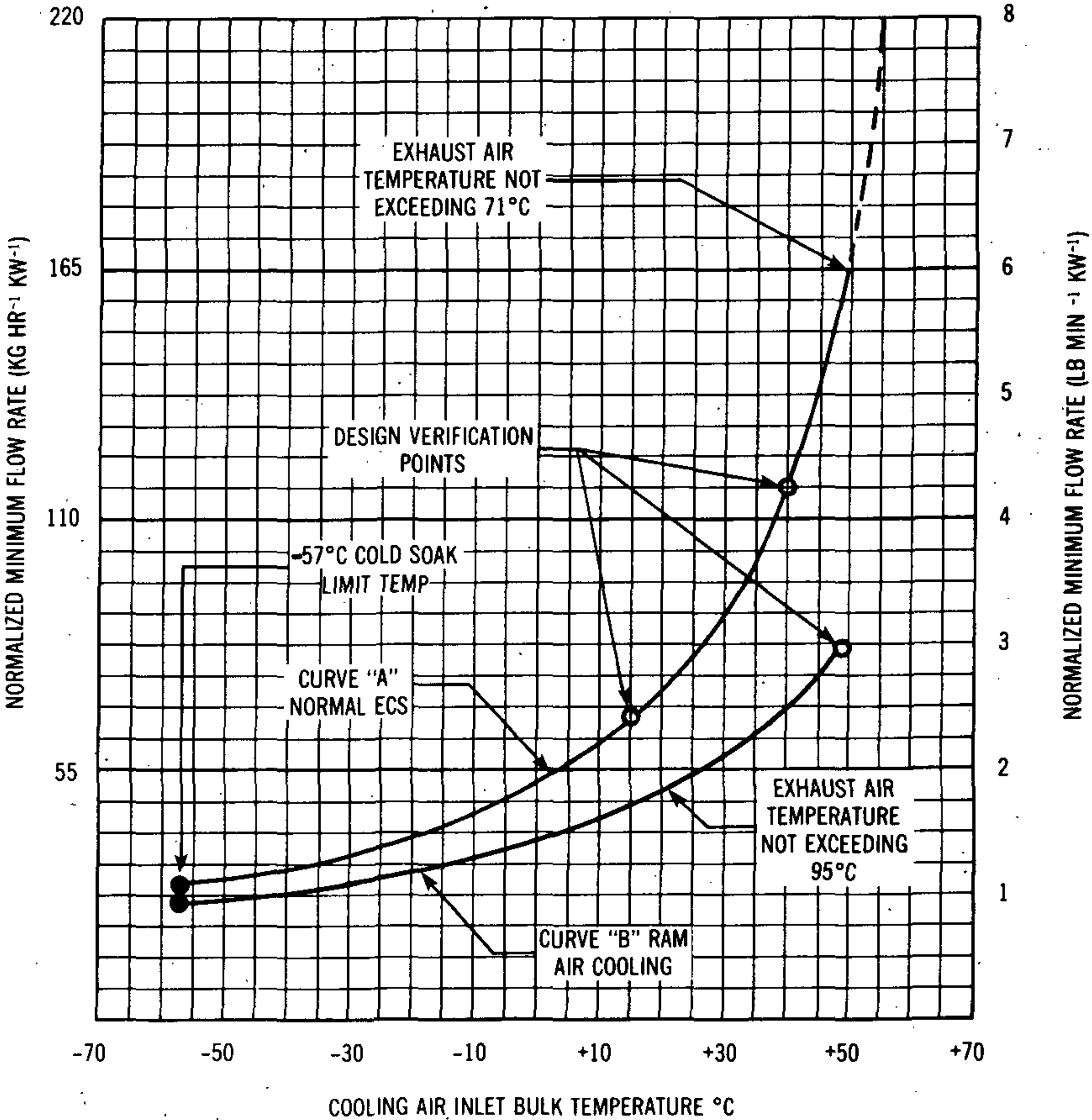


FIGURE 8. Cooling airflow requirements.

4.2.6.3 Equipment bay temperature altitude combination. Equipment bay temperature altitude combination shall be as shown on figure 7.

a. Continuous operation shall be as shown on figure 7, curve A, which represents normal operation.

b. Intermittent operation shall be as shown on figure 8, curve B, which represents RAM-AIR operation.

4.2.6.4 Vibration. The LRU shall be hard mounted when tested to the random vibration levels specified on figure 9.

4.2.6.5 Acceleration. Acceleration shall be as follows.

4.2.6.5.1 Steady acceleration levels for operation with no subsequent performance degradation, misalignment, or damage shall be as follows:

a. Horizontal plane shall be ±6.1g laterally, ±7.5g longitudinally. Vertical axis shall be up 11.3g and down 6.0g.

b. Where the orientation of an LRU in the aircraft is not determined by its functional characteristics, the steady acceleration for all axes shall be 11.3g. Any unnecessary constraint of the mounting orientation of an LRU reduces its general applicability, and interchangeability between aircraft types and models.

4.2.6.5.2 Steady acceleration levels for positive retention in the mounting (damage allowed) shall be 1.5 times the values of 4.2.6.5.1.

4.2.6.5.3 Crash acceleration levels for positive retention of LRUs that are mounted where they constitute a personnel hazard shall be forward 20g, laterally ±14g, backward 40g, upward 20g, and downward 10g.

4.2.6.6 Other environmental conditions-LRU. The LRU shall meet the requirements of the following environmental conditions.

4.2.6.6.1 Humidity-LRU. The LRU shall withstand exposure to humidity without degradation of performance when tested in accordance with 5.2.4.1 herein.

4.2.6.6.2 Bench handling: shock-LRU. The LRU shall withstand, without damage, the shock environment encountered during servicing when tested in accordance with 5.2.4.7 herein.

4.2.6.6.3 Sand and dust-LRU. The LRU shall withstand, in both an operating and nonoperating condition, exposure to sand and dust particles, as encountered in operational areas of the world, when tested in accordance with 5.2.4.3 herein.

4.2.6.6.4 Fungus-LRU. The LRU shall withstand, in both an operating and nonoperating condition, exposure to fungus growth, as encountered in tropical climates, when tested in accordance with 5.2.4.4 herein.

4.2.6.6.5 Salt atmosphere-LRU. The LRU shall withstand, in both an operating and nonoperating condition, exposure to salt-sea atmosphere when tested in accordance with 5.2.4.5 herein.

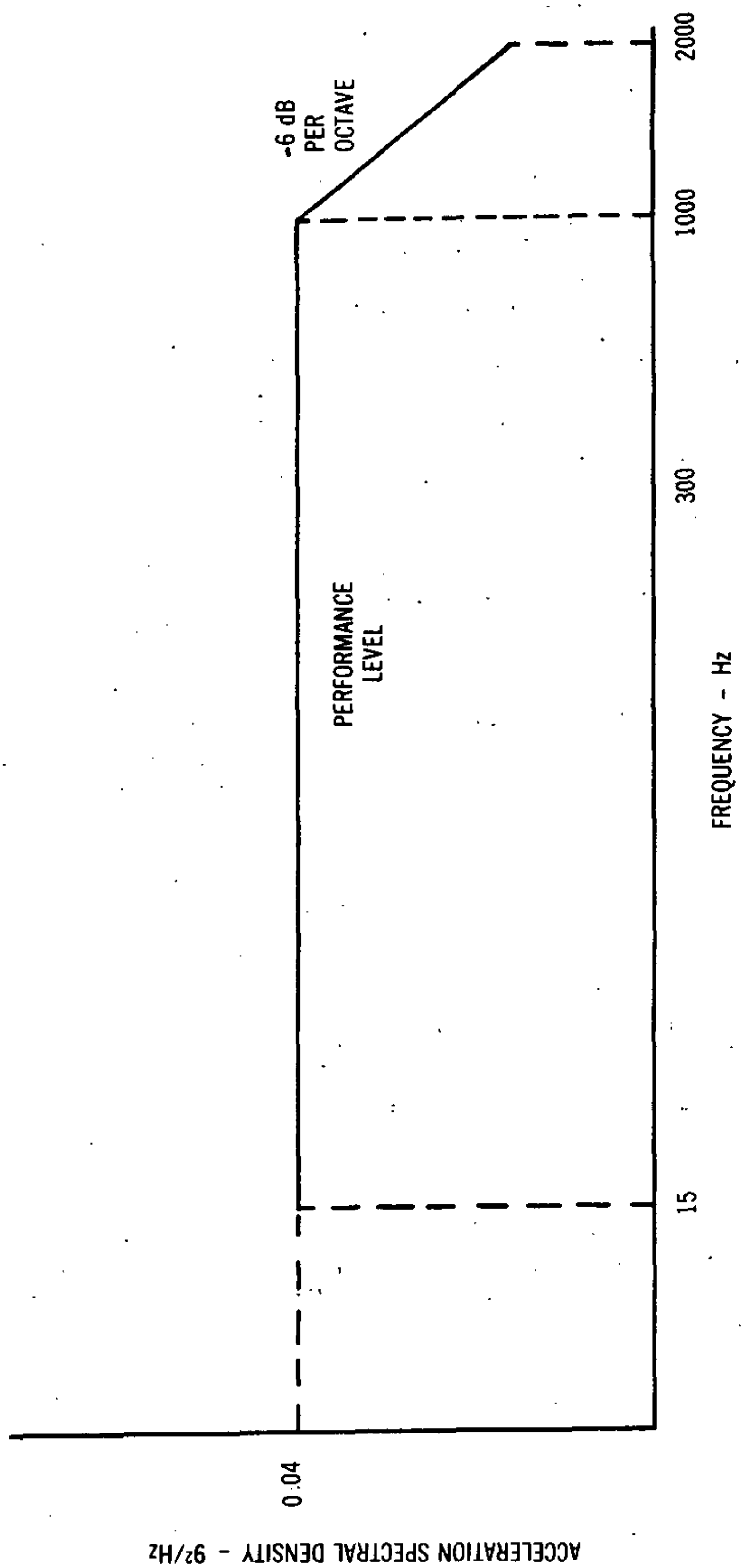


FIGURE 9. Vibration test requirements.

4.2.6.6.6 Explosive conditions-LRU. The LRU shall not cause ignition of an ambient-explosive-gaseous mixture with air, when operating in an explosive atmosphere, when tested in accordance with 5.2.4.6 herein.

4.2.6.6.7 Rain-LRU. The LRU shall withstand exposure to rain when tested in accordance with 5.2.4.2 herein.

4.2.7 LRU thermal management. The LRU design shall be thermally optimized within appropriate design constraints, to minimize the LRU Life Cycle Cost (LCC) and optimize the LRU reliability (based on the predicted reliabilities of the individual parts). A thermal management program containing a detailed thermal/reliability design analysis shall be used conducted down to the individual part level. This analysis shall be used for optimizing part placement and part design characteristics, based on the individual part reliabilities and the electrical performance of the assembly. The Thermal Appraisal Test of paragraph 4.5.5 shall verify the validity of the thermal/reliability analysis. As a result of the thermal/reliability analysis of the final production design, the relationships of the LRU total reliability and the LRU LCC shall be plotted as a function of varying the delivered coolant flow rates to the LRU at the design conditions of paragraph 4.5.1.

4.3 Avionics equipment rack. An avionics equipment rack shall provide a method of installing a number of LRUs in any particular location in the aircraft. The equipment rack shall provide a means of interfacing the LRU with aircraft wiring, equipment cooling system, and other equipment in the aircraft. Rack structure may very depending on aircraft constraints, such as available space, equipment required, and mechanical considerations, to allow each airframe manufacturer to best accommodate the required LRUs within the volume available. See figure 10 for the general arrangement of a typical rack assembly.

4.3.1 LRU spacing on rack shelf. Shelves shall be designed to accommodate any combination of LRU trays or guides. Figure 11 shows a typical shelf arrangement.

4.3.1.1 The spacing between LRU guides on a shelf shall be as shown on figure 3. These guides direct and position each LRU so that the connector on the rack or backplate, and the connector on the LRU, align for mating.

4.3.1.2 The spacing between the guide surface of one LRU guide and the adjacent guide surface on the next LRU guide, and the application of these dimensions to a shelf, shall be as shown on figure 11.

4.3.1.3 For all LRUs normally installed in an upright position, the total assembled width of any group of LRUs (including spacing) shall be equal to the width of any other group of LRUs (including spacing) having the same arithmetic sum of modular sizes.

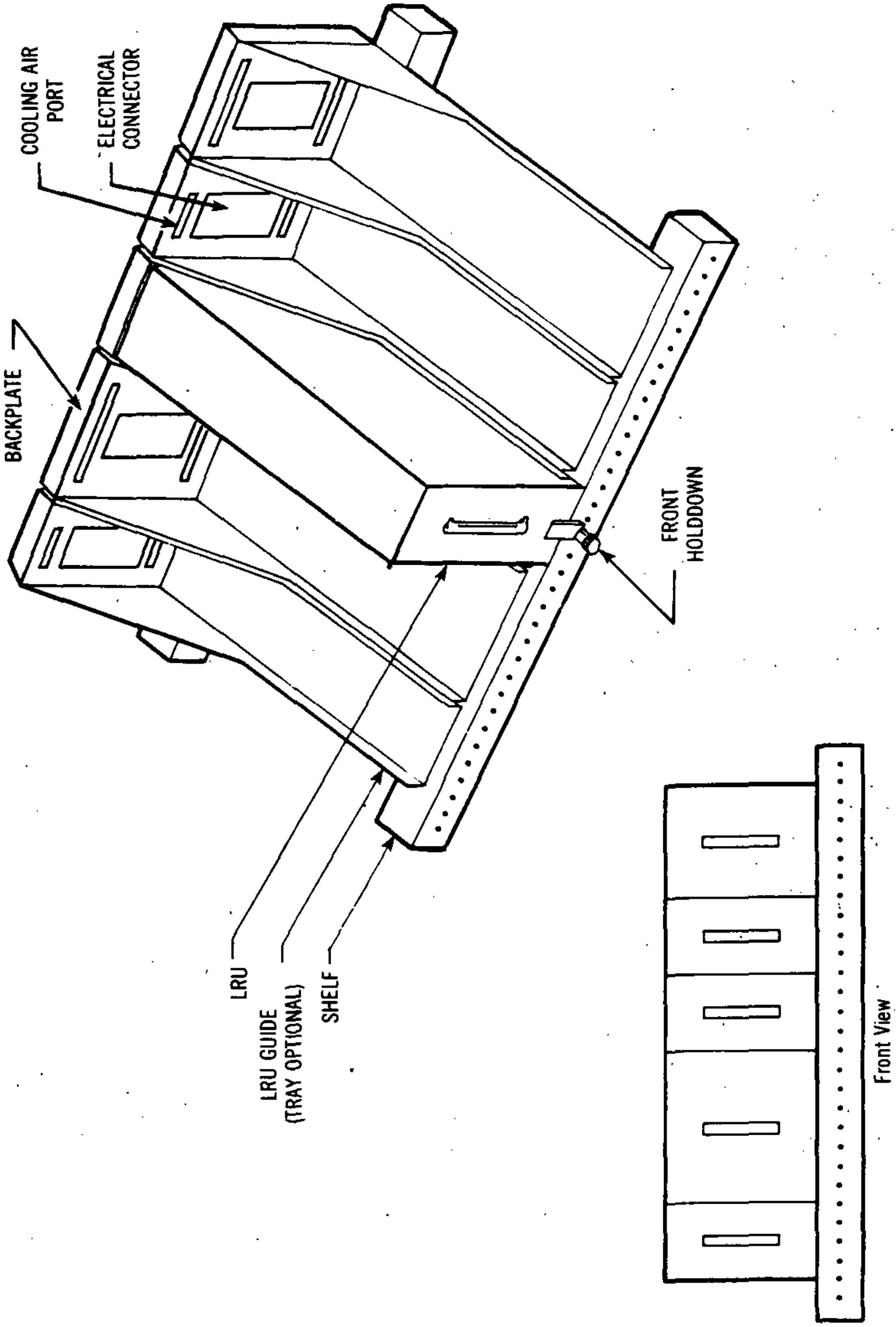


FIGURE 10. Typical rack assembly.

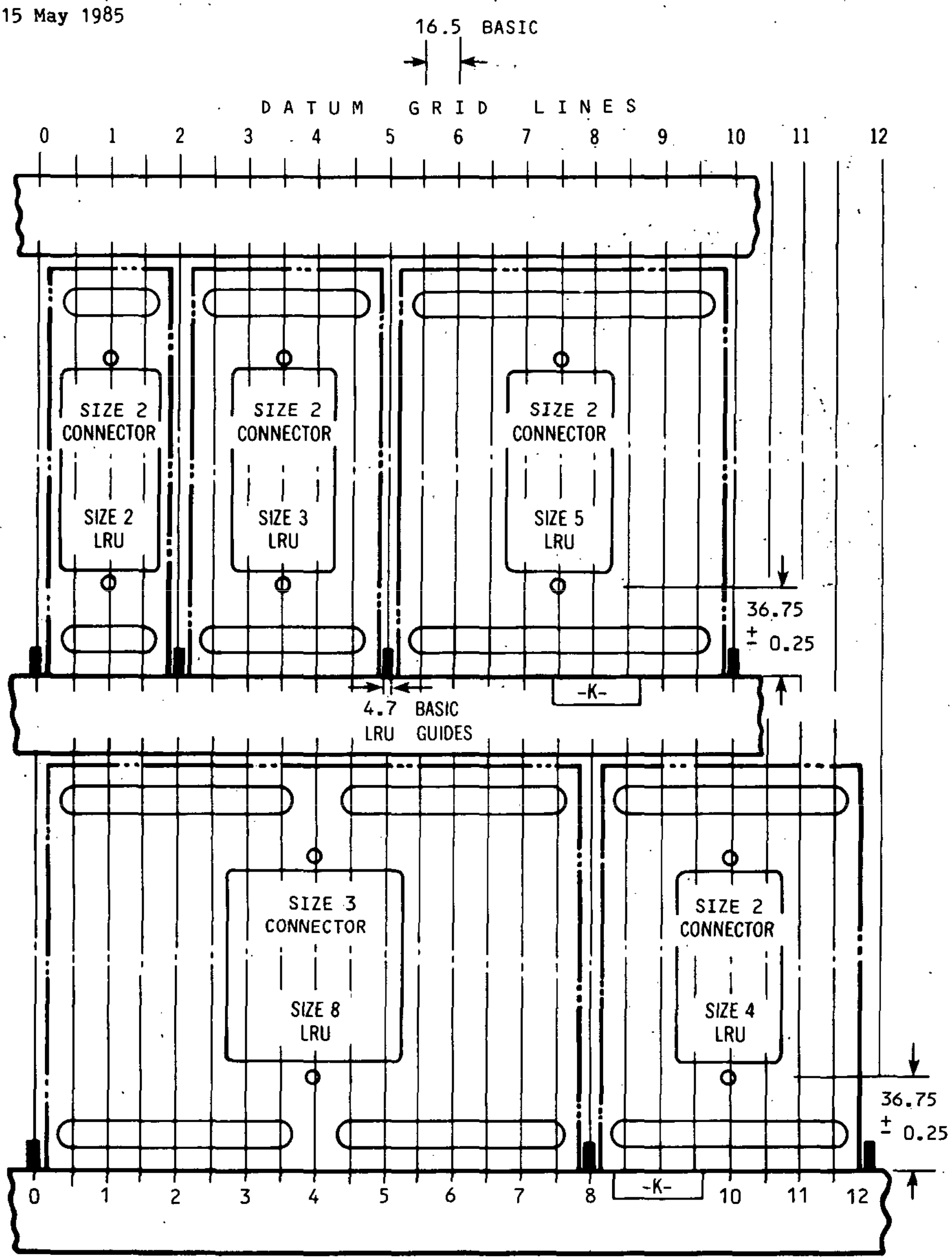


FIGURE 11. Standard shelf datum line grid and LRU location.

4.3.2 Mechanical interface with the LRU. The rack shall be designed such that individual LRUs can be installed in, or removed from, the rack without disturbing any other LRU. The rack shall provide the mechanical attachment points required by each LRU, such as the electrical connector shell at the backplate, and the attachment points for holddowns. The location of holddown attachments shall be as shown on figure 3.

4.3.2.1 Backplate assembly. The assembly of the backplate to the shelf, tray, or rack structure, shall be designed to meet the tolerance requirements shown on figure 5.

4.3.2.1.1 The backplate deflection during the period when the LRU is installed, is being installed, or is being removed from the rack, shall not exceed the dimensions specified on figure 5.

4.3.2.1.2 The rack trays and backplates shall be designed to be compatible with the allowable LRU insertion force specified in 4.3.2.3.1. Gauging of the shelf backplate is considered essential to establish the perpendicularity of the shelf connector mounting face relative to the plane of the shelf load-bearing surface.

4.3.2.2 Cooling system interface. The rack shall serve as the interface between the avionics equipment cooling system and the LRU. The racking shall include ducting so arranged that the cooling air shall be delivered to the LRU through the openings shown on figures 5 and 6. The resilient seal and metering plate used to direct and control the flow of cooling air into each LRU air inlet opening shall be attached to, and form a component part of, the rack or tray. Prevention of loss of cooling air when an LRU is temporarily removed from the aircraft shall be controlled by the tray or rack.

4.3.2.3 Front retainer. The shelf, rack, or tray shall provide a force-limiting, manually-operated means of pushing the LRU into its mating connector, means of holding the LRU in place, and a means for extracting the LRU from its connector. Means shall be provided to prevent the front of an unlatched LRU being offset more than 5 millimeters in the vertical direction when it is being engaged or disengaged from the rack mounted connector.

4.3.2.3.1 LRU holddown details. The means for inserting and holding down the LRU to the shelf shall be as shown on figure 3. The line of application of the insertion force shall be inclined to the horizontal as shown. The force applied by each holddown shall be limited by a mechanism which prevents over-stressing the LRU. The interface of the LRU with the shelf/rack holddown shall be the MIL-F-85731/2 fasteners, or structurally and mechanically equivalent devices. Forces on size 3 through 12 LRUs shall be provided by two holddown devices, as shown on figure 3. Requirements of the LRU holddowns shall be as follows:

a. The LRU shall be retained in the fully mated position with the rack-mounted connector, and the front shall be securely held to the shelf against the flight accelerations specified in 4.2.6.5.

b. The insertion force along the axis of the screw shaft of the front retainer device, supplied with the rack or tray, shall be limited by the retainer device. The maximum value of force from each device shall be 900 newtons, with the minimum value between 650 and 900 newtons.

c. The attachment shall absorb tolerances of the shelf and LRU lengths and the engagement travels of the connector and holddown, as illustrated on figure 5.

4.3.2.3.2 LRU extractor details. The shelf, rack, or tray shall provide an extractor mechanism which shall give mechanical advantage to assist in removing the LRU from the rack. The extractor shall have the capability to operate against the front lip, as shown on figures 1 and 3. When finger torques are applied within the limits of MIL-STD-1472, the extractor shall apply forces as shown in table V.

TABLE V. Extractor forces.

LRU Size	Minimum Extractor Force
12-3 (two extractors)	1300 Newtons (200 lb)
2 (one extractors)	650 Newtons (100 lb)

4.3.2.3.3 Low profile mounting tray. Where necessary, a size 2, 3, 4 or 5 LRU shall be mounted on its side in a specially adapted tray such as that illustrated on figure 6, unless a specific mounting attitude is required for functional reasons.

4.3.3 Electrical power interface. The electrical power interface at the equipment rack shall be in accordance with MIL-STD-704.

4.3.4 Signal interface. The design shall provide for both analog and digital interfaces through the rack and panel connector. Approved standard multiplex bus, such as MIL-STD-1553, shall be included. Specific connector provisions shall be as specified in connector specification DOD-C-83527 and related documents.

4.3.5 Electrical bonding interface. All metal parts of the rack and shelves shall be maintained at airframe potential by the application of suitable bonding and grounding techniques. The ground path provided shall be capable of conducting the maximum fault (short circuit) current to which the rack may be exposed. Under such conditions, the resistance of the ground path shall not exceed 2.5 milliohm in accordance with MIL-B-5087, paragraph 4.3.6.1. The ground path shall provide the greatest surface area possible to allow a low impedance ground path for radio frequency currents. When composite structures are used, the same bonding requirements of MIL-B-5087 shall apply.

4.3.6 Service conditions (environmental). The rack or tray assembly shall withstand the service conditions specified and the avionics LRUs shall remain within the alignment tolerances of figures 5 and 6, and shall not suffer damage or fail to operate due to environmental conditions applied to the rack or tray assembly as follows.

4.3.6.1 Vibration environment. The avionics installation concepts and design approaches employed shall address the location of the standard avionics, and the design of the racks, shelves, and trays, to control the vibration inputs that are transmitted to the avionics LRU to no more than 0.04 g^2/Hz between frequency limits shown in figure 9.

4.3.6.2 Acceleration environment. LRUs shall be supported to withstand the steady accelerations of 4.2.6.5 without damage to supporting structures and while maintaining alignment tolerances. LRUs and supporting structures which constitute a personnel hazard during a crash shall remain intact and restrained when exposed to the crash accelerations of 4.2.6.5.3.

4.3.6.3 Temperature/altitude. The rack or tray shall be designed to withstand the temperature/altitude environment shown on figures 7 and temperature shock rates of change up to ±1 degree per second over the range -57°C to +95°C.

4.3.6.4 Electromagnetic compatibility. The rack, tray, and connector assembly, as installed in the aircraft, shall meet the requirements of MIL-E-6051.

4.3.6.5 Other environmental conditions-avionics equipment rack. The avionics equipment rack shall meet the requirements of the following environmental conditions.

4.3.6.5.1 Humidity. The equipment rack shall withstand 100% humidity with condensation on and within the rack, shelf or LRU supporting structure when tested in accordance with 5.2.4.1 herein.

4.3.6.5.2 Sand and dust. The avionics equipment rack shall withstand, in both an operating and nonoperating condition, exposure to sand and dust particles as encountered in operational areas of the world when tested in accordance with 5.2.4.3 herein.

4.3.6.5.3 Fungus. The avionics equipment rack shall withstand, in both an operating and nonoperating condition, exposure to fungus growth as encountered in tropical climates when tested in accordance with 5.2.4.4 herein.

4.3.6.5.4 Salt atmosphere. The avionics equipment rack shall withstand, in both an operating and nonoperating condition, exposure to salt-sea atmosphere when tested in accordance with 5.2.4.5 herein.

4.3.6.5.5 Explosive conditions. The avionics equipment rack shall not cause ignition of an ambient-explosive-gaseous misture with air when operating in an explosive atmosphere when tested in accordance with 5.2.4.6 herein.

4.3.7 Rack maintenance and accessibility. Easy access shall be provided to allow maintenance and modification work in such areas as wiring, wire integration, connectors, mechanical devices, and environmental control facilities. The rack shall be so designed that normal hand tools may be used in maintenance, and space for the use of those tools shall be provided. Any special tools or equipment needed for rack maintenance shall be approved by the procuring agency.

4.3.8 Avioinics equipment rack design evaluation. The aircraft LRU structural support device or rack shall be evaluated in accordance with the mechanical and structural considerations procedures defined in 5.2.2.2, to ensure that it meets the design criteria established above.

4.4 Connector specification. The rack and panel connector shall meet the requirements of DOD-C-83527, "Connectors, Plug and Receptacle, Electrical, Rectangular, Multiple Insert Type, Rack to Panel, Environment Resisting, 150°C Continous Operating Temperature," and shall be suitable for use under the environmental conditions of 4.2.6 and 4.3.6.

4.4.1 Connector. The connector used for equipment designed to meet this standard shall utilize low insertion force technology. The connector shall provide the electrical and rear mechanical interface between the LRUs and the aircraft equipment rack.

4.4.2 Connector mechanical. The connector shell shall serve as the mechanical interface between the rear of the LRU and the avionics equipment rack. The mated shells of the connector shall be of sufficient strength to retain the LRU in position in all three axes when subjected to the vibration environment of 4.2.6.4 and the acceleration loads of 4.2.6.5. The force required to keep the connector halves mated shall be provided by the front mounted retainers (holddowns). The connector shell shall be designed to accomodate a lateral and vertical misalignment of the LRU or rack of 2.5mm, but not both.

4.4.2.1 The connector shell shall act as a stop or limit for LRU insertion into the rack. The connector shall withstand the limit forces specified in DOD-C-83527 referenced in 4.4.

4.4.2.2 The connector shell shall provide for an indexing capability to ensure that the LRUs are not inadvertently placed in wrong locations. The indexing shall be accomplished by means of three index pins located within the connector shell.

4.4.2.3 In retrofit applications, when it is not cost-effective to modify the aircraft's existing racking and wiring installation, and a rear mounted connector cannot be used, the alternate rear holddown shall be provided in accordance with figures 12 and 13. Under no circumstances shall this alternate rear holddown co-exist wtih the standard rear connector specified herein.

4.4.3 Connector interface. The connector shall serve as the electrical interface between the rear of the LRU and the avionics equipment rack. To ensure connector mateability, the use of more than one rear connector shall not be permitted.

4.4.3.1 LRU electrical interface. The connector shell shall be installed on the inside surface of the back of the LRU (see Datum A, figures 1 and 4), and shall project into, but not through, the opening in the rear of the LRU. Connector mounting hardware shall be within the limits shown on figure 1 to avoid possible interference with the mating rack connector support (see 4.4.3.2). The exposed signal sockets shall be located on the LRU receptacle while the more protected signal pins shall be located on the rack mounted plug. The number of electrical circuits allocated to the LRU connector shall take into account both test requirements and the operational function. Test requirements to be considered include airborne, on-board, and shop. Where a dedicated connector is required for on-board and shop testing, it shall be located on the front of the LRU.

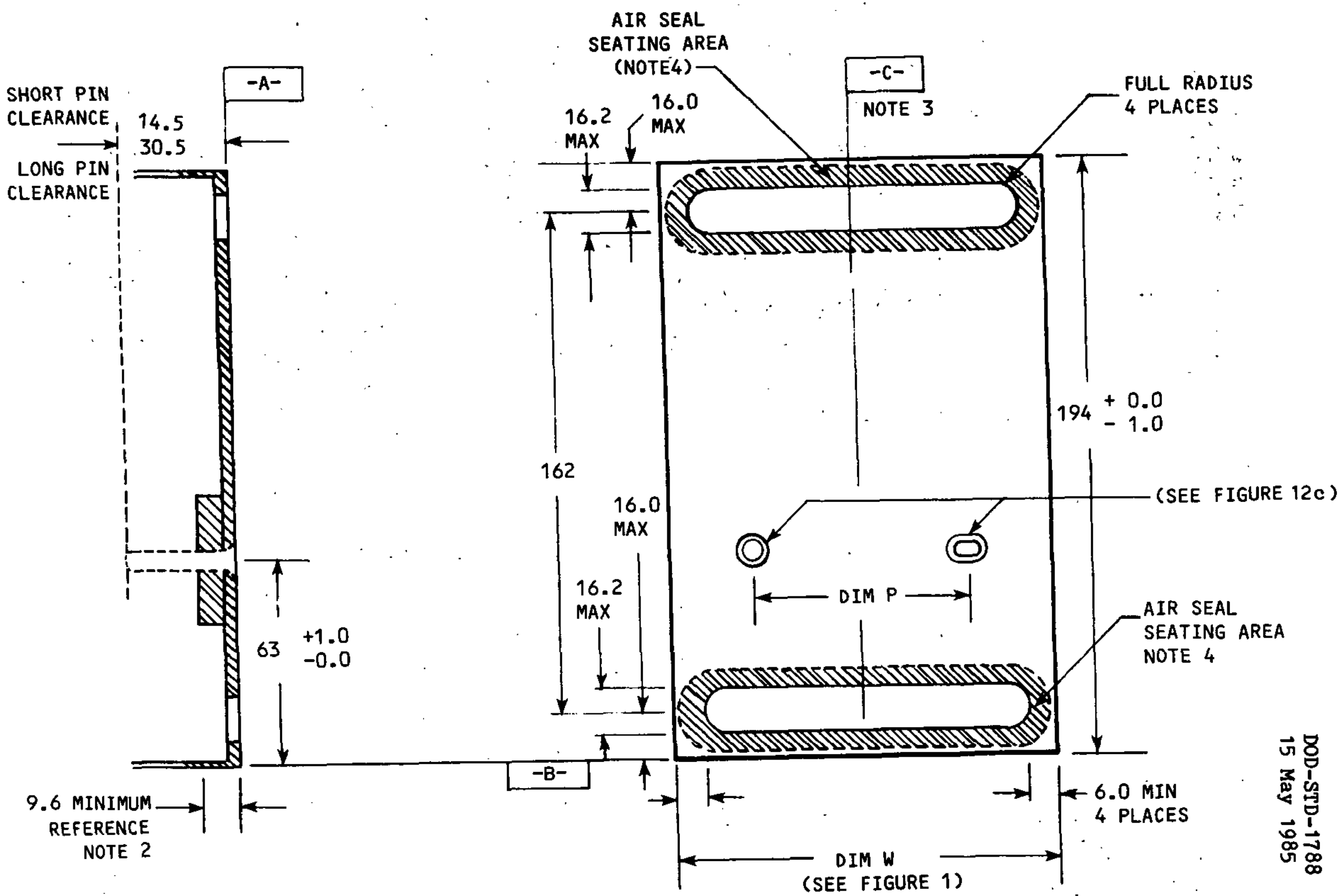


FIGURE 12a. Vertical mounting for LRU sizes 4 through 12.

FIGURE 12. Alternate rear holddown - LRU receptacles.

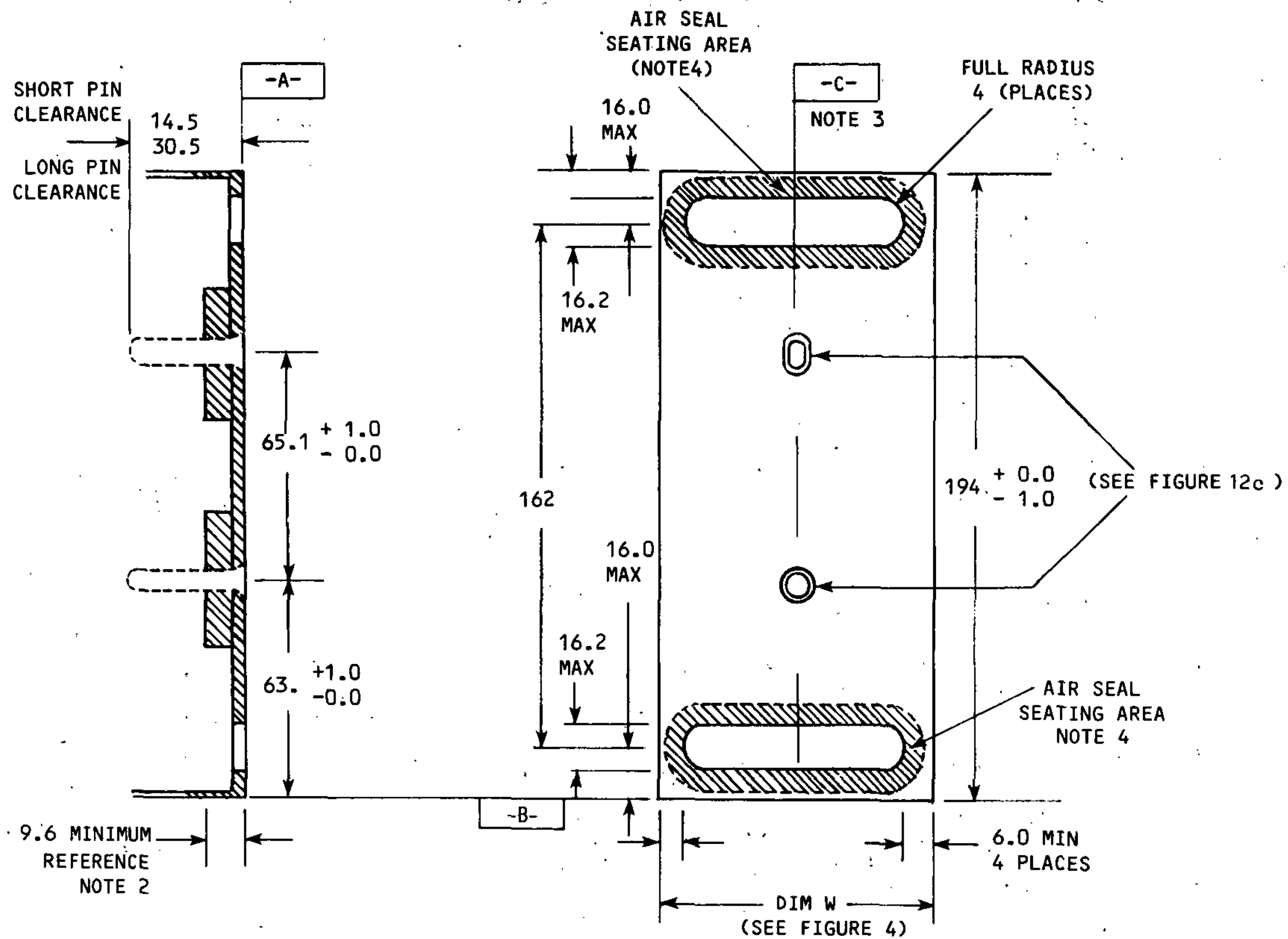
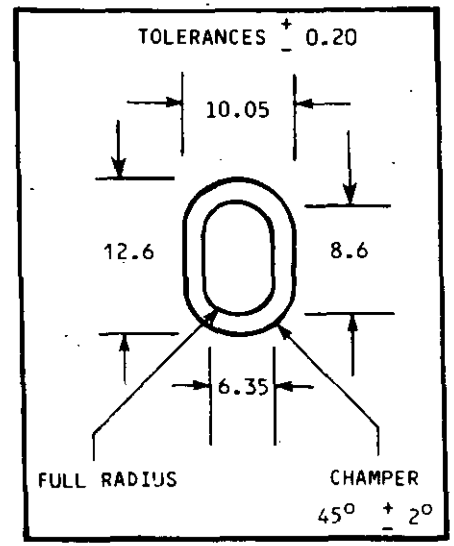


FIGURE 12b. Vertical mounting for LRU sizes 2 and 3.

FIGURE 12. Alternate rear holddown - LRU receptacles. -Continued

LRU SIZE	DIM. P Tol. ±.50
4	66
5	99
6	132.1
7	165.1
8	198.1
9	231.1
10	264.2
11	297.2
12	330.2

NOTES:
1. Dimensions are in millimeters. Unless otherwise specified, the tolerance is ±1.0 mm.
2. The material surrounding the mounting pinhole shall be 9.6 mm thick, and shall be 25 mm in diameter, centered on the mounting pinhole.
3. Datum -C- is the vertical centerline of the LRU.
4. The air seal seating area is reserved. There shall be no projection within this area.



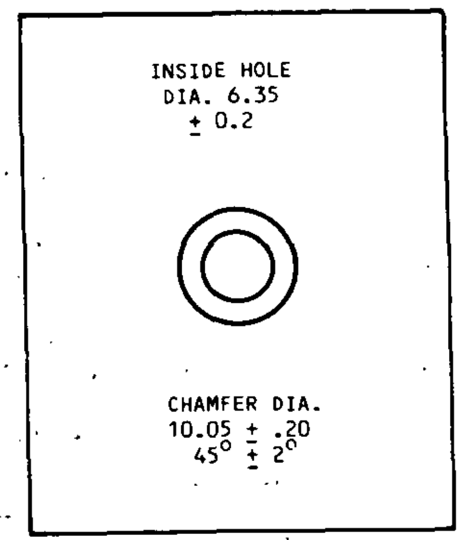


FIGURE 12. Alternate rear holddown - LRU receptacles. - Continued

FIGURE 12c. Slot receptacle details.

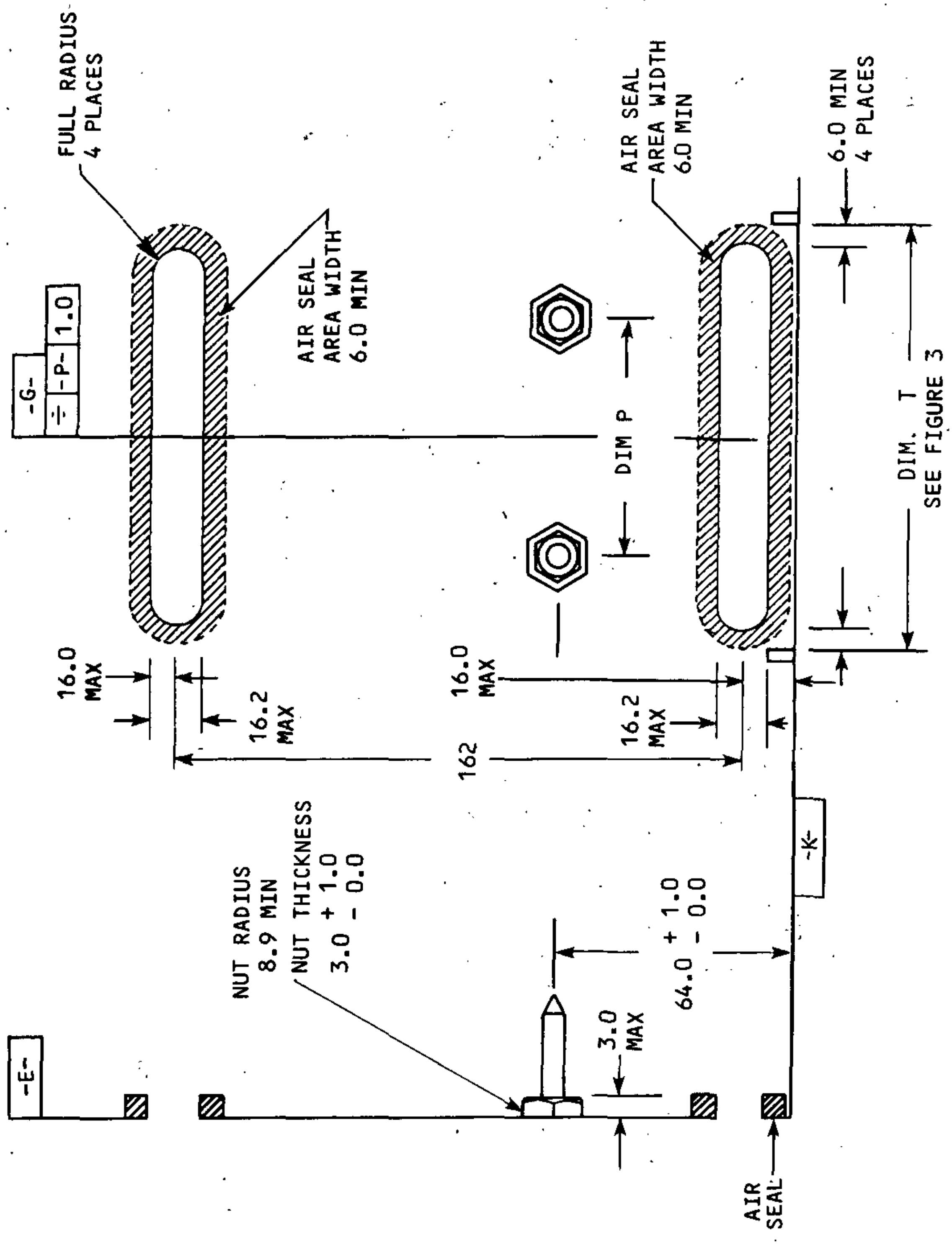


FIGURE 13a. Vertical mounting for LRU sizes 4 through 12.

FIGURE 13. Alternate rear holddown - pins for rack or tray mount. - Continued

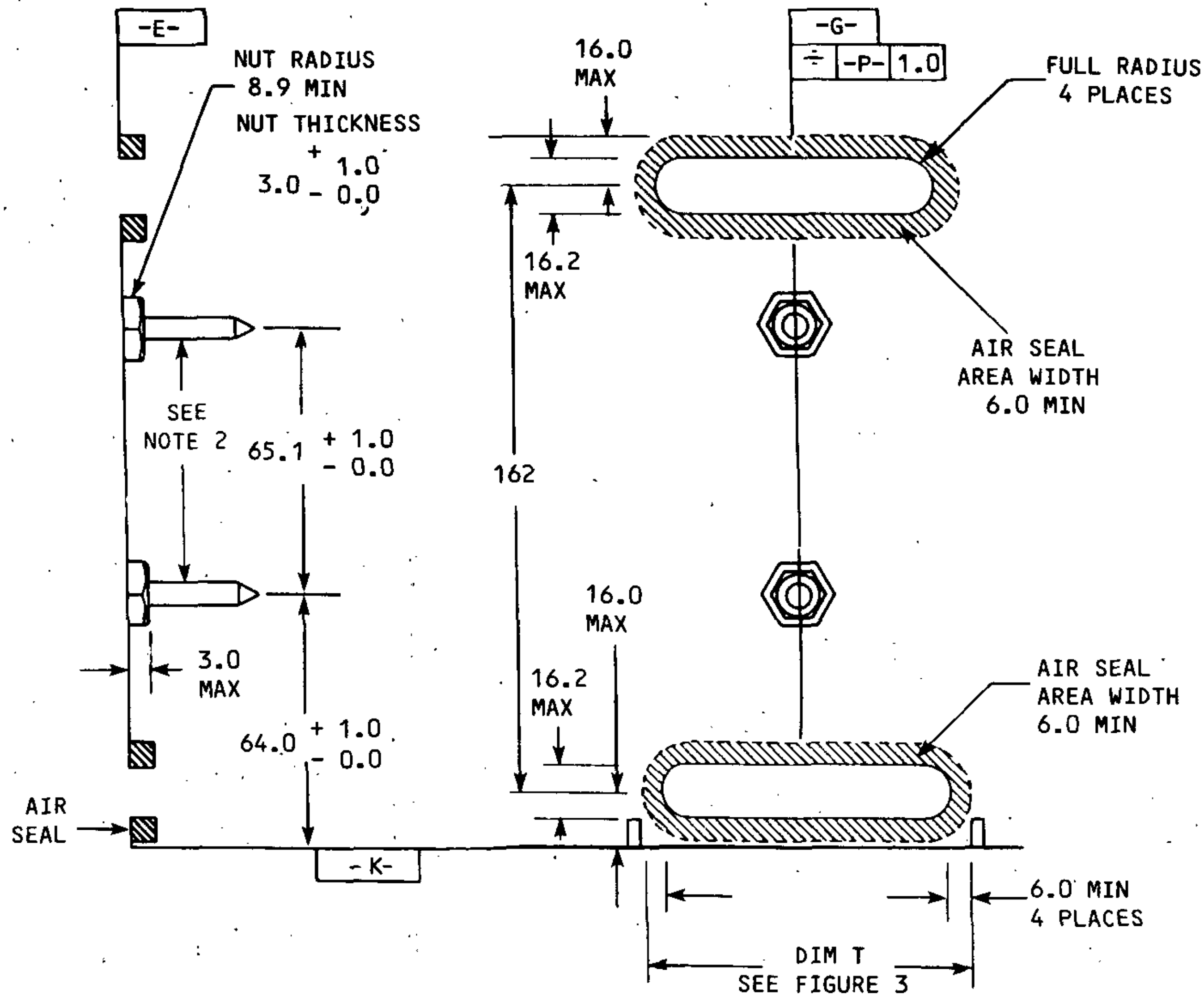
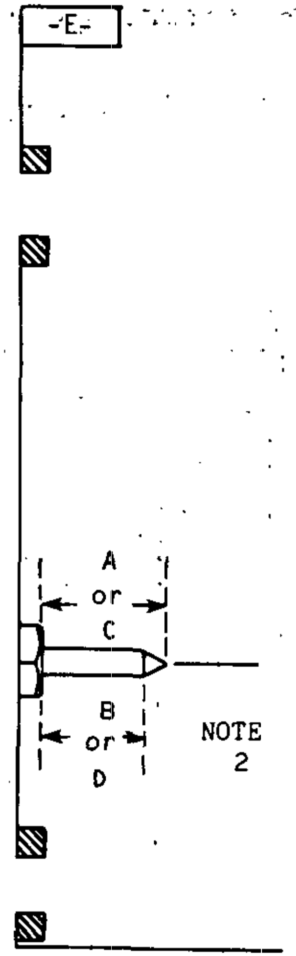


FIGURE 13b. <u>Vertical mounting for LRU sizes 2 and 3</u>.

FIGURE 13. <u>Alternate rear holddown - pins for rack or tray mount</u>. - Continued

LRU SIZE	DIM. P Tol. ±.50
4	66
5	99
6	132.1
7	165.1
8	198.1
9	231.1
10	264.2
11	297.2
12	330.2



PIN DIAMETER
6.299
6.286

PIN LENGTH		
TOL		mm ±.25
SHORT	A	14.00
	B	9.65
LONG	C	30.00
	D	25.35

NOTES:
1. Dimensions are in millimeters. Unless otherwise specified, the tolerance is ±1.0 mm.
2. Short pins are used when no connector is incorporated into the back. Long pins are used in conjunction with an optional rear floating connector.

FIGURE 13. Alternate rear holddown - pins for rack or tray mount. - Continued

4.4.3.1.1 Connector position. The rear connector position shall be as shown on figure 4. The close tolerance locating bosses in the backplate shall be used to accurately position the connector on the LRU (see figure 4). The locator bosses, on the connector, control the horizontal position, vertical position, and vertically, with reference to Datum C and Datum B shown on figures 1 and 4. The use of locator bosses permits replacement of a damaged connector in the field with the same accuracy as achieved in the original factory installation. The connector location shall not be dependent on accurately located connector mounting screws.

4.4.3.1.2 Bonding and grounding. The impedance from any point of the LRU chassis to the connector shell, when measured at a direct current equivalent to the maximum supply current of the LRU, shall not exceed 2.5 milliohms. This is the primary ground.

4.4.3.1.3 AC and DC supply input grounds, and all electrical circuits inclusive of all other secondary ground connections, shall be routed through separate pins in the LRU connector.

4.4.3.2 Rack/tray electrical interface. The connector shell shall be installed on the backplate in accordance with 4.3.2.1. If the connector is to be mounted on the back of the backplate, the connector hardware shall be within the limits shown on figures 14 to avoid possible interference with the mating LRU connector (see 4.4.3.1).

4.4.3.2.1 Backplate connector positions. The connector position shall be as shown on figures 5 and 6, as defined by Datum G and Datum K. The spacings between connectors mounted on a common backplate shall be as shown on figure 11.

4.4.3.2.2 Backplate deflection. The perpendicularity requirements of figures 5 and 6 shall be met when all avionics equipment is installed.

4.4.4 Test connectors. Connectors, when required for connection to external test equipment, shall be mounted on the front face of the LRU and shall be in accordance with MIL-C-38999 or as specified in the detailed equipment specification for mating with existing test equipment cabling.

4.5 Thermal interface

4.5.1 Thermal design condition. The thermal design condition represents normal operation of the avionics equipment as installed in a military aircraft. For the test and design computational purposes herein, two thermal design conditions shall be as follows (see 4.5.1.6).

4.5.1.1 Avionics equipment in a steady-state thermal condition.

4.5.1.2 Avionics equipment in the electrical operating mode which shall yield the maximum steady-state heat dissipation.

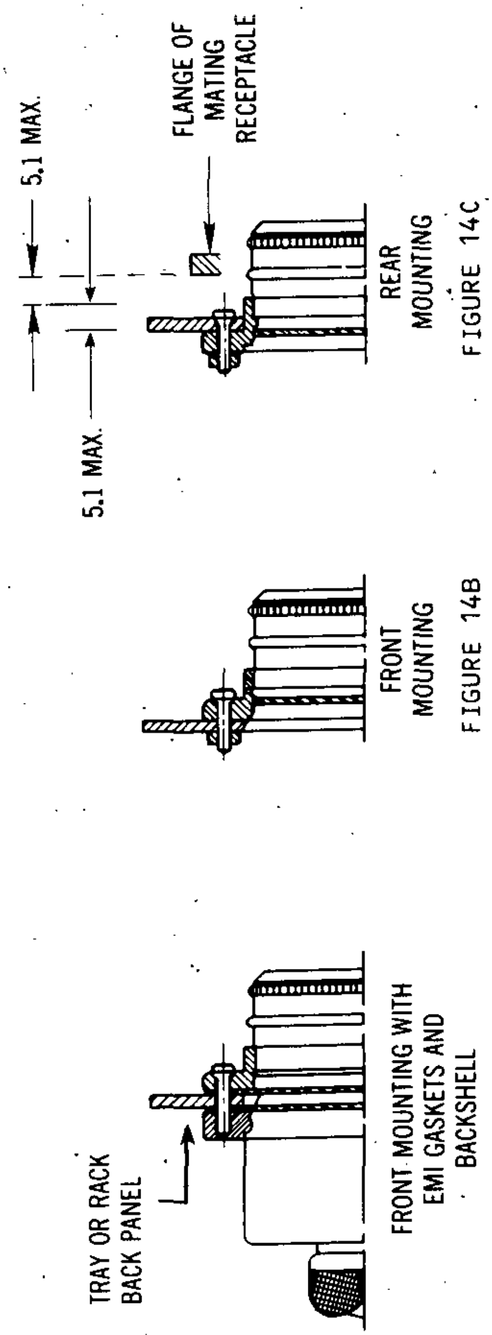


FIGURE 14. Back panel options.

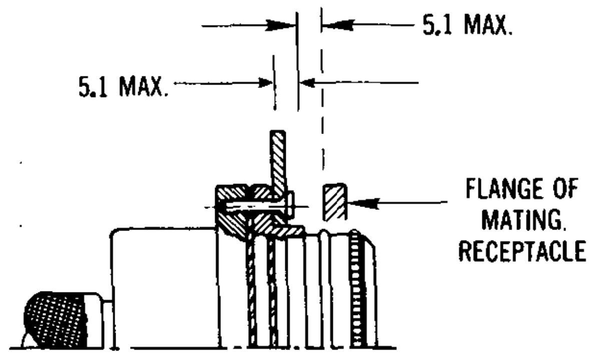


FIGURE 14D

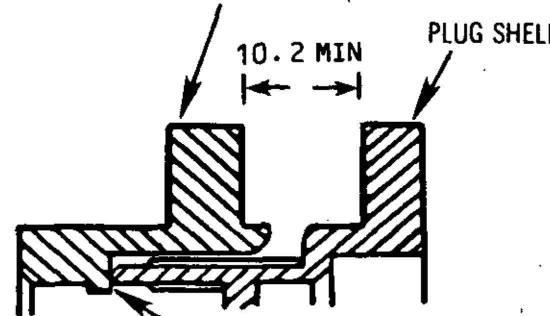


FIGURE 14E

NOTES:

1. Dimensions are in millimeters. Unless otherwise specified, the tolerance is $\pm$1.0 mm.
2. The 5.1 MAX panel, plus fastener head dimensions, are critical to one hundred percent mating of the connector pair, without interference of the fasteners.

FIGURE 14. Back panel options. - Continued

4.5.1.3 Ambient pressure shall be equivalent to 70,000 feet altitude for non-forced air cooled equipment. For forced air cooled equipment, the ambient pressure shall be equivalent to 70,000 feet altitude or the highest altitude maintainable in the test facility, whichever is lower. The ambient pressure existing during the test shall be described in the test report.

4.5.1.4 Ambient temperature, except for variations caused by 4.5.1.5 below, at +71°C.

4.5.1.5 Air velocities immediately surrounding the avionics equipment not greater than those caused by air movement due to natural (free) convection effects.

4.5.1.6 Cooling air bulk inlet temperature at +15.5°C and +40°C.

4.5.1.7 Cooling airflow rate in accordance with the schedule given on figure 8, curve A, based on actual heat dissipation at condition 4.5.1.2 above.

4.5.1.8 Inlet cooling air relative humidity not greater than 40 percent.

4.5.1.9 Avionics equipment located in surrounding and supporting structure which simulates standard in-service usage, including adjacent units with surface temperatures of +76°C and minimum emissivities of 0.85.

4.5.2 Ambient temperature. The ambient temperature shall be the ambient air temperature immediately surrounding the equipment rack. For test purposes, ambient temperature shall be measured 75mm in front of the LRU.

4.5.2.1 The ground survival temperature, nonoperating, shall be from -57°C to +95°C. These are the lowest and highest ground temperatures expected to be experienced by avionic equipment during aircraft storage or exposure to climatic extremes with power off.

4.5.2.2 The short term operating temperature, 30 minutes duration, shall be from -54°C to +71°C.

4.5.2.3 The low and high operating temperature, ground or flight, shall be from -54°C to +71°C.

4.5.3 Coolant air. Coolant air shall be supplied to LRUs installed in an aircraft in accordance with the design requirements of MIL-E-87145. The coolant air characteristics shall be as follows:

4.5.3.1 Coolant air, bulk temperature. The coolant air, bulk temperature at the LRU inlet, from minimum to maximum, shall be as follows:

Transient: Shall be from +71°C to -57°C in a one-minute time period.
Normal: Shall be in accordance with figure 8, curve A.
Ram-Air Backup: Shall be in accordance with figure 8, curve B.

4.5.3.2 Coolant air flow rate. Cooling air shall be supplied to each equipment in proportion to the equipment's steady-state heat dissipation. The design airflow rate shall be not less than with the mass flow versus inlet bulk temperature relationship shown in figure 8, curve A.

4.5.3.3 Coolant air delivery pressure. The nominal coolant air static pressure shall be 50.5mm, and 5mm of water at the rated flow rate of air at +27°C at sea level. This pressure does not include the drop through any metering orifice located external to the equipment case. For test purposes, at ambient pressure other than standard, corrections shall be allowed. The system shall be balanced at the lowest delivery pressure that is consistent with maintaining the required airflow rates through all LRUs in the system.

4.5.3.4 Coolant air leakage. The leak rate at the airframe/LRU interface, at a static pressure differential of 51mm water gauge shall not exceed two percent of the design flow rate specified for +27°C cooling air at sea level.

4.5.4 LRU surface temperature. Under the thermal design conditions specified in 4.5.1, to limit the maximum radiant and convective heat load that one LRU can impose upon its neighbors and upon other adjacent surfaces, the average temperature of any LRU side panel shall not exceed +76°C.

4.5.5 LRU thermal appraisal. The LRU shall meet the minimum standards of thermal design specified herein. The thermal design shall be demonstrated and documented in a thermal appraisal test report intended to demonstrate that critical components remain within the temperature range of the thermal/reliability analyses required in 4.2.7. An engineering development thermal evaluation test shall be conducted on a thermally representative LRU in accordance with 5.2.2.

4.6 Dissimilar metals. All metallic structures in either the LRU container or the rack, used in direct contact, shall meet requirement 16 of MIL-STD-454.

5. VERIFICATION

5.1 Responsibility for verification. Unless otherwise specified in the contract, the contractor is responsible for the performance of all verification requirements as specified herein. Except as otherwise specified in the contract, the contractor may use his own or any other facilities suitable for the performance of the verification requirements specified herein, unless disapproved by the Government. The Government reserves the right to perform any of the verifications set forth in the standard where such verifications are deemed necessary to assure supplies and services conform to prescribed requirements.

5.2 Verification inspections. Verification inspections shall be as stated herein.

5.2.1 Quality program plan. Subject to approval by the Government, a quality program plan shall be generated and used which assures that the aircraft avionics interface design, including all contractor-furnished devices and the avionics functional equipment subsystems, shall satisfy all the requirements of this standard. When a single contractor is responsible for both the aircraft avionics interface design and the installed avionics equipment, two quality program plans shall be prepared; one for the aircraft avionics interface design, and the second for the installed avionics equipments. The use of separate plans shall facilitate separate inspection and acceptance procedures in the event of subcontracts. When the avionics equipment is government-furnished or procured separate from the weapon system contract, the quality program plan shall apply only to those provisions of the standard specifically related to the avionics line-replaceable units or the aircraft avionics interface design and applicable to the specific contract.

5.2.2 Avionics interface design and equipment evaluation. The avionics interface design and equipment line-replaceable units shall be evaluated using the procedure set forth in the quality program plan, as approved by the Government, and the test requirements specified herein. A test report shall be prepared and submitted.

5.2.2.1 LRU thermal appraisal test. A test shall be conducted on the LRU to determine compliance with this standard and the detailed equipment specification in the following areas:

a. The total wattage input and actual heat dissipation for all modes of electrical operation.

b. The temperature of avionics equipment sidewalls at the thermal design condition.

c. Pressure drop through the avionics equipment versus coolant airflow rate.

d. Temperature characteristics at the thermal design condition and other anticipated transient and abnormal environmental operating conditions.

e. The validity of thermal and reliability analytic and design parameters under critical operating conditions.

5.2.2.1.1 Test apparatus. The test apparatus, test equipment, instrumentation methods and accuracies used for this test shall be in accordance with MIL-STD-810.

5.2.2.1.2 Installation of test item in test facility. The test chamber installation shall be designed to be representative of aircraft avionics bay conditions. The cooling air (where applicable) shall be separately controlled, and shall be supplied through fully representative inlet ducting and LRU exhaust conditions. Heat sources representing adjacent avionics LRUs shall be included. The avionics rack assembly shall be used.

5.2.2.1.3 Measurements for cooling evaluation test. Instrumentation shall be provided to measure the following items, as applicable, during testing.

5.2.2.1.3.1 Test chamber instrumentation

a. Ambient temperature external to the test chamber.

b. Bulk temperature of the coolant entering the test chamber ducting.

c. Ambient temperature surrounding the LRU under evaluation.

d. External surface temperatures of the LRU under evaluation; front, top, bottom, and sides. The measurement shall be representative of the average surface temperature. When hot spots, caused by concentrated internal heat sources, are present, several measurements shall be required to obtain an average surface temperature.

e. Temperature of surfaces facing the test unit.

f. Power input of simulated LRUs, as applicable.

g. Bulk temperature of the coolant exiting the unit.

h. Ambient pressure external to the test chamber.

i. Chamber pressure external to the LRU under evaluation.

5.2.2.1.3.2 Thermal instrumentation internal to the LRU under evaluation. Temperature measurements internal to the LRU shall include, as a minimum, the following:

a. The three highest power dissipating components in each of the three highest power dissipating subassemblies.

b. The three most temperature-critical components in the LRU.

c. The three hottest components of each type, such as resistors, capacitors, transformers, and power devices.

d. The three components with the largest thermal inertia.

e. The three components in the LRU which are required, by performance reasons, to operate at or near their maximum performances level.

f. Each component that dissipates 10% or more of the LRU's input power.

g. The component on each circuit board or subassembly with the highest predicted failure rate.

h. Other thermal interfaces, such as the positions of overtemperature indicators, heat sink surfaces, and heat exchanger mechanical interfaces.

i. A maximum of 50 parts shall be instrumented, unless otherwise specified.

5.2.2.1.3.3 LRU functional measurements. LRU functional measurements shall include the following:

a. The pressure drop (in mm of water) from the cooling air inlet of the LRU under test to the outlet or exhaust port shall be determined. The pressure drop shall not include any drop across metering devices external to the LRU or other miscellaneous losses. This test shall be conducted at a cooling air inlet temperature of +27°C ±2°C with the allocated flow for the LRU heat dissipation.

b. Bulk temperature of the coolant entering the test unit.

c. Mass flow rate of the coolant through the test unit.

d. Test unit's heat dissipation. (Equal to power input to the test unit minus power output from the test unit not dissipated as heat.)

e. Test unit's functional performance characteristics.

5.2.2.1.4 Required test procedure. The required test procedures shall be as follows:

5.2.2.1.4.1 Step (1) - heat dissipation. Measure the total wattage input and determine the actual heat dissipation in watts for all modes of electrical operation for which the equipment was designed; such as standby, receiving, and transmitting. These measurements shall be made at the laboratory ambient temperature, which shall be recorded. Identify the electrical operating mode corresponding to maximum steady-state heat dissipation (see 3.1.10).

5.2.2.1.4.2 Step (2) - coolant pressure drop through LRU versus flow rate. ΣP_s shall be measured at +27°C, and the rated flow per 4.2.2.2.

5.2.2.1.4.3 Step (3) - normal continuous operation (thermal design conditions). With the test unit operating at maximum steady-state heat dissipation, the equipment shall be stabilized at the conditions stated below:

a. Sea level shall be +71°C ambient temperature, inlet cooling air shall be +40°C.

b. Maximum altitude and ambient temperature shall be in accordance with figures 7, inlet cooling air shall be +40°C. Maximum altitude shall be limited to the maximum altitude capability of the teset facility or 70,000 feet, whichever is lower.

c. Sea level shall be -54°C ambient, -54°C cooling air.

5.2.2.1.4.4 Step (4) - transient thermal environments. Transient thermal environments shall be nonoperational soak to stabilized +71°C, ambient +40°C cooling air inlet operation at maximum steady-state heat dissipation. Cooling air flow shall then be shut off for 5 minutes. Cooling air flow shall be restored at +40°C, and all conditions shall be restabilized before transition to -54°C ambient and -54°C cooling air temperatures.

5.2.2.1.4.5 Step (5) - abnormal cooling flow conditions. With the equipment operating at maximum steady-state heat dissipation, the cooling air temperature shall be adjusted to +48°C and the flow rate to 80 kG. hr^{-1} kW^{-1} (see figure 8, curve B). Ambient temperature shall be adjusted to +95°C, and the equipment shall continue operating for a total period of 30 minutes.

5.2.2.2 Mechanical and structural evaluation

5.2.2.2.1 Structural evaluation. An analysis or test of the rack or tray shall be conducted by the rack or tray supplier to ensure that the rack or tray meets the deflection and bending requirements, under specified conditions of load; and that the rack has the required strength to resist all operational stresses, in accordance with 4.3.2.

5.2.2.2.2 Mechanical evaluation program. A program shall be developed containing a series of tests integrated into LRU development. Tests shall be designed and scheduled to provide design feedback information, and shall be conducted as early as possible and throughout LRU development. MIL-STD-810 shall be used as a source for test techniques, procedures, tolerances, and data reduction methods. Test criteria shall be tailored to specific test objectives. Testing should be primarily wideband random vibration. However, acoustic noise, narrowband random vibration, sinusoidal vibration, shock, or acceleration (steady load) may be used as diagnostic tools or for specific objectives. Tests shall be conducted on selected items from component, subassembly, brassboard, engineering model, and preproduction hardware. Tests shall be designed to provide diagnostic information and to evaluate performance and life under stress. In general, both goals shall be pursued in each test but sometimes more limited objectives are appropriate, such as when trouble shooting. Diagnostic information shall include such things as vibration mode shape, frequencies and damping, relative motions between structures, subassemblies, or components, and static deflections of structures. Special attention shall be given to assuring that chassis, subassembly, and component resonant frequencies are separated to minimize amplification of input motions. This is important to avoid problems due to transient loads and vibration. A recommended method of evaluation under stress is to increase test severity progressively until failure occurs or performance deteriorates.

5.2.2.2.2.1 Determination of resonant frequencies, mode shapes, and damping shall be key elements in conducting and utilizing results or dynamic tests. Resonances shall be detected visually (strobe light), by sound (changes in level and pitch), and with instrumentation (accelerometers, velocity pickups, microphones, proximity pickups). Detection of motions inside close equipment shall be necessary). This shall also include covers with windows or holes, or covers removed (where structural response is not significantly changed) as well as instrumentation.

5.2.2.2.3 Mechanical evaluation test report. The mechanical evaluation test report shall contain a summary of the mechanical evaluation test program to show through program results that the LRU is qualified. It shall also include test hardware descriptions, test criteria, and summaries of data and failure analyses for each test.

5.2.2.3 Electromagnetic interference control (EMIC)

5.2.2.3.1 LRU EMIC evaluation. A test shall be performed to determine compliance with 4.2.4, according to the specific requirements of MIL-STD-461 and MIL-STD-462 contained in the detailed equipment specification.

5.2.2.3.2 Avionics integration EMIC evaluation. A test shall be performed to determine compliance with MIL-E-6051 on a total system basis with all LRUs installed.

5.2.3 Avionics equipment verification. A test shall be conducted to ensure that the avionics equipment, including trays, racks or shelf, meet weight, vibration and acceleration requirements in accordance with 4.2.1.4, 4.2.6.4 and 4.2.6.5. Verification by analysis, simularity, or other types or testing, in lieu of the testing specified herein, shall be subject to approval by the procuring activity.

5.2.4 Testing for other environment conditions. The specified environmental testing shall be in accordance with the methods of MIL-STD-810.

5.2.4.1 Humidity. Unless otherwise specified, each LRU and rack shall be tested in accordance with Method 507.1, procedure I.

5.2.4.2 Rain. Unless otherwise specified, each LRU and rack shall be tested in accordance with Method 506.1, procedure I.

5.2.4.3 Sand and dust. Unless otherwise specified, each LRU and rack shall be tested in accordance with Method 510.1, procedure I.

5.2.4.4 Fungus. Unless otherwise specified, each LRU and rack shall be tested in accordance with Method 508.1, procedure I.

5.2.4.5 Salt atmosphere. Unless otherwise specified, each LRU and rack shall be tested in accordance with Method 509.2, procedure I.

5.2.4.6 Explosive atmosphere. Unless otherwise specified, each LRU and rack shall be tested in accordance with Method 511.1, procedure I.

5.2.4.7 Bench handling shock. Unless otherwise specified, each LRU shall be tested in accordance with Method 516.2, procedure V.

6. NOTES

6.1 Intended use. It is intended that this standard shall be provided for use by using commands, avionics development agencies, airframe manufacturers, and avionics/electronics manufacturers. It is recommended that the dimensional standards, environmental control parameters, and thermal design criteria and guidance set forth in this standard, be used by all military organizations for aircraft equipment interface designs, and when specifying and developing new electronic systems.

6.2 Application guidance. This standard is issued for the benefit of aircraft equipment designers to provide guidance in making adequate provision for avionics mounting and cooling in the specification and initial layout phases of aircraft design, with due regard for future avionics suite update and reconfiguration needs; and to avionics designers to define an avionics packaging configuration and environmental specification that is compatible with those standard aircraft interface design provisions.

6.3 Data requirements. When this standard is used in an acquisition, the data identified below shall be delivered only when the task paragraph(s) applicable to the specific DID is applied in a contract and the applicable DID is specified on the DD Form 1423, "Contract Data Requirements List (CDRL)". DD Form 1423 is not used and DAR 7-104.9(n)(2) is cited, the data identified below shall be delivered in accordance with requirements specified in the contract or purchase order. Deliverable data associated with the requirements of this standard are cited in the following paragraphs.

Paragraph No.	Data Requirement Title	Applicable DID
4.1	Program Plans	DI-M-30413
4.2.7	Environmental Design Criteria and Test Plan,	DI-R-7125
	Environmental Test Report	DI-R-7127
5.2.1 and 5.2.2	Quality Program Plan(s)	DI-M-30413
5.2.2.2.2	Vibration and Acoustic Analyis	DI-S-30581
5.2.2.2.3	Vibration and Noise Test Report	DI-T-30735
5.2.3	Subsystem Design Analysis Report	DI-S-3581

(Copies of DIDs required by manufacturers in connection with specific acquisition functions should be obtained from the Naval Publications and Forms Center or as directed by the contracting officer.)

Custodians:
Air Force - 11
Army - AV
Navy - AS

Review activities:
Air Force - 85
Army - MI
Navy - EC

Preparing activity:
Air Force - 11

(Project No. GDRQ-0019)

User activities:
Navy - MC

*U.S. GOVERNMENT PRINTING OFFICE: 1985-505-038:22749

INSTRUCTIONS: In a continuing effort to make our standardization documents better, the DoD provides this form for use in submitting comments and suggestions for improvements. All users of military standardization documents are invited to provide suggestions. This form may be detached, folded along the lines indicated, taped along the loose edge *(DO NOT STAPLE)*, and mailed. In block 5, be as specific as possible about particular problem areas such as wording which required interpretation, was too rigid, restrictive, loose, ambiguous, or was incompatible, and give proposed wording changes which would alleviate the problems. Enter in block 6 any remarks not related to a specific paragraph of the document. If block 7 is filled out, an acknowledgement will be mailed to you within 30 days to let you know that your comments were received and are being considered.

NOTE: This form may not be used to request copies of documents, nor to request waivers, deviations, or clarification of specification requirements on current contracts. Comments submitted on this form do not constitute or imply authorization to waive any portion of the referenced document(s) or to amend contractual requirements.

(Fold along this line)

(Fold along this line)

DEPARTMENT OF THE AIR FORCE
ASD/ENES
Wright-Patterson AFB OH 45433-6503

NO POSTAGE NECESSARY IF MAILED IN THE UNITED STATES

BUSINESS REPLY MAIL

FIRST CLASS PERMIT NO. 73236 WASHINGTON D. C.

POSTAGE WILL BE PAID BY THE DEPARTMENT OF THE AIR FORCE

ASD/ENES
Wright-Patterson AFB OH 45433-6503

STANDARDIZATION DOCUMENT IMPROVEMENT PROPOSAL

(See Instructions – Reverse Side)

1. DOCUMENT NUMBER	2. DOCUMENT TITLE
DOD STD 1788	

3a. NAME OF SUBMITTING ORGANIZATION

b. ADDRESS *(Street, City, State, ZIP Code)*

4. TYPE OF ORGANIZATION *(Mark one)*

- ☐ VENDOR
- ☐ USER
- ☐ MANUFACTURER
- ☐ OTHER *(Specify)*: ______

5. PROBLEM AREAS

a. Paragraph Number and Wording:

b. Recommended Wording:

c. Reason/Rationale for Recommendation:

6. REMARKS

7a. NAME OF SUBMITTER *(Last, First, MI)* – Optional

b. WORK TELEPHONE NUMBER *(Include Area Code)* – Optional

c. MAILING ADDRESS *(Street, City, State, ZIP Code)* – Optional

8. DATE OF SUBMISSION *(YYMMDD)*

DD FORM 1426 82 MAR — PREVIOUS EDITION IS OBSOLETE. — ASD/ENES OVERPRINT, JAN 85