FAA-G-2100G
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U.S. Department
of Transportation

**Federal Aviation
Administration**

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Specification

ELECTRONIC EQUIPMENT, GENERAL REQUIREMENTS

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1. SCOPE AND PURPOSE

1.1. Scope

This specification is the technical baseline for ground based electronic equipment acquired for applications in the National Airspace System (NAS). This specification defines the conditions under which electronic equipment must operate satisfactorily and reliably: identifies acceptable fabrication materials and processes, selection and application of parts, installation of equipment, and methods to verify electronic equipment meets requirements. Individual electronic equipment specifications must identify applicable requirements of this specification. This specification is intended for use in the procurement of all electronics hardware, prototype systems, developmental equipment or commercial off the shelf integrated systems, delivered in any quantity to satisfy an established air traffic need or proof of concept configuration.

1.2 Intended Use

This specification is to be used in conjunction with the equipment specification to establish the procurement requirements. This specification is not to be invoked on a blanket basis in equipment specifications or as a criterion for system acceptance. The approved equipment or system specification determines the superceding requirements for a particular procurement. The interfaces between equipment is beyond the scope of this document and should be addressed in a System Level Specification, Interface Requirements Document, or an Interface Control Document. Software is not part of this specification.

1.3 Tailoring of this Specification

The requirements set contained in Section 3 of this general specification need to be tailored by the responsible FAA acquisition program office so that the applicable requirements of FAA-G-2100g are stated in the individual system or subsystem specifications.

1.4 Classification

Electronic equipment acquisition alternatives that are available include NDI, COTS, and developmental items. To meet the functional requirements of the system and the requirements of the specification, various components of the system may need to be acquired by all three alternatives. Tailoring of system component acquisition alternatives to comply with the specification is the responsibility of the FAA acquisition program office.

2. APPLICABLE DOCUMENTS

2.1. Government documents

The listing of government documents referenced in this document is contained in Appendix II.

2.2. Non-Government documents

The listing of non-government documents referenced in this document is contained in Appendix III.

3. REQUIREMENTS

3.1. General

3.1.1. Electrical Power

a. All internal wiring to the equipment shall be in accordance with paragraph 3.3.1.3.10, Wiring. Refer to Section 6.2.6 for wiring interface points.

b. The equipment shall interface to building wiring in accordance with NFPA 70 (National Fire Protection Association National Electric Code), FAA-STD-032 (Design Standards for National Airspace System (NAS) Physical Facilities), and FAA-C-1217F (Electrical Work, Interior), in that order of precedence.

c. Electrical enclosures, cabling, and wiring shall be approved by a nationally recognized testing laboratory.

3.1.1.1. Physical Requirements

3.1.1.1.1. Physical Construction

a. Accessibility:

(1) The accessibility of test equipment or maintenance equipment shall be in accordance with NFPA 70 Article 110.

(2) All access for electrical components, connections, wiring, etc., shall comply with the accessibility requirements of section 3.1.2.4 of this document.

b. Equipment Directly Connected to Line Power:

(1) Controls and indicators for electrical line voltage of an equipment rack shall be located in accordance NFPA 70. When switches or circuit breakers function as main power disconnecting means, operating either directly or through a contactor, they shall break the incoming line immediately before the line filter, terminal block or connector, fuses or other parts without compromising RFI, EMI shielding integrity.

(2) Equipment Connected By Cord and Plug to Line Power. Cord connected equipment/systems may be disconnected by means of the plug.

c. Plugs and receptacles provided for connection of the equipment to the AC supply line shall be of the locking type and in accordance with the requirements of W-C-596, W-C-596G, and installed in accordance with the requirements of NFPA-70.

d. Power cords provided for the connection of the equipment to the AC supply line shall, as a minimum, be a 3 conductor cord in accordance with the requirements of UL62 and installed in accordance with the requirements of NFPA-70.

e. Detachable power cords rated 125V (volts) maximum and 15A (amperes) maximum shall be 3 conductor type SF.

(1) The supply end shall have a plug in accordance with the requirements of W-C-596/100A.

(2) The equipment end shall have a female connector per DESC 87204 (Connector, Plug, Electrical, Midget Locking, Specific Purpose, General Grade, Grounding, 2 Pole, 3 Wire, 15 A, 120V, 50/60Hz (Hertz) (Female)).

f. Convenience outlets provided in or with the equipment shall be duplex receptacles in accordance with W-C-596/12-2, installed and wired in accordance with the requirements of NFPA-70. The equipment design shall include the provisions required to provide power to these outlets from a source independent of the equipment power source.

g. Where sensitive test equipment must be connected to the same power source as the equipment, receptacles for this purpose shall be in accordance with W-C-596/12-3, clearly identified, and protected from general use.

3.1.1.2 Electrical Power Measurements

a. All Rack/Equipment power measurements shall be taken at the power source input of the distribution panel circuit breaker feeding the Rack/Equipment.

b. For each individual Rack/Equipment the measurement shall be at the distribution panel feeder breaker.

c. For system level testing the measurements shall be at the input breaker (main breaker) of one or more distribution panels depending on the system configuration.

3.1.1.3 Load Power Characteristics

3.1.1.3.1 Power Factor

a. The power factor shall be within the ranges specified for the following ranges of facility source KVA capacity measured at the rack/equipment power input location:

KVA of Source Generator or Transformer	**PF (power factor)**
1500 <KVA	0.6 (lag) – 0.7 (lead)
200≤ KVA ≤ 1500	0.8 (lag) – 0.9 (lead)
200<KVA	0.9 (lag) – 1.0

b. Power factor (PF) shall be defined as the absolute value of the product of the displacement component of power factor and the distortion component of power factor.

$PF = |PF_{disp} \times PF_{dist}|$

c. The displacement component of the power factor, PF_{disp}, is equal to the cosine of the angle between voltage and current which can be calculated by dividing the power dissipation in watts by the apparent power in volt-amperes (VA).

PF_{disp} = COS(theta) = Watts/VA

d. The distortion component of the power factor, PF_{dist}, is equal to the reciprocal of the square root of one plus the square of the total harmonic distortion of the equipment (THD) as defined in IEEE STD 519 (Harmonic Control and Reactive Compensation of Static Power Converters, Guide for).

$$PF_{dist} = \frac{1}{\sqrt{1 + (THD)^2}}$$

3.1.1.3.2 Inrush Current

Inrush current is defined as the peak amount of current that a load or device draws when first energized.

a. Inrush current shall be measured by energizing the load or device within ten degrees of the positive (80 to 90 degrees), and the negative (260 to 270 degrees) peaks of the sine wave of applied voltage as shown in Figure 1.

b. The steady state values of root mean square (rms) current shall be measured.

c. The test voltage source shall have at least five (5) times the full load or steady state rms current rating of the load or device under test at the point of connection of the device or load under test. Total voltage distortion of the source shall not exceed three percent (3%).

d. Cord connected equipment shall be connected to the test voltage source with the same size, type and length of cord to be furnished with the load or device under test. All other devices or loads shall be connected to the test voltage source with four (4) foot long conductors sized for their rms current in accordance with NFPA-70. All cords and conductors shall be directly connected to the test voltage source.

e. The ratio of peak inrush current to rms current for loads or devices up to 40A, measured on the phase conductor with highest current, shall be equal to or less than the ratio defined by Figure 2.

f. The ratio of peak inrush current to rms current for loads or devices greater than 40A and equal to or less than 80A, measured on the phase conductor with the highest current, shall be equal to or less than the ratio defined by Figure 2.

g. The inrush current limits for all direct current (DC), and all AC devices or loads whose rms current is greater than 80A shall be defined in the system level specification for that device or load.

Figure 1. Inrush Current Limit Measurements

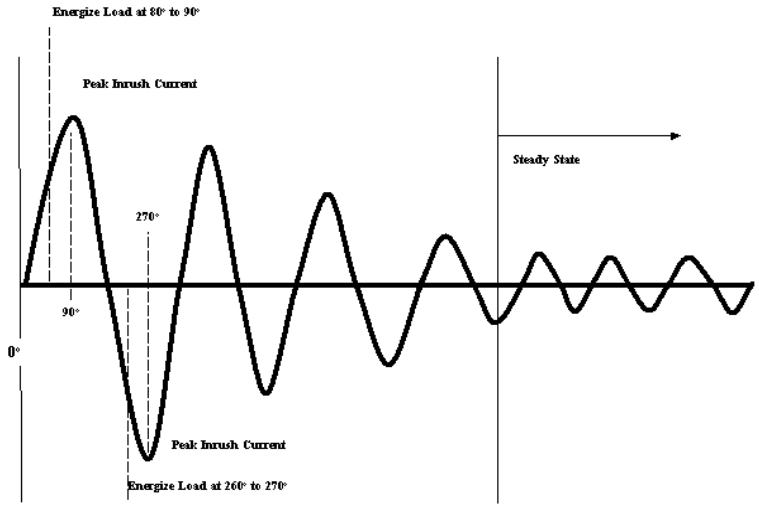
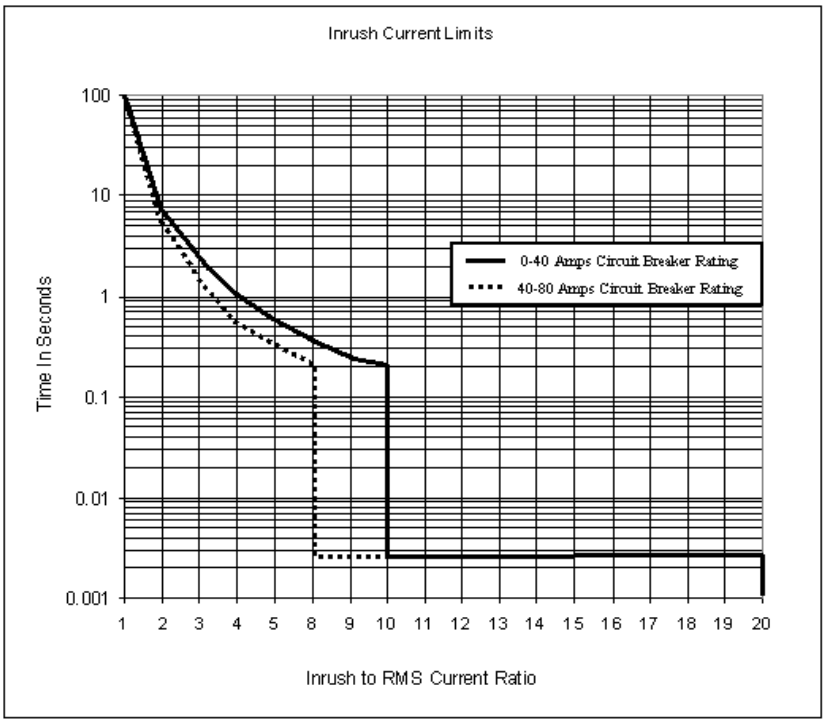


Figure 2. Inrush Current Limit Ratios



NOTE: $I_{overcurrent} = \frac{I_{max.\ peak}}{I_{SS(rms)}}$

The Inrush Current Limit Ratio curves in figure 2 are based on the following factors.

1. The actual time current curves and tolerances of several manufacturers standard molded case circuit breakers spanning ratings of 15 to 100+A.

2. The actual current inrush, (as defined by the IEEE, see page 9 of IEEE-Std 1100-1999), of transformers, capacitors, motors, light bulbs, and switch mode power supplies.

3. Many standard molded case breakers can respond in 5 ms (milliseconds).

4. Amperes determine the size of circuit breakers and distribution systems. The responsibility for facility distribution system design to support the load requirements is the FAA's. The voltage drop created by energizing the load, at any supply voltage, is minimal and tolerable when the facility distribution system is properly designed.

5. All standard molded case breakers have common trip curve characteristics in the ampere ranges defined. The shape/slope is common, but the actual values are not common.

6. Cardinal points of manufacturers curves were used to create these composite curves. It is conservative, but recognizes, and allows, true inrush of most devices.

7. There will be a small number of special load applications that will require either special circuit breaker applications or load inrush modifications. A heavily loaded, high inertia motor, or a large HVAC fan for example, may require reduced voltage starting or a facility distribution special circuit breaker application.

3.1.1.4 Electrical Load Balance

The current load on each phase of all multiple phase power sources, including 3-wire 120/240, shall be balanced within ten percent (10%), i.e. the smallest current shall be greater than or equal to ninety percent (90%) of the largest current.

3.1.1.5 Harmonics

The individual current harmonic distortion (I_N) produced by each individual equipment item or subsystem (consisting of several items combined in a single power circuit) shall be less than the limits listed in Table I measured at the input side of the power distribution where the rack or equipment is attached.

TABLE I. Limits of Individual Harmonics

Harmonic Order	Maximum Limits (mA) for 50 < W < 600 (1 phase)	Maximum Limits (mA) for 600 < W < 40000 (1 of 3 phases)
2	1.00 x W	400+ (0.05 x W)
3	3.60 x W	1440+ (1.20 x W)
4	1.00 x W	400+ (0.05 x W)
5	2.00 x W	800+ (0.66 x W)
6	0.50 x W	200+ (0.02 x W)
7	1.50 x W	600+ (0.05 x W)
8	0.50 x W	200+ (0.02 x W)
9	1.00 x W	400+ (0.033 x W)
10	0.10 x W	100+ (0.01 x W)
11	0.60 x W	240+ (0.20 x W)
12	0.10 x W	100+ (0.01 x W)
13	0.51 x W	203+ (0.17 x W)
14	0.10 x W	50+ (0.01 x W)
15	0.44 x W	176+ (0.15 x W)
16	0.10 x W	50+ (0.01 x W)
17	0.39 x W	155+ (0.13 x W)
18	0.10 x W	50+ (0.01 x W)
19	0.35 x W	139+ (0.12 x W)
20	0.10 x W	50+ (0.01 x W)

Notes:
1. W equals power in Watts
2. Power is active power in Watts for both single phase and polyphase circuit as defined by ANSI/IEEE standard 100. "IEEE Standard Dictionary of Electrical and Electronic Terms"

The total current harmonic distortion (THD) for equipment or subsystems requiring power of 40 kilowatts or more shall be limited to 10 percent. THD is defined in IEEE STD 519.

3.1.1.6 Circuit Overload Protection

a. Current Overload protection:

1. Current overload protection for the equipment shall be provided by fuses, circuit breakers, or other protective devices for primary circuits.

2. Overcurrent devices shall have a minimum of 10,000-Ampere Interrupting Capacity (AIC) rating.

b. Devices/components shall be protected from damage due to a loss of power or loss of one or more phases of power.

c. Overcurrent protective devices shall provide selective fault isolation rated for the available fault current calculated at the device location.

d. Available fault current shall be calculated from information concerning the facility in which the equipment is located.

e. Series combination system overcurrent protection shall not be permitted.

f. Transient protection shall be provided in accordance with IEEE C62.41, IEEE Recommended Practice on Surge Voltages in Low Voltage AC Power Circuits, Reference Table 2, and verified by testing in accordance with IEEE C62.45, IEEE Guide on Surge Testing for Equipment Connected to Low-Voltage AC Power Circuits.

3.1.1.7 Input Power Conditions

The equipment shall operate in accordance with the following power parameters.

a. Voltage

Nominal FAA Voltage	Voltage Range	Remarks
208/120 3 Phase	+10%, -15%	
480/277 3 Phase	+10%, -15%	
240/120 3 Phase	+10%, -15%	
120/240 1 Phase	+10%, -15%	
DC 48 Volts	+/- 20%	AC Ripple $\leq$ 5%
DC 25 Volts	+/- 20%	AC Ripple $\leq$ 5%
DC 12 Volts	+/- 20%	AC Ripple $\leq$ 5%

b. Voltage phase imbalance, phase to phase: 2% as defined by Paragraph 3.8.2 of IEEE STD 141 (Recommended Practice for Electric Power Distribution for Industrial Plants (Red Book))

$$\text{Phase-voltage imbalance} = \frac{\text{Maximum deviation from average phase voltage}}{\text{Average phase voltage}}$$

c. Frequency

(1) Steady State

(a) Steady state 60 Hz +/– 3 Hz

(b) Steady state rate of change 1.5 Hz/sec

(c) Steady state frequency variation + /– 0.5 Hz

(2) Momentary deviations (.5 seconds to 3 seconds)

(a) 60 Hz + 5 Hz, - 7 Hz

(b) Rate of change 5 Hz per sec.

d. Voltage Harmonic Distortion

(1) 10% Voltage Total Harmonic Distortion, V_{THD}

(2) 3% Any one Harmonic

e. Voltage/Time Events: See the voltage and current values given by Tables 3 and 4 of IEEE Standard IEEE C62.41. For appropriate exposure locations, see sections 7.3.3, 8.3 and Table 5, earthed neutrals.

f. Voltage/Time events for 120V single phase applications.

(1) As a minimum, the equipment shall maintain normal operation during the voltage time events as defined by the ITI/CBEMA curve in Appendix 1.

(2) The system level specification may require the equipment to maintain normal operation during voltage time events as defined by the Federal Aviation Administration Input Power Tolerance Envelope in Appendix 1.

3.1.1.8 Performance Upon Fault Condition of Radio Frequency Equipment Output Circuit

a. All equipment output circuits shall be designed to include circuit protection and to prevent damage to equipment upon occurrences of opens or shorts on the output terminals.

b. When the short or open is removed, circuit performance shall show no sign of performance degradation. In addition, transmitter output circuitry shall be so designed that, when operated at any voltage standing wave ratio (VSWR), the unit shall not be damaged nor shall any part exceed dissipation limits.

c. The transmitter may shut itself down upon detection of a high VSWR.

3.1.1.9 Grounding and Bonding

a. The ground reference for the equipment/system shall be in accordance with FAA-STD-019 (Lightning Protection, Grounding, Bonding and Shielding Requirements for Facilities), FAA-STD-020 (Transient Protection, Grounding, Bonding and Shielding Requirements for Equipment), FAA-C-1217, NFPA 70, and sections 8 and 9 of IEEE 1100 (Recommended Practice for Powering and Grounding Sensitive Electronic Equipment). FAA facilities utilize the following ground systems: (1) "multi-point"; (2) "single point"; (3) NEC power; and (4) "transient": as identified in FAA-STD-019.

b. Shielding and bonding shall be per FAA-STD-019 and FAA-STD-020.

c. Rack-mounted Equipment: Any rack-mounted, i.e., drawer type or removable, equipment whose chassis is intended for multi-point grounding shall have a flexible grounding strap or braid connecting each unit, assembly, or subassembly of equipment to the rack, using bonding connections per FAA-STD-020.

d. Enclosure and rack doors shall have grounding straps or braids across the hinges to ensure grounding of the door, bonded properly per FAA-STD-020.

e. Isolated ground receptacles shall be wired per NFPA-70.

f. For equipment connected to an AC supply line, the DC resistance to ground for each line input shall be at least 1 megohm.

3.1.1.10 Corona Prevention (High Voltage/High Current)

a. Corona prevention shall be as follows:

(1) When equipment is terminated with the cabling or other accessory equipment, with which it is intended to be used, and when operated under the specified service conditions of humidity, temperature, condensation and barometric pressure with the specified power source frequencies and voltages (including commonly recurring transients), the corona level shall be compatible with the specified electromagnetic interference requirements.

(2) The corona level shall not degrade the equipment performance beyond the specified limits and shall not produce long-term degradation of the properties of materials or parts that may cause premature equipment failure.

(3) The corona extinction voltage shall be at least 150 percent of the peak circuit voltage, corresponding to the maximum specified steady-state root mean square supply voltage, at any point that does not involve materials resistant to the effects of corona.

(4) Corona inception and extinction voltages shall be in accordance with ASTM D1868 (Standard Test Method for Detection and Measurement of Partial Discharge (Corona) Pulses in Evaluation of Insulation Systems).

(5) Sharp edges and points shall be avoided on all metal parts which are included in high-intensity electric fields. These are elements that contribute to formation of corona discharge.

b. Electrical breakdown prevention shall be as follows:

(1) The equipment shall be designed and manufactured with electrical clearance spacing, leakage (migration/creepage) distances, and insulation levels adequate to prevent electrical breakdown under the specified service conditions of humidity, condensation, barometric pressure, temperature, service life, contamination, and operating voltage (including transients).

(2) Liquid dielectrics, gases other than ambient air, or pressurization to prevent electrical breakdown shall not be used.

3.1.1.11 Transformer Isolation of Non-Switching DC Power Supplies

a. All non-switching DC power supplies energized from the AC line power source shall be isolated from the AC line through a power transformer with separate primary and secondary windings.

b. The DC resistance from each input line terminal (with fuses in place and AC line control contacts closed) to the signal or chassis ground shall be greater than 1 megohm.

3.1.2 Mechanical

3.1.2.1 Removable Parts and Mating Connectors

a. Electronic equipment shall be furnished with a complete set of installed fuses, lamps, plug-in relays, plug-in crystals, ferrule-type resistors, and other parts which are used in the equipment and which are similarly designed for quick removal and replacement. Plug-in parts that provide expanded equipment capabilities are waived from this requirement.

b. Parts which may be damaged by shipment in the operating sockets shall be packed in the normal part shipping container along with information to identify the operating socket.

c. Mating connectors of equipment mounted coaxial or cable connectors shall be provided.

d. Mating connectors shall be provided when two or more pieces of equipment require interconnection.

e. Circuit card guides shall support and retain the card in the guides during all phases of removal and insertion.

3.1.2.2 Installation

The equipment shall be designed for installation, removal and reinstallation without special tools unless approved by the FAA.

3.1.2.3 Construction

a. The equipment shall be constructed so that no fixed part shall become loose during transport and during normal maintenance and operations functions.

b. The total load from the equipment/enclosure to the floor shall not exceed 125 pounds per square foot.

c. The total load from equipment/enclosures supported directly to the building foundation may exceed 125 pounds per square foot but shall be less than the designed load bearing capacity of the foundation.

3.1.2.3.1 Equipment Racks

3.1.2.3.1.1 Pullout Drawers

a. All equipment pullout drawers shall be of a full-suspension roller type with latching stops. Friction-slide construction is prohibited.

b. Slides shall be of sufficient rigidity to prevent bowing and/or having rollers jump their track when the drawer is fully extended and components are being replaced/maintained.

c. Drawers shall be equipped with handles to permit withdrawing the drawer into the open position and latches on active panel fasteners to secure the drawer in the closed position.

d. The rack cabinet shall not tip over during normal operation and all maintenance activities.

3.1.2.3.1.2 Rack Panels

a. Where rack panels are used, they shall be in accordance with ANSI/EIA 310-D (Cabinets, Racks, Panels, and Associated Equipment).

b. Panel slot/hole pattern shall be the universal hole spacing pattern for 1U, 2U, and 3U panels and the wide hole spacing for panels 4U and higher.

c. Nominal thickness for aluminum panels shall be 3/16 inch, or greater.

d. Nominal thickness for steel panels shall be at 1/8 inch or greater.

3.1.2.3.2 Shelf Life

Materials and the processes shall ensure the equipment will meet performance requirements after a period of two years in a non-operational state after Government acceptance.

3.1.2.3.3 Moisture

a. Equipment in its operational environment shall not collect moisture.

b. Equipment shall have drainage or purging capability to remove moisture.

c. Removal of moisture shall be considered as part of the Mean Time To Repair (MTTR) calculations.

3.1.2.3.4 Windows

a. Equipment windows, including dial windows, shall be made of shatterproof transparent material.

b. Windows shall be secured to the panels in bezels by means of clips or other devices to prevent displacement of the window.

c. The use of adhesives to secure windows shall require FAA approval.

3.1.2.4 Accessibility

3.1.2.4.1 General

a. Equipment shall be designed for accessibility, operating compatibility, maintenance, electromagnetic compatibility, and enclosure requirements.

b. All non-hinged shields or plates which are normally opened or removed in servicing equipment, shall be secured with captive fasteners.

c. Captive fasteners shall be spaced on centers not exceeding 10 inches and shall be located around the entire periphery of the shields or plates.

3.1.2.4.2 Connections

Connections to parts inside a removable container shall be arranged to permit removal of the container without threading connection leads through the container.

3.1.2.4.3 Lowest Replaceable Units (LRUs)

a. Lowest Replaceable Units (LRUs) shall be removable and replaceable.

b. LRU Mounting devices shall provide the capability of the LRU to be repeatedly installed and removed without degrading performance.

c. Where LRU plug-in modules or assemblies are used, they shall be capable of being inserted in the proper location when correctly oriented without damage to equipment or parts being engaged.

d. LRU plug-in modules and assemblies shall be designed to prevent insertion into the improper location or incorrect orientation.

3.1.2.4.4 Enclosures

a. No enclosure, or part thereof, shall support or sustain combustion in excess of the requirements of NEMA 250.

b. Enclosures for equipment or systems, up to 1,000 volts, installed outside a building (outdoors) shall be either NEMA Type 4 or type 4X as directed by the system specification.

c. Enclosures for equipment or systems, up to 1,000 volts, installed inside a building in any location where dripping or splashing liquids, or dust, may normally be present shall be NEMA Type 12 or Type 13.

d. Enclosures for equipment or systems, up to 1,000 volts, installed inside a building where no dripping or splashing liquids or dust are normally expected shall be NEMA Type 1.

e. Enclosures for indoor use in hazardous locations classified as Class 1, Division 1, Groups A, B, C, or D as defined in NFPA 70 shall be NEMA Type 7.

f. Enclosures for outdoor use in hazardous locations classified as Class 1, Division 1, Groups A, B, C, or D as defined in NFPA 70 shall be NEMA Type 8.

g. Enclosures for indoor use in hazardous locations classified as Class II, Division 1, Groups E, F, or G as defined in NFPA 70 shall be NEMA Type 9.

h. Accessibility to chassis, assemblies, or parts contained within cabinets, consoles or other enclosures shall be provided from outside the basic equipment.

i. Mounting such items on withdrawal slides, swinging doors, through cable extenders and cable retractors, and provisions for circuit card extenders shall allow part or module operation in the open position.

j. Locks shall be provided to lock the chassis in the servicing position.

k. When withdrawal slides are used they shall be of guided sectional construction.

l. Complete removal and access for servicing of electronic equipment contained within cabinets, consoles or other enclosures shall be provided from either the front or rear of the

equipment.

m. Guide pins (or locating pins), or the equivalent, shall be provided for mechanical alignment during mounting.

3.1.2.5 Thermal Design

a. The equipment shall be capable of operating in the environment specified.

b. When air filters are required with forced air cooling, the air filters shall be in accordance with Federal Specification A-A-1419.

c. The difference between the exhaust air temperature (measured inside the cabinet or console in front of the exhaust air vent) and input air temperature (measured outside the cabinet or console directly in front of the input air vent) shall be less than 15°C with the equipment operating under normal service conditions.

d. All ventilation openings shall be designed and located to comply with electromagnetic interference, undesired radiation and enclosure requirements.

e. Air exhaust shall be directed away from operating personnel.

NOTE: MIL-HDBK-251 (Reliability/Design Thermal Applications) may be used as a guide for detail information on thermal design of electronic equipment.

f. Cooling methods such as liquid, evaporative coolants, and vapor cycle refrigerants shall not be used.

g. When required, a visual or aural warning device shall be used to indicate failure of a cooling device.

h. Equipment that requires forced cooling to operate shall have control features to prevent equipment damage due to failure of the forced cooling.

3.1.3 Equipment Software/Firmware

Software, including firmware, includes programs written for applications, test and diagnosis, initialization and operating systems, and support programs such as for configuration management, and for downloading/burning PROM-type devices.

Any maintenance, modification, and/or replacement of software/firmware programs and data shall be accomplished according to specific system requirements and procedures, such as by electronic means or replacement of PROM-type devices, called out in an approved program specific software/firmware management plan.

Firmware/software programs shall be in accordance with the requirements for performance, reliability and maintainability in the system/subsystem specification.

Modified and/or newly written software shall be in accordance with the requirements in FAA Standard 026, NAS Software Development, or the applicable standard in effect at the time of development.

3.2 Characteristics

3.2.1 Environmental Conditions

3.2.1.1 Operating Conditions

3.2.1.1.1 Seismic Zone Design

a. All equipment and systems shall, at a minimum, be designed to seismic forces and seismic relative displacement associated with seismic design category D using techniques of IBC 2000, in conjunction with the current version of FEMA 302, NEHRP Recommended Provisions for Seismic Regulations for New Buildings and Other Structures, Chapter 6. For facilities located in regions located very close to major active faults, seismic design categories E or F shall be used as applicable.

b. All equipment and enclosures shall be designed and installed so that the enclosure and the mounted LRU and/or components will remain upright and in place, and all access panels, doors, and drawers shall remain secured to the enclosure under the above conditions.

c. Design shall be performed and certified by a registered design professional.

3.2.1.1.2 Common Outdoor Operating Environmental Conditions

a. Elevation from sea level in feet: -300 to +10,000.

b. Wind velocity, any direction: 0 to 100 miles per hour.

c. Ice loading as defined by ASCE Manual 74.

d. Temperature, Solar Radiation and Humidity as defined in Table C-1 of MIL-STD-810F for the entire set of conditions defined as BASIC in the column headed CLIMATIC CATEGORY.

e. The system level specification shall define the required CLIMATIC CATEGORIES of HOT, COLD, and SEVERE COLD as defined in Table C-1 of MIL-STD-810F when appropriate.

3.2.1.1.3 Indoor Operating Environments

a. Elevation from sea level in feet: -300 to +10,000.

b. Temperature and Humidity of unmanned or unattended facility and storage or equipment areas of any facility: 0°F to +100°F, uncontrolled humidity.

c. Temperature and humidity of manned or attended facilities: +55°F to +85ºF with relative humidity of 30% to 80% in the defined temperature range.

d. The system level specification shall define the required operating environment(s).

3.2.1.2 Non-Operating Conditions

Equipment to be delivered to the government packaged for storage, shipping or transporting (non-operating) shall, as packaged, withstand the following environmental conditions:

(a) Temperature -50°C to +56°C

(b) Relative humidity 0% to 100% including condensation due to temperature changes

(c) Altitude 0 to 50,000 feet above sea level

3.2.2 Physical Characteristics

3.2.2.1 Electronic Equipment Assembly Requirements

Equipment assemblies, subassemblies, printed wiring assemblies, terminal board assemblies, electronic modules, etc., shall be Class 2 or Class 3 as defined in ANSI/J-STD-001B (Requirements for Soldered Electrical and Electronic Assemblies).

3.2.2.1.1 Component Mounting

Component mounting shall be in accordance with IPC-CM-770 (Guidelines for Printed Board Component Mounting) or ANSI/IPC-CM-780 (Component Packaging and Interconnecting with Emphasis on Surface Mounting), as applicable, except the term “not recommended” shall be interpreted as “reject.”

3.2.2.1.2 Printed Boards

Printed boards shall be in accordance with IPC-A-600E (Acceptability of Printed Boards).

3.2.2.1.3 Assembly

Assembly shall be in accordance with ANSI/IPC-A-610 (Acceptability of Electronic Assemblies) and ANSI/J-STD-001B.

3.2.2.2 Wire Wrap

Wire wrap shall not be used on printed circuit boards.

3.2.3 Reliability

The reliability of the equipment shall be such that the availability requirements in NAS-SR-1000 are met or exceeded. The reliability of the equipment can be ensured by the establishment of a reliability program that includes but is not limited to, subcontractor surveillance and control, program reviews, failure reporting, analysis and correction, reliability predictions, and parts control.

3.2.4 Maintainability

The maintainability of the equipment shall be such that the availability requirements in NAS-SR-1000 are met or exceeded. The equipment maintainability can be ensured by the establishment of a maintainability program that includes but is not limited to, subcontractor surveillance and control, program reviews, maintainability predictions, and maintainability demonstrations.

In addition, the following maintainability requirements apply:

a. Unsoldering of wires, wire harnesses, parts or assemblies shall not be required in order to gain access to terminals, soldered connections, mounting screws and the like during routine servicing and maintenance.

b. When it is necessary to displace a part in order check or remove another part, the former part shall be wired and mounted so that it can be moved without being disconnected and without causing circuit detuning or instability.

c. Removal of the front panel or any sub-chassis for maintenance purposes shall be accomplished without unsoldering or soldering of connections.

d. Replacement of air filters shall be accomplished without the shutdown of fans.

e. The equipment shall automatically return to normal operation when input power is restored after a power interruption.

f. Built-in test equipment devices shall maintain their accuracy under all operating conditions required by the specification.

g. Built-in test equipment devices shall be provided with connections or access for their operational checkout or calibration.

h. Test points and controls for adjustment shall not be located in compartments with voltage points of 300 volts or more.

i. All test points and controls for adjustments shall be located to preclude accidental shock to personnel engaged in normal operating or maintenance activities.

j. Protection shall be provided in the test point circuitry to prevent equipment damage caused by the external grounding of test points.

k. Provisions for testing shall be so designed that any failure of built-in-test (BIT) devices will not degrade equipment operation or cause equipment shutdown unless equipment is specifically designed to shut down in case of BIT device failure.

l. Test points on plug-in circuit cards shall be immediately accessible inside the electronic component cabinet.

3.2.5 External Equipment Interfaces

External systems interfacing with the equipment shall be in accordance with the requirements in the system level specification. Failure of external systems, such as remote maintenance monitoring systems, shall not affect the operation of the equipment or cause the equipment to fail.

3.2.6 Electrostatic Discharge

No system failures or service interruptions shall occur due to electrostatic discharge to the equipment case under the following conditions:

a) While in a non-operating state, when subjected to either a voltage discharge of 12kV, as stored in a 100 picofarad (pF) capacitor and discharged to the case through a series impedance of 100 ohms, or a transient current with an energy content of 7.2 millijoules (mJ).

b) During operation, when subjected to either a voltage discharge of 7kV, as stored in a 100 pf capacitor and discharged to the case through a series impedance of 500 ohms, or a transient current with an energy content of 2.45 mJ.

3.2.7 Transportability

The equipment transportability shall be in accordance with the requirements in the system level specifications.

3.3 Equipment Design and Construction

3.3.1 Materials, Processes, and Parts

3.3.1.1 Materials

3.3.1.1.1 Dissimilar Metals

a. Selection of metals for use in electronic equipment shall be made in accordance with the requirements of MIL-STD-889 (Dissimilar Metals).

b. Where electronic design requirements preclude the isolation of incompatible metal combinations as identified in MIL-STD-889 from one another, specific attention shall be paid to isolating the combination from exterior environments.

3.3.1.1.2 Metals, Corrosion Resistance

a. Metals shall be corrosion resistant or shall be coated or metallurgically processed to resist corrosion.

b. Materials and processes for metallic parts shall conform to applicable requirements in MIL-STD-889 and MIL-HDBK-1516.

c. Coatings shall be selected from MIL-HDBK-1516.

d. Non-corrosion resistant steel alloys, except where specifically required for electronic purposes shall not be used.

3.3.1.1.2.1 Corrosion-resisting Ferrous Alloys

a. Austenitic corrosion-resisting steel shall be used for all structural parts which will be subjected to severe corrosive conditions, such as exposure to sea water and combustion gases.

b. Corrosion-resisting steels shall be given a passivation treatment.

c. Other protective finishes or platings are permitted for electrical or mechanical reasons.

3.3.1.1.3 Flammable Materials

Materials used in the end item configuration shall be noncombustible or fire retardant in the most hazardous conditions of the equipment environment.

3.3.1.1.3.1 Additives

a. Fire retardant additives may be used provided they do not adversely affect the specified performance requirements of the basic materials.

b. Fire deterrence shall not be achieved by use of nonpermanent additives to the basic material.

3.3.1.2 Equipment Manufacturing Processes

3.3.1.2.1 Strain Relief

Each part lead terminating at a connection point shall have allowance for strain relief to minimize tensile or shear stress.

3.3.1.2.2 Painted Finish

a. Metal surfaces not otherwise protected as described herein shall be painted.

b. The painted surfaces shall withstand the environmental conditions defined by the equipment specification for the entire service life of the equipment without flaking, cracking, or allowing any corrosion of the underlying surface.

c. Painted finish shall be in accordance with FAA-STD-001 (Color and Texture of Finishes for National Airspace System (NAS) Equipment).

d. Leaded paint or paints containing isocynates and hazardous substances shall not be used.

3.3.1.2.3 Cadmium Plating

a. Cadmium plating shall not be used if it is in direct contact with other FAA equipment, located in confined spaces adjacent to waxes, phenolics, or other organic materials that react with the cadmium to cause growth or the formation of cadmium soaps.

b. Cadmium plating shall not be used if the surface is subjected to wear from friction. *(Note: This requirement addresses the cancerous hazards or risks of cadmium.)*

c. Cadmium plating shall be in accordance with Type II, Class 1 of ASTM B766 (Standard Specification for Electrodeposited Coating of Cadmium) plating with the following exceptions:

(1) Bolts, studs, washers, nuts, and articles with portions externally threaded. These parts have a minimum of class 3 thickness.

(2) Parts whose dimensional tolerances will not permit a class 2 thickness shall be given the maximum thickness of plating compatible with dimensional tolerances.

(3) Holes, recesses, internal threads, and other areas where a controlled deposit cannot be obtained normally shall not be subject to a thickness requirement.

(4) Corrosion-resistant internal-threaded inserts, or protective anti-seize compounds, or internal threads, shall be used where necessary in cadmium-plated parts.

3.3.1.3 Electrical Parts

3.3.1.3.1 Batteries

Batteries shall not be used unless specifically required to meet the equipment specification, and shall be in accordance with the following:

a. A battery within an electronic equipment/enclosure is defined as a secondary power source or a back-up power source.

b. Batteries shall be in accordance with applicable recognized industry standards.

(1) Equipment containing batteries shall be able to operate and be maintained in accordance with their formally documented procedures for a minimum of 2 years before the batteries require replacement.

(2) The replacement of the batteries shall not exceed 30 minutes.

(3) Battery back-up time shall be as specified in the System Level Specification.

(4) Batteries shall not leak or generate toxic, corrosive or combustible fumes.

c. Battery compartments shall be provided in accordance with the following:

(1) Contain devices to firmly secure the batteries.

(2) Provide access for battery installation, maintenance, testing, and removal without disassembly of equipment.

(3) Prevent build-up from heat, gases, liquids, or chemicals released during battery operation, charging, deterioration, or rupture.

(4) Prevent build-up of heat, gases, liquids, or chemicals from entering the electronic compartment.

d. Batteries used with or assembled to microelectronics used to supply power to microelectronics shall not require a dedicated battery compartment. Non volatile RAM ICs and button-type batteries are examples of batteries not requiring a dedicated battery compartment.

e. Connections, polarity, minimum acceptable voltage for equipment operation, nominal voltage, and type(s) of batteries required shall be marked as applicable in a prominent place on or adjacent to the battery compartment.

3.3.1.3.2 Circuit Breakers

3.3.1.3.2.1 Selection and Application

a. Circuit breakers shall be selected based on the environmental conditions specified in the System Level Specification.

b. Circuit breakers shall be in accordance with the requirements of UL 489 (Molded-Case Circuit Breakers, Molded-Case Switches, and Circuit-Breaker Enclosures).

c. Each pole of all circuit breakers shall provide complete overcurrent protection by having inverse time and instantaneous tripping characteristics.

d. Circuit breakers shall be operated by a toggle type handle and have a quick-make, quick-break, over-center switching mechanism, operating all poles, that is mechanically trip free from the handle so that the contacts cannot be closed against short circuit currents.

e. Circuit breakers shall be capable of manual operation to the open (off) and closed (on) conditions.

f. Circuit breakers shall not be used as switches unless they are specifically approved and listed for switching duty.

g. Circuit breakers operating handles shall clearly indicate, by visual or tactile means, the open (off), closed (on), and tripped states of the breaker.

h. Equipment or system circuit breakers shall be coordinated with the circuit breaker providing power to the equipment or system circuit breakers. The coordination shall be complete so that any overcurrent condition in the equipment or system will trip one or more equipment or system circuit breakers without tripping their power feed circuit breaker protecting the facility bus.

i. Equipment and system circuit breakers shall provide complete continuous overcurrent protection for the load served and be unaffected by load harmonics and inrush current.

j. Circuit breakers shall be full size units or multiples thereof.

k. Circuit breakers shall be permanently identified as to their continuous ampere rating.

l. Standard trip curve circuit breakers shall be used to the limits possible.

m. Circuit breakers that are used in an Underwriters Laboratory approved equipment item or load are not required to meet the requirements of b., h. and j.

n. Circuit breakers shall not perform the function of thermal overload relays.

3.3.1.3.3 Electrical Connectors

Electrical connectors shall function in the environmental conditions stated in the System Level Specification.

3.3.1.3.3.1 Selection

a. All electrical connectors shall be UL listed for their application and use.

b. Intended use information contained in the individual connector specifications shall be considered prior to making connector selections.

c. Contact crimp, installing, and removal tools shall be in accordance with the individual connector specifications.

(1) Tools shall be selected from the FAA tools list.

3.3.1.3.3.2 Connectors with Thermocouple Contacts

a. All connectors used in conjunction with thermocouples shall have their contact materials identified by one of the following methods:

(1) Nameplate securely attached to each connector half or mounted on the panel mounted receptacles.

(2) By means of insulation sleeving or other markers designed for attachment around wire bundles.

b. Markers shall be attached adjacent to the plug.

c. Contact materials shall be identified with abbreviations in accordance with Table II.

Table II Abbreviations for Thermocouple Materials

Chromium	Cr
Cobalt	Co
Alumel	AL
Tungsten Rhenium	W Re
Iron	Fe
Tungsten	W
Constantan	CN
Iridium	Ir
Copper	Cu
Rhodium	Rh
Platinum	Pt
Iridium Rhodium	Ir Rh
Platinum Rhodium	Pt Rh
Molybednum	Mo
Rhenium	Re
Gold	Au

3.3.1.3.3.3 Power Connectors

a. All power connectors shall be in accordance with NEMA standards.

b. Polarized connectors are required and shall be used to ensure safety of equipment and personnel.

3.3.1.3.3.4 Protective Measures

a. All unmated connectors shall be protected with metal or plastic caps or otherwise suitably protected during maintenance, storage and shipment.

b. Unmated connectors with exposed contacts which may contain electrically hot circuits shall be covered with moisture-proof and vapor-proof caps.

c. Protective caps shall remain linked to the equipment when not in active use.

3.3.1.3.4 Fuses, Fuse-holders, and Associated Hardware

3.3.1.3.4.1 Selection

a. Fusing shall be coordinated so that fuses in branch circuits will open before the fuses in the main circuit.

b. Fuses shall not perform the function of thermal overload relay devices.

c. Fuse ratings shall be compatible with both starting and operating currents.

d. Each individual fuse shall be replaceable in 5 minutes.

e. Connections to extractor post type fuse holders shall be such that the load is connected to the fuse terminal which terminates in the removable cap assembly.

f. Fuses shall have a minimum interrupting capacity of 10,000 A when used in any AC line whose voltage exceeds 100V.

3.3.1.3.5 Indicating Meters

a. Meters used solely for indication of equipment status may be digital or analog type. Meter accuracy shall be no less than ten percent (10%) of the parameter measured.

   1. Analog meters shall indicate normal conditions using the upper half of their scale.

   2. Digital meters shall indicate normal in the approximate center of their range.

b. Meters used for calibration shall have accuracy, and display of reading, at least ten (10) times more accurate than the value being calibrated.

3.3.1.3.6 Printed Wiring Board Modification

Modifications to printed wiring boards such as the use of cuts and/or jumpers or any other changes shall require FAA approval.

3.3.1.3.7 Conformal Coating of Printed Circuit Boards

a. Printed circuit boards exposed to extreme environmental conditions as defined in the System Level Sspecification shall have conformal coating.

b. When conformal coating is required, coating material shall conform to ANSI/IPC CC-830 (Electrical Insulating Compound for Printing Board Assemblies, Qualifications and Performance of).

3.3.1.3.8 Electromagnetic Shielding

a. Magnetically sensitive devices shall be shielded to control the effects of electromagnetic fields.

b. Such devices shall be protected to ensure that their performance will not be degraded beyond equipment specification limits, by fields external to the equipment, nor produce emissions in excess of the specified operating limits per commercial specification as appropriate to the environment.

c. Shielding shall be in accordance with FAA-STD-020 Section 3.10.

3.3.1.3.9 Switches

Switches shall maintain their indicated state, i.e., open or closed, when subjected to any accidental force on the switch or the switch mounting equivalent to a 10g acceleration of either switch or mounting.

3.3.1.3.10 Wiring

The selection, application, and wiring practices for cable and wire shall be in accordance with the following subparagraphs:

3.3.1.3.10.1 Clearance and Leakage (creepage) Distances

Clearance between solder connections or bare conductors (such as terminal strips, stand-offs, or similar connections), shall not allow accidental contact occurring between adjacent connections when subject to service conditions specified in the equipment specification. (For electrical clearance and leakage distances, see Table III.)

3.3.1.3.10.2 Marking

a. All signal, control, and power wiring shall be uniquely identified to and within the enclosure along the wire and at each termination by either permanent, insulation markings or by heat shrink labels.

b. Marking/labeling of the wiring shall occur at structural penetrations and at every 20 feet of wiring.

3.3.1.3.10.3 Wiring Protection

a. The wiring shall be secured and protected against chafing due to vibration or movement (such as slide out racks or drawers).

b. Wiring to pullout drawers shall employ cable retractors to protect the equipment.

c. When clamping is used, the cable shall not be degraded.

Table III. Electrical Clearance and Leakage (Creepage) Distances

VOLTAGE AC (RMS) OR DC	CLEARANCE		LEAKAGE DISTANCE (inches)	
	CONDITION	INCHES	ENCLOSURE I	ENCLOSURE II
To 150	A	1/16	1/16	1/16
	B	1/8	1/8	1/4
	C	1/4	3/8	3/4
150-300	A	1/16	1/16	1/16
	B	1/8	1/8	1/4
	C	1/4	1/2	3/4
300-600	A	1/16	1/8	1/8
	B	1/8	1/4	1/4
	C	1/4	1/2	3/4
600-1000	A	1/8	1/8	1/2
	B	1/4	1/4	1
	C	1/2	1-1/2	2

Notes:

1. Condition A is for use where the effect of a short circuit is limited to the unit; and where normal operating power does not exceed 50-watts.
2. Condition B is for use where short circuit protection in the form of fuses, circuit breakers, etc, is provided; and where normal operating power does not exceed 2000 watts.
3. Condition C is for use where short circuit protection in the form of fuses, circuit breakers, etc, is provided; and where normal operating power exceeds 2000 watts.
4. Enclosure I is an equipment enclosure which has no openings or the openings are constructed so drops of liquid or solid particles striking the enclosure, at any angle from 0 degrees to 15 degrees from the vertical, cannot enter the enclosure directly or by striking and running along a horizontal or inwardly inclined surface.
5. Enclosure II is any equipment enclosure which provides less protection than Enclosure I.

3.3.1.3.10.4 Insulation Cold Flow

For insulated wire susceptible to cold flow, care shall be exercised so there will be no cold flow of the insulation.

3.3.1.3.10.5 Cable Ducts

Where cable ducts are employed, provisions shall be made for the removal of any wire that may become faulty. For example, covers may be employed at intervals to aid in the removal of a faulty wire.

3.3.1.3.10.6 Bend Radius

The bend radius of wire and cable shall not be less than five (5) times the cable diameter to avoid establishing a permanent set in the cable.

3.3.1.3.10.7 Sleeving

a. Flexible plastic sleeving, nonflammable, self-extinguishing, or flame retardant shall be used on cables subject to flexing, such as panel door cables.

b. The sleeving shall be secured under cable clamps at each end.

c. The cable shall be formed and secured so the cable will not be subject to abrasion in its normal flexing motion.

d. In cases where abrasion cannot be avoided, additional protection shall be provided.

3.3.1.3.10.8 Panel Door Cables

a. Wiring to parts on a hinged door shall be contained in a minimum number of cables, arranged to flex without becoming damaged when the door is opened and closed.

b. Cabling shall be arranged in such a way to maintain access to the equipment.

3.3.1.3.10.9 Through Hole Protection

a. Whenever wires are run through openings in metal partitions, shields, and the like, which are less than 1/8 inch in thickness, the holes shall be equipped with suitable mechanical protection (grommet) or insulation.

b. Openings in panels 1/8 inch or more in thickness shall have either grommets or the edges of the openings rounded to a minimum radius of 1/16 inch.

c. Grommets for wires operating at RF potentials exceeding $500V_{rms}$ shall be of ceramic or plastic material of suitable dielectric strength, except for coaxial cables which have outside protection, where rubber or neoprene is acceptable.

d. Insulating grommets are not required for wires or groups of wires passing through shields or other metallic partitions where clearance can be maintained sufficiently to preclude the possibility of accidental contact or damage by abrasion.

3.3.1.3.10.10 Wiring Arrangement

a. All wiring shall be arranged in a manner to allow access to and maintenance of all components. The use of preformed cables and wiring harnesses is preferred to the point-to-point method of wiring.

b. Signal, data, control, and other low power conductors shall not be placed adjacent to line power conductors.

c. Materials used for lacing, binding, sleeving, and strapping shall be compatible with the conductor or cable insulation or jacket, and shall meet the same flame retardant and self-extinguishing requirements.

d. Wiring shall be arranged to permit bundling or permanently mounted in cable ducts.

3.3.1.3.10.11 Slack

Discretely terminated wires and cables shall be as short as practicable, except that sufficient slack shall be provided to:

a. Prevent stress on cable forms, wires, and connections, including connections to support parts resiliently.

b. Allow replacement of end terminations/connectors without disconnecting other parts.

c. Facilitate field repair of broken or cut wires.

d. Permit units in drawers and slide out racks to be pulled out to the limit of the slide and rotated (if rotatable) or support travel without breaking connections.

e. When drawers or racks are fully extended and rotated (if rotatable), the cable bend radius shall not be less than three (3) times the cable assembly diameter.

f. When flat molded cable assemblies are used, the bend radius shall not be less than ten (10) times the cable assembly thickness.

g. Ensure freedom of motion of contacts or terminals normally intended to have a degree of movement (i.e., floating contacts in connectors).

h. The only exceptions to this provision are cases where RF leads must be as short as possible for electrical reasons and when fixed path rotating is specified or the amount of slack is limited by space available as occurs in automatic machine wire panels and multi-pin connectors.

3.3.1.3.10.12 Wiring in Terminal Boxes

Wiring and cables in terminal boxes shall be fanned out to identify terminals for check purposes if test points for required maintenance information are not provided.

3.3.1.3.10.13 Entrance Cabling and Wiring

Wiring from cable entrances to terminal boards, plugs, jacks, and similar devices shall be harnessed and clamped or supported in a cable duct. Flat cable may be used where suitable.

3.3.1.3.10.14 Wire

a. Stranded wire is preferred; however, solid wire may be used in the equipment, provided such wire is insulated and held in place so that it does not fail or show excessive motion likely to result in failure when the equipment is subjected to vibration and shock encountered under the specified service conditions.

b. Wire shall be continuous from point of origin, on a discrete device or terminal, to the point of destination, on a discrete device or terminal. When pre-assembled cabling is used to interconnect equipment sections the use of listed, polarized, connectors are permitted to

facilitate installation and maintenance.

3.3.1.3.10.15 Support

a. Wire and cable shall be supported and secured to prevent stress on the conductors and terminals and change in position of the wire or cable during and after subjection of the equipment to specified service conditions, or after service or repair of the equipment in a normal manner.

b. When shielding on wire or cable is unprotected by an outer insulation, support is necessary to prevent the shielding from coming in contact with exposed terminals or conductors.

c. Twine or tape shall not be used for securing wire and cable.

3.3.1.3.10.16 Conductor's Insulation Sleeving

Insulation sleeving of conductors shall be UL listed for the application.

3.3.1.3.10.17 Fungus Protection

a. Fungus protection shall be provided based on the environmental conditions required by the System Level Specification.

b. Prior to attachment of terminals to prepared lengths of cables containing materials that will support fungus, the ends shall be protected against entrance of moisture and fungus by treatment with a fungicidal varnish conforming to ASTM D295 (Standard Test Methods for Varnished Cotton Fabrics Used for Electrical Insulation) and ASTM D3955 (Standard Specification for Electrical Insulating Varnishes) and in accordance with MIL-T-152B (2).

3.3.1.3.10.18 Aluminum Conductors

Aluminum conductors shall not be used for interconnections between LRUs.

3.3.1.3.10.19 Termination of Signal and Control Wiring

All external signal and control wiring entering the equipment shall be terminated with a connector.

3.3.1.3.10.20 Fiber Optics

Use of fiber optics shall be in accordance with FAA-STD-049 (Fiber Optics Standard for Telecommunications Systems and Equipment).

3.3.1.3.10.21 Raised Floor Cabling

Cabling under raised floor areas shall be in accordance with section 645-5(d) of NFPA 70.

3.3.1.4 Mechanical Parts

3.3.1.4.1 Bearings

3.3.1.4.1.1 Bearing Lubricant

a. Adequate lubricant shall be provided either within the bearing or externally in the form of oil reservoirs or grease re-lubrication facilities except as noted herein.

b. Where lubricant replenishment is required, precautions shall be taken to prevent purged or lost lubricant from entering and adversely affecting the operation of the equipment.

c. Where bearings coated with preservative are installed in closed housings, the preservative shall be compatible with the lubricant used in the assembly.

3.3.1.4.1.2 Seals and Shields

All rolling element bearings shall be protected by seals or shields on the bearing or installed in housings which provide shielding to prevent foreign matter from entering the bearing.

3.3.1.4.1.3 Self-Lubricating Bearings

Permanently lubricated bearings or bushings of plastic, metallic-plastic combinations, or all metallic materials with or without dry film lubricants may be used provided wear products produced during operation will not cause or contribute to failure of the equipment or bearings.

3.3.1.4.1.4 Un-lubricated Bearings

Un-lubricated bearings or bushings may be used only in applications where the presence of a lubricant would be undesirable or detrimental and the functional, environmental, and service life requirements can be met in this condition.

3.3.1.4.1.5 Electrical Grounding

Ball and roller bearings used for rotating electrically energized equipment shall be electrically shunted to prevent current flow through the bearings.

3.3.1.4.1.6 Alignment

Bearings shall be located to ensure proper shaft alignment and support.

3.3.1.4.2 Controls and Switches

Controls and switches shall be in accordance with DOT/FAA/CT-961, FAA Human Factors Design Guide.

3.3.1.4.2.1 Direction of Movement

a. Controls shall be connected in the circuit so the controlled characteristics (e.g., sensitivity, volume, or voltage) increase with clockwise rotation of the control as seen from the operating position.

b. Movement of a control forward, clockwise, right, or up, shall turn the equipment on, or cause the quantity to increase, the equipment to move forward, clockwise, to the right, or up.

3.3.1.4.2.2 Operating Controls

Controls necessary for the operation of the equipment shall be readily accessible, and shall be located on the front panel of the unit.

3.3.1.4.2.3 Adjustment Controls

a. Adjustment controls that are required for periodic alignment or calibration shall be mounted behind covered openings (such as access doors), and on the faces of the equipment most accessible when installed.

b. When not adjustable by hand, controls shall be designed to accept a common screwdriver blade tip.

c. Controls which are infrequently adjusted need not be accessible from the operating panel, but shall be readily accessible for servicing without the use of an extender card when the equipment is opened for maintenance purposes.

d. The adjustment range shall not be large enough to cause equipment damage.

3.3.1.4.2.4 Operation

a. Play and backlash in controls shall be held to a minimum commensurate with intended operational functions and shall not cause poor contact or inaccurate setting.

b. Controls shall operate freely and smoothly without binding, scraping, or cutting. Controls may be lubricated when lubrication does not interfere with operation and is specified in the detail equipment specification.

c. Normal settings of all continuously variable controls shall not fall in the first tenth or last tenth of angular rotation.

3.3.1.4.2.5 Stops

a. Mechanical stops shall be provided for all adjustable controls, except controls designed for unlimited rotation.

b. Stops shall be provided on the driving end of the shaft where flexible control shafts are employed, or where stops that are integral to the adjustable control or the mechanism could be damaged by excessive torque.

3.3.1.4.2.6 Locking Devices

a. Control locking devices shall retain the controls in any given setting within the range of control.

b. The locking and unlocking action shall be easily and quickly accomplished, and shall not affect the setting of the control.

c. When in the unlocked position, the locking devices shall not interfere with the normal operation of the control.

d. Where vernier controls are used, the locking devices shall operate on both main and vernier controls, if necessary, to prevent damage.

3.3.1.4.2.7 Non-turn Devices

All non-turning controls and bodies or cases of turning controls shall be equipped with a positive device to prevent their turning in the panel or in the assembly on which they are mounted.

3.3.1.4.2.8 Shafts and Couplings

a. Control shafts and couplings shall be of design and strength commensurate with their respective loads.

b. Coupling between or to shafts shall be accomplished by means of metallic or insulated couplings rigidly secured.

c. Couplings transmitting two (2) horsepower or less may be secured to the shaft with two (2) set screws that are spaced ninety (90) to one hundred twenty (120) degrees apart.

d. Flexible couplings will be permitted for controls where the use of rigid couplings would interfere with the satisfactory operation or mounting of such controls.

e. Flexible couplings shall not be employed for frequency determining circuits.

f. Couplings transmitting more than two (2) horsepower shall be of the taper locking bushing type. All shall be of one type or source for all equipment or systems defined by a system level specification.

3.3.1.4.2.9 Gears, Sheaves, Sprockets, Clutches and Brakes in mechanical drive systems

a. All shall be of taper locking bushing design when available as a catalog item and of one type or source for all equipment or systems defined by a system level specification.

b. The system specification may allow gears, sheaves and sprockets transmitting one (1) horsepower or less exemption when the equipment item is a standard design packaged unit.

3.3.1.4.3 Fastener Hardware

Fastener hardware shall be in accordance with the following subparagraphs:

3.3.1.4.3.1 General

a. Fasteners shall be able to be removed and installed without damage to hardware.

b. Fasteners shall remain secure when exposed to equipment operational and environmental stresses.

c. Except for those items designed to be affixed with one fastener, parts shall be secured so failure of a single fastener will not free the part completely.

d. Friction between mating surfaces shall not be employed as the sole means of preventing fixed parts from rotating or shifting.

e. Fasteners shall be selected to minimize the number of standard tools used during maintenance.

3.3.1.4.4 Special Tools

Special tools shall be capable of performing the required functions throughout the life of the equipment they support.

3.3.1.5 Miscellaneous Items

3.3.1.5.1 Glass

All glass used in the equipment, except for cathode ray tubes, shall be of the shatterproof type and appropriate for the specified environmental condition.

3.3.1.5.2 Motors

3.3.1.5.2.1 One Horsepower and Larger

All electric motors one horsepower or larger shall:

a. Be NEMA Design B rating, Class H insulation, and NEMA Design E rated.

b. Have permanently lubricated ball bearings.

c. Open drip-proof frame if installed indoors in a clean and dry environment.

d. Totally enclosed, fan cooled (TEFC) frame if installed in a dusty or outdoor environment.

e. Epoxy encapsulated windings if specified by the system level specification.

f. Cycled or switched by a contactor and equipped with thermal overload relay protection for each phase.

g. Either single-phase 230V rated for 3-wire 120/240 applications or 208V, 3 phase.

h. If the system or equipment in which the motor is used is a single phase, nominal 115V system, single phase 115V motors whose full load current does not exceed 16A are permitted.

3.3.1.5.2.2 Fractional Horsepower (less than one horsepower)

All electric fractional horsepower motors shall:

a. Be single phase, appropriate voltage for the equipment or system, but less than 16 amperes full load in any case.

b. Have permanently lubricated ball bearings.

c. Be NEMA Design-E rated energy efficient rated when available as a standard catalog item.

d. Be protected from overload with a device embedded in their windings or mounted in the

motor that interrupts power to the windings when an over temperature condition is detected.

e. Be of open frame construction for clean and dry applications.

f. Be a totally enclosed frame construction for all other applications.

g. Fractional Horsepower Motors that are part of a UL approved device or equipment item are exempt from any other requirement.

3.3.1.5.2.3 Ventilating Fan Motors

All ventilating fan motors (commonly called pancake type) shall:

a. Be ball bearing.

b. Not be required to have overload protection if they are of inherently safe construction i.e., can be continuously energized with their rotation blocked.

c. Not be required to be energy efficient.

d. Be of any frame construction type.

3.3.2 Electromagnetic Compatibility

(Note: Electromagnetic compatibility requirements of this specification are applicable to the extent defined in the individual equipment or subsystem specification.)

a. All radar and RF transmitting equipment shall meet the applicable technical standards specified in the 47CFR300 (Telecommunications, Federal Communications Commission, Part 300, National Telecommunications and Information Administration Manual of Regulations and Procedures for Radio Frequency Management (NTIA Manual)), hereafter referred to as the NTIA Manual.

b. Equipment shall meet the appropriate Federal Communications Commission (FCC) authorizations as defined in 47CFR2 (Telecommunications, Federal Communications Commission, Part 2 Frequency Allocations and Radio Treaty Matters: General Rules and Regulations) and 47CFR15 (Telecommunications, Federal Communications Commission, Part 15, Radio Frequency Devices) of the FCC Rules and Regulations.

c. The electromagnetic compatibility requirements shall be as indicated for Ground, Navy in Table V (Requirements Matrix) of MIL-STD-461E (Electromagnetic Emission and Susceptibility Requirements for the Control of Electro-magnetic Interference) and defined in the appropriate sections of MIL-STD-461E.

d. All equipment designed for interface and connections to public or private switched telephone networks, shall meet the requirements of 47CFR68 (Telecommunications, Federal Communications Commission, Part 68, Connection of Terminal Equipment to the Telephone Network) of the FCC Rules and Regulations.

3.3.3 Nameplates and Marking

3.3.3.1 Nameplates

a. Each subsystem shall have one or more nameplates determined by the equipment configuration.

b. Each nameplate shall be in accordance with Figure 3.

c. Nameplates shall be attached by removable 4-40 pan-head screws.

3.3.3.1.1 Equipment Titles

a. Unless specifically set forth in the equipment specification, titles and type designations shall be approved by the Government.

b. The titles of the equipment specifications shall not be assumed to be the correct equipment titles for use on the nameplates.

3.3.3.1.2 Serial Numbers

a. Serial numbers shall start with one (1) for each equipment unit having an individual nameplate and continue consecutively up to the total number of such equipment units required.

b. Serial numbers for a given part number shall not be duplicated or reassigned.

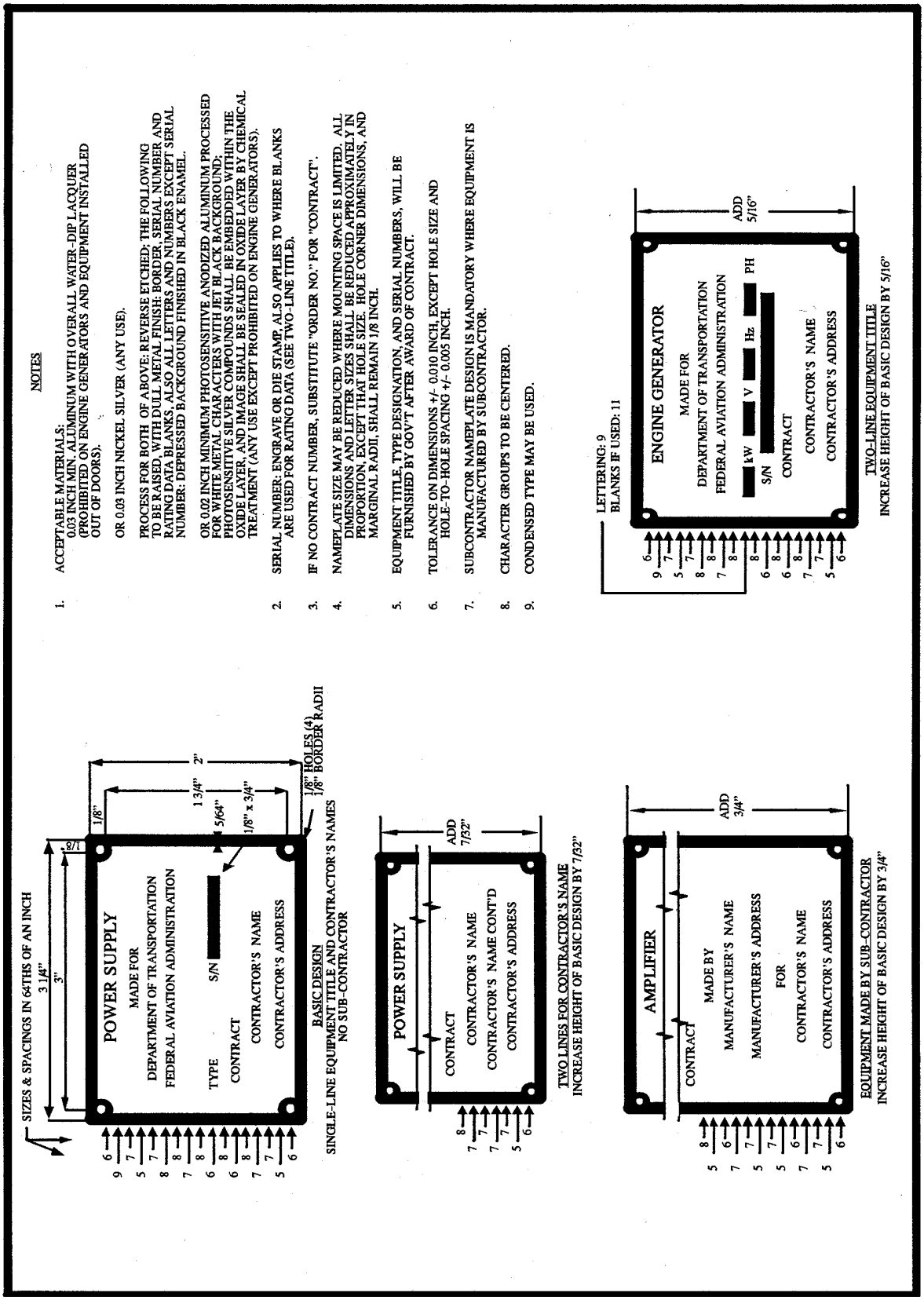


Figure 3. Standard FAA Nameplate

3.3.3.2 Marking

a. A marking shall be permanent and legible during normal operation and maintenance usage.

b. A marking shall be as specified in ANSI/IEEE-200 (IEEE Standard Reference Designations for Electrical and Electronics Parts and Equipment).

3.3.3.2.1 Visibility of Parts Labels

All LRU parts which have labels or markings identifying data or ratings, shall be mounted so that the data is visible to maintenance personnel without the necessity for disassembly of parts or of adjacent functional or structural parts.

3.3.3.2.1.1 Fuse Positions

All fuse positions shall be marked with the rated current capacity of the fuse to be employed therein and approved by the FAA.

3.3.3.2.1.2 Terminal Strips, Blocks, and Wafer Switches

All terminal strips, blocks and wafer switches shall be identified.

3.3.3.2.1.3 Controls and Indicating Devices

a. Markings shall be provided on the front of each exterior and interior panel and panel door, and also on control-mounting surfaces of each chassis, sub-panel, etc., to clearly designate the functions and operations of all controls, fuses, and indicating devices mounted thereon, protruding, or available through access holes therein. This includes all equipment that supports operations and maintenance.

b. All markings shall be located on the panel or chassis in correct relationship to the respective designated items.

3.3.4 Interchangeability

Items shall be interchangeable in form, fit, and function without mechanical adjustment.

3.3.5 Personnel Safety and Health

a. Equipment shall be constructed with safe clearances, workspaces and other safety factors per NFPA Code 70.

b. To ensure personnel safety, the equipment shall be equipped to be anchored and remain in place during a seismic occurrence as stated in the National Earthquake Hazards Reduction Program (NEHRP) FEMA Publication 302 Section 6.3.

c. Equipment design shall provide for personnel safety in accordance with Table 2 of ANSI/IEEE C95.1-1991, Standard for Safety Levels with Respect to Human Exposure to Radio Frequency Electromagnetic Fields, 3 kHz to 300 GHz.

d. Equipment shall be in accordance with UL 1950 (Safety of Information Technology Equipment).

e. Personnel shall be protected from harm of moving parts when replacing filters.

f. Personnel shall be protected from injury by sharp edges of equipment or cabinets during maintenance. Use of edge guards is required.

3.3.5.1 Electrical Safety

a. A means shall be provided to protect personnel from accidental contact with voltages in excess of $30V_{rms}$ or DC during normal operations or maintenance of the equipment.

(1) After power to the equipment is turned off, the equipment shall discharge all potential stored power within 2 seconds.

(2) Personnel shall be protected from circuits greater than 21mA AC and 80mA DC.

b. The power input side of the switch and the incoming power line connections shall be given physical protection against accidental contact.

3.3.5.1.1 Ground potential

a. The design and construction of the equipment shall ensure that all external parts, surfaces, and shields, exclusive of antenna and transmission line terminals, are at ground potential at all times during normal operation.

b. Any external or interconnecting cable, where a ground is part of the circuit, shall carry a ground wire in the cable terminated at both ends in the same manner as the other conductors.

c. In no case, except with coaxial cables, shall the shield be depended upon for a current-carrying ground connection.

d. Antenna and transmission line terminals shall be at ground potential, except for radio frequency (RF) energy on their external surfaces.

e. Plugs and convenience outlets for use with metal cased portable tools and equipment shall have provisions for automatically grounding the metal frame or case of tools and equipment when the plug is mated with receptacle, and the grounding pin shall make first, break last.

f. All outer metal cases of components shall be at ground potential or covered by an external casing made of insulating material.

g. The external casing shall enclose the original case on all sides except the terminal sides.

h. A point on the electrically conductive chassis or equipment frame shall serve as the common tie point for the static or power ground.

3.3.5.1.2 Hinged or Slide Mounted Panels and Doors

a. Hinges or slides are not considered adequate grounding paths, therefore doors and panels with hinges or slides shall be grounded by use of a flexible ground strap in accordance with FAA-STD-019.

b. A ground shall be considered satisfactory if the electrical connection between the door or panel and the system tie point exhibits a resistance of 0.1 ohm or less and has sufficient capacity to ensure the reliable and immediate tripping of equipment over-current protection devices.

3.3.5.1.3 Shielding

a. Except where a conflict with grounding requirements would be created, shielding on wire or cable shall be grounded to the chassis or frame.

b. The shielding shall be at a sufficient distance from exposed conductors to prevent shorting or arcing between the conductor and the shielding under normal operating conditions and worst case environmental conditions.

3.3.5.1.4 Bonding in Hazardous Areas

Electronic equipment that is to be installed in areas where explosive or fire hazards exist shall be bonded in accordance with NFPA 70 and FAA-STD-019.

3.3.5.1.5 Guarding of Radio Frequency (RF) Voltages

Transmitter output terminals, antennas and other devices that carry sufficient RF voltage that may burn or injure personnel shall be protected from accidental contact.

3.3.5.1.6 Interlocks

Interlocks shall conform to the following:

a. No interlocks are required when all potentials in excess of 70 volts are completely protected with guards or barriers to prevent accidental contact under all conditions of operation or any level of maintenance.

b. Interlocks are required when voltages between 70 and 500 volts are exposed when the access door, cover or plate is opened.

c. Bypassable interlock switches shall be momentary action (spring-return) switches marked "INTERLOCK BYPASS" and are provided to allow interlocked access doors and covers to be opened with a manual latch for "on" position to be operated in the exposed interlock switch, without removing power from the equipment.

d. Bypassable interlocks are allowed internal voltages that may be unguarded only if they are not exposed during direct support or operator maintenance.

e. The bypass switches shall be located so that one person can operate the switch, open the door or cover, and set the manual latch.

f. Non-bypassable interlocks are required for access doors, covers and panels when the voltage accessible or exposed exceeds 500V and the current available exceeds 100mA AC or 160mA DC.

3.3.5.1.7 Shorting Rods

a. Shorting rods shall be provided with all transmitting equipment where voltages are in excess of $70V_{rms}$ or DC.

b. Shorting rods shall be stored within the transmitting equipment and be permanently attached and readily accessible to maintenance personnel.

3.3.5.1.8 Meter Safety

a. Meters shall have provisions for overload bypass, or alternate protection to eliminate high voltage potential or current at the terminals in the event of meter failure.

b. In addition, meters shall be provided with protection so that not over 1500V, maximum peak value, shall exist between any terminal of each meter and the metal panel on which it is mounted in the equipment.

3.3.5.1.9 High Voltage Protection

a. Assemblies operating at potentials in excess of 500V shall be completely enclosed from the remainder of the assembly and interlocked in accordance with the requirements herein.

b. Test probe holes may be provided in the barriers or guards where maintenance testing is required.

c. When the operation or maintenance of equipment is employing potentials in the excess of 300V peak, the equipment shall be provided with test points so these voltages can be measured at a relatively low potential level, but in no case shall the potential exceed 300V peak relative to ground.

d. Test points with voltages above 30V shall have the conducting material recessed at a distance no less than the diameter of the probe hole and a minimum of 0.06 inch.

e. If a voltage divider is used, the voltage divider resistance between the test point and ground must consist of at least two equally valued resistors in parallel.

f. Full details shall be given in the instruction book or maintenance manual as to the method used in the equipment to obtain the voltage at the test points.

3.3.5.1.10 High Current Protection

All power buses supplying 25A or over shall be protected against accidental short circuiting by tools, jewelry, or removable conductive assemblies.

3.3.5.1.11 Discharging Devices

a. Discharging devices shall be provided to discharge high voltage circuits and capacitors unless they discharge to 30V within two seconds or less after power removal.

b. These protective devices shall be positive acting, highly reliable, and shall actuate automatically when the case or rack is opened.

c. Shorting bars shall be actuated either by mechanical release or by an electrical solenoid when the door or cover is open.

d. When resistive bleeder networks are used to discharge capacitors, the bleeder network shall consist of at least two equal valued resistors in parallel.

e. The particular discharging device that is chosen must ensure that the capacitor is discharged to 30Vor less within two seconds.

3.3.5.1.12 Electrical Connectors

a. The design of the connector shall be such that the operator is not exposed to electrical shock or burns when normal disconnection methods are used.

b. Exposed pin contacts shall not be energized (hot) after being disconnected from the socket contacts.

3.3.5.2 Laser Radiation Limits

3.3.5.2.1 Laser Radiation

Laser equipment and system design, installation, and written operational and maintenance procedures shall conform to 21CFR1040, Food and Drug Administration, Department of Health and Human Services, Part 1040 Performance Standards for Light-Emitting Products.

3.3.5.3 Switches

3.3.5.3.1 Safety Switches

a. Enclosed, non-fused knife switches in accordance with NEMA KS-1 shall be provided to electrically disconnect system items/parts or equipment that is required to have these disconnecting means by either NFPA-70 or OSHA.

b. The switch shall have auxiliary contacts that furnish a signal to the system or equipment controls when an accidental opening of the switch while in operation would damage the system or equipment.

c. The switches shall be rated for the maximum fault current available at the point of installation.

d. All mechanical drive units shall have a disconnecting knife switch.

3.3.5.3.2 Momentary Override

Momentary contact switches may be used to override interlocks and permit access to the manual override for efficient servicing.

3.3.5.4 Mechanical Hazards

a. Rack mounted equipment shall be located to prevent the enclosure from tipping over.

b. Suitable protection shall be provided to prevent contact with moving mechanical parts such as gears, fans, and belts when the equipment is operating.

c. Sharp projections on cabinets, doors, and similar parts shall be avoided. Doors or hinged covers shall be rounded at the corners and provided with stops to hold them open.

d. Provisions shall be enhanced to prevent accidental pulling out of drawers or rack mounted equipment components which could cause equipment damage and injury to personnel.

e. Equipment power switches shall be designed and located to prevent accidental contact by personnel from changing the equipment state.

3.3.5.4.1 Mechanical Interconnection

a. The design shall provide positive means to prevent the inadvertent reversing or mismatching of fittings, couplings, fuel, oil, hydraulic, pneumatic lines, mechanical linkage, and instrument leads and electrical connections.

b. When prevention of mismatching by design considerations is not feasible, coding or marking shall be employed when approved by FAA. Coding and marking will not be approved as a substitute for proper design of items involving explosives, emergency, or safety-critical systems.

3.3.5.4.2 Cathode Ray Tubes (CRTs)

Cathode ray tubes shall conform to the requirements of UL 1418 (Cathode-Ray Tubes).

3.3.5.4.3 Glass Fibers

Glass fibrous materials shall not be used as the outer covering on cables, wire, or other items where they may cause skin irritation to operating or maintenance personnel unless specified in the equipment specification.

3.3.5.5 Markings, Signs, Tags, and Symbols

3.3.5.5.1 Markings

a. Guards, barriers, and access doors, covers or plates shall be marked to indicate the hazard which may be reached upon removal of such devices.

b. A hazard marking shall be located on the equipment such that it is not removed when the barrier or access door is removed.

c. Warnings of hazards internal to a unit shall be marked adjacent to hazards if they are significantly different from those of surrounding items.

d. Physical hazards shall be marked with color codes in accordance with ANSI Z535.1 (Safety Color Code) where applicable to electronic equipment.

e. Center-of-Gravity shall be marked on equipment which has a center-of-gravity fifty percent (50%) different from the center-of-volume of the chassis.

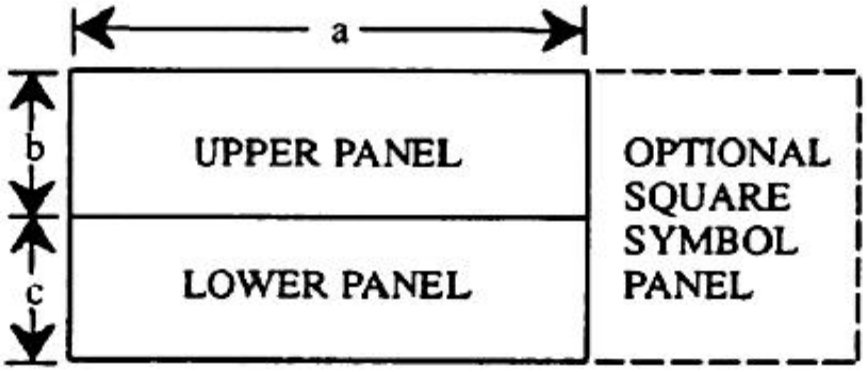
3.3.5.5.2 Accident Prevention Signs and Labels

a. Accident prevention signs and labels shall be provided whenever equipment has characteristics or operating conditions which present a hazard to operators, and maintaince or other personnel.

b. Signs and labels shall have the same life expectancy as the equipment on which they are affixed.

3.3.5.5.2.1 Sign Design

a. Signs shall consist of three panels as shown in the following diagram.



General Layout – Two Panel Sign With Optional Symbol Panel

(1) The ratio of width to height of the upper panel (a:b) shall fall within the range of 2:1 to 5:1 inclusive.

(2) The lower panel shall be equal to the upper panel width (both equal to a).

(3) The lower panel height shall be equal to or greater than the upper panel height, but less than twice the width of the sign (b<=c<2a).

(4) The optional symbol panel shall be square with its edge equal to the sum of the upper and lower panel (b+c) and placed to the right.

(5) The upper panel shall contain the signal or key word.

(6) The lower panel shall contain additional direction or explanation. Wording of this panel shall be brief, provide positive direction, and be limited to a single hazard.

3.3.5.5.2.2 Sign Classifications and Detailed Design

3.3.5.5.2.2.1 Class I (Danger)

a. These signs indicate immediate and grave danger, peril, or hazard capable of producing irreversible damage or injury, and prohibitions against harmful activities.

b. These signs shall have the word “DANGER” in white within a red oval outline with a white on black rectangle in the upper panel.

c. The lower panel, for additional wording, shall be in black or red on a white background.

3.3.5.5.2.2.2 Class II (Caution)

a. These signs are used to call attention to potential dangerous hazard capable of or resulting in severe but not irreversible injury or damage.

b. These signs shall have the signal word “CAUTION” in yellow on a black rectangle in the upper panel. The lower panel, for additional wording, shall be in black on a yellow background.

3.3.5.5.2.2.3 Class III (General Safety)

a. These signs include notice of general practice and rules relating to health, first aid, housekeeping, and general safety other than the two cases above.

b. These signs shall have the appropriate keyword in white on a green rectangle in the upper panel.

c. The lower panel, for additional wording, shall be in black or green on a white background.

3.3.5.5.2.2.4 Class IV (Fire and Emergency)

a. These signs shall be used only to label or point the way to fire extinguishing equipment, shutoffs, emergency switches, and emergency procedures.

b. These signs shall have the keyword in white on a red rectangle in the upper panel.

c. The lower panel, for additional wording, shall be in red on a white background.

3.3.5.5.2.3 Sign placement

a. Signs shall be placed to alert and inform personnel to avoid the hazard or to take appropriate action.

b. Signs shall be readable from a distance commensurate with a. above, create no additional distractions, or be hazards themselves.

c. DOT/FAA/CT-961 (FAA Human Factors Design Guide) shall be used for additional guidance for general label placement.

3.3.5.5.3 Marking of Radioactive Materials

The marking or labeling of commodities containing radioactive materials shall be in accordance with 10CFR20 (Energy, Nuclear Regulatory Commission, Part 20: Rules and Regulations Standards for Protection Against Radiation) and 29CFR1910.1096 (Occupational Safety and Health Administration, Department of Labor, Part 1910 – Occupational Safety and Health Standards, Ionizing Radiation).

3.3.5.5.4 Symbols

The following symbols shall be used as applicable:

a. Ionizing radiation hazard - ANSI N2.1 (Radiation Symbol).

b. Microwave and radio frequency radiation - OSHA 29CFR1910.97 (Non-ionizing Radiation), Figure G-11, Radio-Frequency Radiation Hazard Warning Symbol.

c. Laser symbol - 21CFR1910.

3.3.5.5.5 Alerts/Warnings

All warning displays shall provide the operator with a greater probability of detecting the alerts/warnings than normal observation of the equipment would, in the absence of the display.

3.3.5.5.5.1 Audio Warning Signals

An alarm/warning signal shall provide an audio level in at least one octave band between 200 and 5,000 Hertz such that the signal is at least 10 dB SPL (sound pressure level) above the ambient noise level, or 20 dB SPL above the amplitude of the masked threshold, or at such a level that assures personnel are adequately alerted to the danger or status so as to take the appropriate response, when measured within 1 foot of the responder's ear, or at more than 2 feet from the alarm. The warning should be no more than 30 dB above masked threshold to avoid disruption of verbal communication.

3.3.5.5.5.2 Display Warnings

a. Video display warnings shall be provided on equipment with associated video displays to warn operators of impending danger, to alert operators to critical system changes or equipment status, or to remind operators of a critical action which must be taken.

b. Display alert/warnings shall be designed to incorporate clearly discriminative features which distinguish the warning (color, blink, size, etc.) from other display information.

3.3.5.5.5.3 Battery Warning Label

Except for equipment requiring permanent battery installation, battery-powered equipment shall be labeled externally as follows:

WARNING
REMOVE
BATTERIES BEFORE
SHIPMENT OR INACTIVE STORAGE
OF 30 DAYS OF MORE

3.3.5.6 Hazardous and Restricted Materials

a. Assessment of the hazard potential of a substance and its decomposition products shall be performed prior to material selection.

b. The assessment shall include the relative toxicity of the substance (and decomposition products) as well as the nature of the potential exposure to personnel and equipment.

3.3.5.6.1 Carcinogens

Certain chemicals have been identified by the Occupational Safety and Health Administration (OSHA) as cancer-producing substances (carcinogens). Before using any materials which might contain these chemicals, they shall be evaluated in accordance with the 29CFR1990 (Occupational Safety and Health Administration, Department of Labor, Part 1990 – Identification, Classification, and Regulation of Potential Occupational Carcinogens).

3.3.5.6.2 Dusts, Mists, Fumes, and Gases

a. The materials installed in the equipment and under service conditions specified in the specific equipment specification shall not liberate gases which when combined with the atmosphere form an acid or corrosive alkali, nor shall they generate toxic or corrosive dusts, mists, or fumes which would be detrimental to the performance of the equipment or health of the equipment operators.

b. In addition to equipment operators, gases or fumes shall not be detrimental to plants, fish, or wildlife if vented to the outside.

c. The materials also shall not liberate gases, which will produce a flammable or explosive atmosphere.

3.3.5.6.3 Restricted Materials

Mercury and asbestos shall not be used.

3.3.5.6.4 Radioactive Materials

Use of radioactive materials shall conform to Nuclear Regulatory Commission Regulations and shall require approval of FAA. Radium shall not be used to achieve self-luminosity.

3.3.5.7 Seismic Safety

a. To ensure personnel safety during seismic events, all equipment/equipment enclosures shall meet the minimum life-safety seismic requirements. A primary life-safety concern is the adequacy of the anchoring/bracing system (load path).

b. The load path shall be sufficient to ensure that equipment/equipment enclosures (racks) can be securely mounted (installed) to the host facility's structure to prevent overturning or incidental displacement.

c. The equipment/equipment enclosures shall have the capacity to support the weight of all installed components and equipment without exhibiting immediate or catastrophic failure under seismic design category D (minimum) conditions using techniques of IBC 2000, in conjunction with the current version of FEMA 302, NEHRP Recommended Provisions for Seismic Regulations for New Buildings and Other Structures, Chapter 6.

d. For facilities located in regions located very close to major active faults, seismic design categories E or F shall be used as applicable.

e. All equipment and enclosures shall be designed and installed so that the enclosure and the mounted lowest replaceable unit (LRU) and/or components will remain upright and in place, and all access panels, doors, and drawers shall remain secured to the enclosure under the above conditions.

3.3.6 Human Engineering

General human engineering for design and development of electronics equipment shall be in accordance with this section and include the use of DOT/FAA/CT-961 (FAA Human Factors Design Guide) to establish human factors design goals while working with the appropriate User Teams or Community.

3.3.6.1 Noise Criteria Requirement

a. Noise generated, if not contained indoors, shall conform to local ordinances in accordance with 42 USC 4901 (The Noise Control Act of 1972).

b. Operational areas are those areas requiring frequent telephone or radio use or occasional direct oral communication at distances up to 1.5 M (5 feet). Equipment located in operational areas shall not exceed 55 dB(A) (Operations Centers, Control Rooms, Tower Cabs, Dynamic Simulation Rooms).

c. Equipment areas are those areas requiring occasional telephone use or occasional direct oral communications at distances up to 1.5 M (5 feet). Such areas may be either manned or unmanned. Equipment located in general work areas shall not exceed 65 dB(A) (Computer rooms, engineering areas, equipment rooms, telephone switching center).

d. Special areas or offices are those areas requiring no difficulty with direct oral communications. Equipment located in special areas shall not exceed 45 dB(A) (Conference rooms, Libraries, Administrative Offices, Training Classrooms).

e. Remote areas are those areas located away from operations. These areas are normally unmanned. High noise areas are those areas which exceed 65 dB(A). Equipment located in high noise/remote areas shall not exceed 85 dB(A).

3.3.6.1.1 Identification of Noise Hazard Areas and Equipment

a. Noise levels of greater than 85 dB(A) or impulse noise above 120 dB peak pressure level, regardless of exposure time, at operator or crew positions where one or more individuals will be located, including occasionally occupied positions, require that noise caution signs shall be permanently posted on the equipment.

b. Noise caution signs shall be clearly visible and legible to all personnel exposed to the hazard.

c. Operation and maintenance manuals shall address the requirements for hearing protection, type of hearing protection recommended, the noise level of the equipment and the distance at which the 85 dB(A) or 120 dB peak pressure level will be met.

3.3.6.2 Ergonomic Considerations

Design and installation of equipment shall accommodate the fifth through the ninety fifth percentile male and female user population as stated in DOT/FAA/CT-961.

3.3.6.3 Weight Lifting Limits

Weight lifting limits shall be in accordance with DOT/FAA/CT-961.

3.3.6.4 Visual Displays

Visual displays shall be capable of providing clear indication of equipment condition within the following room illumination levels:

a. Control Room – five (5) to 50 foot-candles.

b. Equipment Room – 50 to 100 foot-candles

c. Air Traffic Control Tower – five (5) to 6,000 foot-candles

3.3.6.4.1 Display Information

a. All information generated by the equipment shall be capable of display to an operator.

b. Information shall be limited to that which is necessary to perform specific actions or to make decisions and shall be selectable by the operator.

c. Numeric digital displays shall not be used as the only display of information when perception of pattern or variation is important to correct comprehension of the information.

d. Numeric digital displays shall not be used when rapid or slow digital display rates inhibit proper understanding.

3.3.6.4.2 Display Positive Feedback

a. Indication or status displays shall signify changes in functional status rather than changes in control input.

b. The absence of an indication on status displays shall not be used to indicate critical occurrences (i.e., indicates that the valve has actually closed and not that the button has been pushed or voltage applied).

3.3.6.4.3 Light-emitting Diodes (LED) Displays

a. LEDs may be used for transilluminated displays, including legend and simple indicator lights, and for matrix (alphanumeric) displays.

b. LED colors shall be chosen to conform with the following; green good, ok, on; yellow/amber warning, in use; red danger, error, off nominal.

3.3.6.4.4 Flash

a. Flashing shall be used only when it is necessary to call attention to some condition requiring immediate attention.

b. The flash rate shall be between three (3) and five (5) flashes per second with approximately equal on and off times.

c. Flashing indicators that could flash at the same time shall be synchronized so that they flash together.

3.3.6.5 Labeling

a. Labels, legends, placards, signs, tags, markings, or a combination of these shall be provided to identify, interpret, follow procedures, or avoid hazards.

b. Labels and information shall be oriented horizontally, placed near the items they identify, placed and grouped to avoid confusion, and placed in a consistent fashion.

c. Labels shall be brief, use words familiar to operators, be easily readable from distances expected with the equipment's use, not covered with tags or obscured by components, and have contrasting background color from the equipment.

d. Label characters shall conform to DOT/FAA/CT-961.

3.4 Documentation

Documentation supporting the equipment maintainability requirements shall be provided in accordance with the guidance provided in FAA-D-2494 regarding general requirements for technical instruction book manuscripts.

3.5 Personnel and Training

Personnel and training issues shall be considered in relation to the equipment utilization and maintainability requirements.

4 QUALITY ASSURANCE PROVISIONS

4.1 Quality System Requirements

Quality Assurance concepts shall be considered in all aspects of the acquisition process. A quality system shall be defined, implemented and maintained in accordance with the requirements of the appropriate ISO-9000 Quality Management and Quality Assurance Standards.

4.1.1 Material Evaluation

Material evaluations normally consist of certification by the manufacturer and are supported by verifying data that all materials which become part of the finished product are in accordance with the specified requirements.

4.1.2 Quality Conformance Evaluation

Quality conformance evaluations verify that the product/equipment is in accordance with the specified requirements.

Quality conformance evaluations may include, but not be limited to, visual inspections, and functional testing.

4.2 Verification/Compliance to Requirements

4.2.1 Requirements Verification Matrix

The requirements in section 3 shall be verified by demonstration, inspection, testing, or analysis as listed in Appendix IV, Requirements Verification Matrix. Certified documentation of previous activities may be an acceptable substitute for performing any of the verifications listed.

The following definitions apply to the table entries:

(1) Demonstration (denoted by “D” in table): Verifying the presence of a function or capability in an item by displaying the results of the function being performed. This activity is similar to testing, as it requires a formal procedure, but no quantitative data recorded.

(2) Inspection (denoted by “I” in the table): Verifying the required characteristics by means of observation. Observation includes seeing with the aid of tools that magnify.

(3) Test (denoted by “T” in table): Verifying the presence of a function or capability in an item by performing a formal procedure to collect quantitative data in a controlled environment.

(4) Analysis (denoted by “A” in the table): Verifying the presence of a function or capability in an item by examining the action performed using mathematical, physical, or chemical principles.

4.2.2 Classification of Tests

4.2.2.1 Design Qualification Tests

The following tests shall be performed on regular production equipment selected by the Government Representative:

a. Rating verification, parts and materials.

b. General specification tests.

c. Design qualification tests as required by the equipment specification.

4.2.2.1.1 Rating Verification of Parts and Materials

Measurements and/or calculations shall be made in order to establish that the parts and insulating materials used in the equipment will not be subjected to voltages, currents, power dissipation, and temperature in excess of the derated values permitted by applicable specification requirements and this specification.

All power supplies over 600 volts which are potted or encapsulated shall be subjected to a 48 hour heat run with all critical internal components instrumented to insure that proper temperature derating has been incorporated in the design.

The instrumented heat run shall be performed with the power supply operating in the equipment in its final configuration location.

4.2.2.1.2 General Specification Tests

Tests shall be performed once on regular production equipment.

4.2.2.2 Type Tests

Tests shall be performed on regular production equipment or systems in accordance with the requirements herein.

4.2.2.2.1 Type Test Equipment Selection

The equipment selection for type testing shall be in accordance with the contract schedule and/or the equipment specification.

In the absence of a specific contract schedule or the equipment specification, the following subparagraphs apply:

4.2.2.2.1.1 Identification

The equipment shall be assigned sequential numbers in order as they reach the stage of completion and readiness for testing. Using these sequential numbers, the equipment shall be divided into groups for type testing as shown in Table IV.

One type test shall be performed for each type test group. With the exception of Type Test No. 1, the FAA Quality representative shall select an item for type test.

Table IV. Type Test Equipment Selection

Production Quantity	TYPE -TEST GROUPS							
	I	II	III	IV	V	VI	VII	VIII
1-10	1							
11-25	1	2-10						
26-50	1	2-10	11-35					
51-75	1	2-10	11-35	36-60				
76-100	1	2-10	11-35	36-75				
101-150	1	2-10	11-50	51-100				
151-200	1	2-10	11-50	51-100	101-150			
201-300	1	2-10	11-50	51-100	101-150	151-200		
301-500	1	2-10	11-50	51-100	101-200	201-300	301-400	
501-700	1	2-10	11-50	51-100	101-200	201-300	301-400	401-600
701 & up	As specified in the procurement document.							

4.2.2.3 Production Tests

Production tests shall be performed in accordance with the Government approved test procedures.

4.2.2.4 FCC Type Acceptance and Registration Procedures

Where applicable, the first production equipment delivered to the government shall be subjected to the FCC type acceptance and registration procedures in accordance with 47CFR2 and 47CFR68.

The environmental temperature range specified by the FCC shall supersede, for the purposes of the FCC Type Acceptance Procedures, the service conditions temperature range which is applicable under this specification.

4.2.2.5 Fail-safe Demonstration Test

A fail-safe demonstration test shall be performed on a production article.

4.2.2.6 RMS Fail-soft Demonstration Test

An RMS fail-soft demonstration test shall be performed on a production article.

4.2.2.7 Maintainability Demonstration Tests

Maintainability demonstration tests shall be conducted as required.

Maintainability demonstration tests shall be performed on regular production equipment.

4.2.3 Normal Testing Conditions

Except for operating range testing, the equipment shall be tested under the normal operating range specified in Section 3.

4.2.3.1 Environmental Testing under Service Conditions

Design qualification tests and type tests to verify environmental requirements shall be done in accordance with MIL-STD-810F. The system specification shall define the specific tests to be done, tailored to the specific system requirements.

Unless changed by the system level specification, the following General Laboratory Test Method Guidelines, as described in section 5 of MIL-STD-810F, shall be followed.

5.1 Standard Ambient Test Conditions

5.2 Tolerances for Test Conditions

5.3.1 Suitability for Environment

5.3.2 Calibration

5.4 Stabilizing Test Temperature

5.4.1 Test Item Operating

5.4.2 Test Item non-operating

5.8.1 Installing the test item in the test facility.

5.8.2 Test item operation.

5.10 Information during Test.

5.11 Interrupted tests including 5.11.1, 5.11.2, 5.11.3

5.16 Water purity

5.18.1 Monitoring test chamber parameters

All other requirements of the aforementioned section 5 of MIL-STD-810F are specifically excluded.

4.2.3.2 Equipment Under Test

Equipment tested while operating shall be energized at the midpoint of the specified voltage input range and adjusted or tuned to the manufacturers specified standards. No further adjustment or tuning of the equipment shall be done during any single test.

When the equipment is tested with a series of tests the equipment shall be readjusted or retuned as necessary to the same parameter values used to begin the first test. The adjustment values for each parameter found necessary to readjust or retune shall be recorded each and every time it is necessary at the beginning of a test.

4.2.4 Test Equipment.

Instrument accuracy shall be a minimum of 10 times more accurate than the reading required accuracy.

When using analog meters, all readings shall be made within the upper 50 percent of the scale arc.

5 PREPARATION FOR DELIVERY

Requirements for packaging, packing, and marking for shipment shall be as specified in the equipment specification and will be in accordance with MIL-STD-2073/1D, (DOD Material Procedure for Development and Application of Packaging Requirements); MIL-STD-129, (Marking for Shipment and Storage); and ASTM-D-3951, (Standard Practices for Commercial Packaging).

Equipment shipped, stored, or transferred in geographic areas that exceed the non-operating temperatures stated in section 3.2.1.1.1.2 shall be packaged to withstand the environmental condition of the geographic area.

6 ACRONYMS AND DEFINITIONS

6.1 Acronyms and Abbreviations

The following list contains all approved contractions and acronyms used by the NAS for the purpose of the specification.

AC	Alternating Current
AIC	Ampere Interruption Capacity
ANSI	American National Standards Institute
ASCE	American Society of Civil Engineers
ASTM	American Society for Testing Materials
BIT	Built-in-Test
C	Celsius
CBEMA	Computer and Business Equipment Manufacturer's Association
CFR	Code of Federal Regulations
COTS	Commercial Off the Shelf
CRT	Cathode Ray Tube
DESC	Defense Electronics Supply Center
DISC	Defense Industrial Supply Center
dB	Decibel
dB(A)	decibel, A scale
DC	Direct Current
DOD	Department of Defense
EIA	Electronic Industries Alliance
EMI	Electromagnetic Interface
FAA	Federal Aviation Administration
FCC	Federal Communications Commission
FEMA	Federal Emergency Management Administration

GHz	Giga Hertz
HDBK	Handbook
Hz	Hertz
IBC	International Building Code
IEEE	Institute of Electrical and Electronics Engineers
ILS	Instrument Landing System
I	Current
IC	Integrated Circuit
I_N	Individual Current Harmonic Distortion
IPC	Institute for Interconnecting and Packaging Electronic Circuits
ITE	Information Technology Equipment
ITI	Information Technology Industry Council
ISO	International Organization for Standardization
kV	Kilovolt
LED	Light-emitting Diode
LRU	Lowest Replaceable Unit
M	meters
mA	milliamps
MIL	Military
MTTR	Mean Time To Repair
NAS	National Airspace System
NEHRP	National Earthquake Hazards Reduction Program
NEMA	National Electronic Manufacturers Association
NDI	Non-Developmental Items
NEC	National Electrical Code
NFPA	National Fire Protection Association
NTIA	National Telecommunications and Information Administration

NRTL	Nationally Recognized Testing Laboratory
OSHA	Occupational Safety and Health Act
PF	Power Factor
pF	Pico-farad
RAM	Read Access Memory
RF	Radio Frequency
RFI	Radio Frequency Interference
RMM	Remote Maintenance Monitoring
RMS	Remote Monitoring Subsystem
Sec	Second
STD	Standard
TC3	Technical Committee 3
THD	Total Harmonic Distortion
UL	Underwriters Laboratories, Inc.
USC	United States Code
V	Volts
VA	Volt Ampere
VSWR	Voltage Standing Wave Ratio
W	Watt

6.2 Definitions

6.2.1 Commercial-off-the-shelf (COTS)

Commercial-off –the-shelf is defined as any item other than real property that is of a type customarily used by the general public for non-governmental purposes, and that has been sold, leased, or licensed to the general public; is sold, leased, or licensed in substantial quantities in the commercial market place; and is offered to the Government without modification, in the same form in which it is sold, leased, or licensed in the commercial marketplace. Within this document, COTS is a subset of NDI.

6.2.2 Developmental item

An item of supply, not previously available, developed uniquely to meet the requirements (performance and otherwise) of a specific procurement contract and/or equipment specification.

6.2.3 Fail-safe

A failure does not adversely affect the safety of the NAS. This means that a failure in the equipment itself or in the equipment's monitoring capability shall cause the system to shut down if this failure would result in a safety hazard to the NAS user. This also means that a failure in the equipment shall not create a safety hazard to the personnel who maintain the equipment.

6.2.4 Fail-soft

A failure in the equipment reduces the operational capability of the equipment but does not degrade the safety of the NAS. For example, when the Remote Monitoring Subsystem (RMS) of an equipment fails, the operational capability to remotely monitor and control the equipment is lost, but the equipment continues to operate safely with the local monitoring system. When the primary transmitter of a category II or III Instrument Landing System (ILS) fails, the equipment continues to operate safely on the standby transmitter, but the operational category is reduced to category I.

6.2.5 Lowest Replaceable Units (LRUs)

An LRU is the lowest possible unit to be replaced within the system component during site level maintenance activities. It is a separate, installable physical package performing a single function or group of closely related functions.

6.2.6 Internal/building wiring

The electronic equipment electrical power interface to the building is shown in Figure 4. Building electrical wiring runs from the electronic equipment enclosure/cabinet to the building power source. Internal electrical wiring runs within the electronic equipment enclosure/cabinet. Electrical wiring connecting the electronic equipment enclosure/cabinet to a receptacle is considered internal wiring and not part of the building.

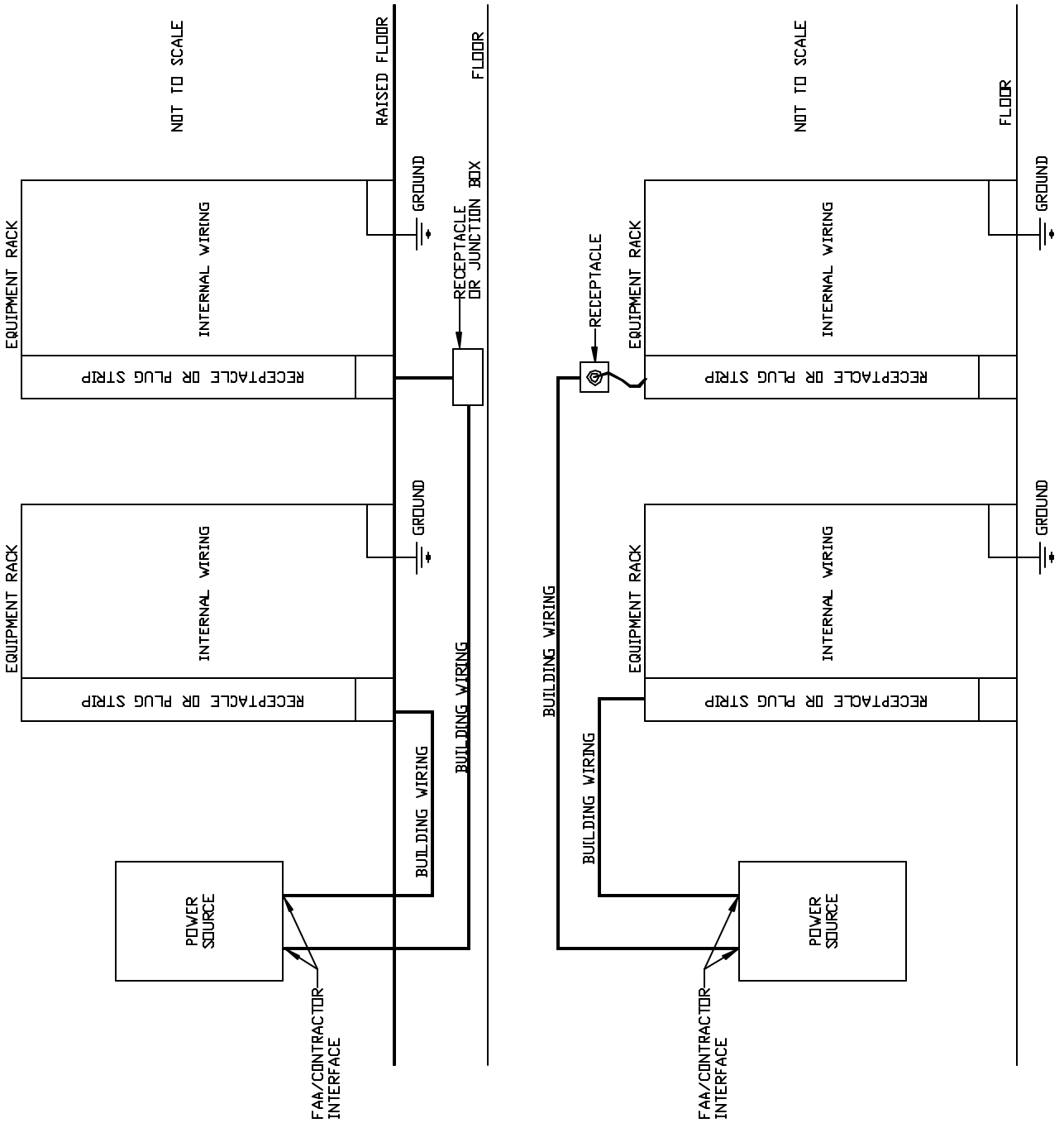


FIGURE 4. Internal/building Electrical Power Wiring Diagram

6.2.6 Modified COTS/commercial type product

COTS equipment that has been modified to meet functional requirements. Also means a commercial product (a) modified to meet some Government-peculiar requirement or addition or

(b) otherwise identified differently from its normal commercial counterparts. Within this document, modified COTS equipment is a subset of NDI.

6.2.7 Nationally Recognized Testing Laboratory (NRTL)

The term nationally recognized testing laboratory (NRTL) means an organization recognized by Occupational Safety and Health Act (OSHA) in accordance with Appendix A of Title 29 of the Code of Federal Regulations CFR Part 1910.7 (29CFR1910.7).

6.2.8 Non-developmental Item (NDI)

NDI equipment can be COTS, modified COTS, or previously developed. NDI shall be defined as any one of the following:

a. An item of supply that is available in the commercial marketplace (COTS).

b. A previously developed item of supply that is in use by a department or agency of the United States, a state or local government, or a foreign Government.

c. An item described above that requires only minor modification to meet the procuring agency's requirements. This includes modified COTS. Minor modifications are defined as modifications that do not adversely affect safety, durability, reliability, performance, interchangeability of parts or assemblies, maintainability, weight (where weight is significant), or any other significant objective of the end item.

d. An item currently being produced that does not meet the above requirements solely because it is not yet in use, or not available in the commercial marketplace.

6.2.9 Rack/Equipment

Rack/Equipment is defined as a single component (i.e. one processor), a rack of components, or multiple racks depending on the system being deployed.

6.2.10 Rack/Equipment Power Input Location

The Rack/Equipment power input location is at the power source input of the distribution panel circuit breaker feeding the Rack/Equipment. A system comprised of multiple racks/equipment will be distributed across multiple panels for balance, diversity, and redundancy.

6.2.11 Series Combination System Overcurrent

Two or more overcurrent protection devices wired in series and relied upon as a combination to provide overcurrent protection.

APPENDIX I

This appendix provides the requirements for voltage/time events tolerances as applied to 120V, 60 Hz, single-phase equipment. The ITI (CBEMA) curve contains the minimum requirements for all FAA electronic equipment. The application note provides the scope, applicability, and a discussion of the conditions considered in the ITI (CBEMA) curve. The FAA Input Power Tolerance envelope is provided for information and consideration as an alternative to the ITI (CBEMA) curve.

The FAA Input Power Tolerance Envelope provides an alternative to the ITI (CBEMA) curve for voltage/time events tolerances. This curve provides a more stringent requirement. Specifying the FAA curve has the potential to increase the availability of essential services and maintain availability during commercial power voltage/time events. A study of data from the Electric Power Research Institute's (EPRI) Distribution Power Quality survey has shown that availability can be increased from 0.999 to 0.99999+ and availability maintained during 94% of commercial power low voltage events. The FAA curve provides an additional safety factor during failures of power conditioning equipment.

The FAA curve is included in this appendix to encourage the evolution and migration of the FAA's electronic equipment to more robust tolerance of voltage/time events. Technical solutions to implement the requirements of the FAA curve exist and are becoming more common in the commercial market place. Costs for these solutions are also decreasing. As a starting point, the FAA curve should be considered for equipment and systems without uninterruptible power systems. The curve should also be considered for equipment or systems that are developed, NDI, or modified COTS.

ITI (CBEMA) CURVE APPLICATION NOTE

The ITI (CBEMA) Curve, included within this Application Note, is published by Technical Committee 3 (TC3) of the Information Technology Industry Council (ITI, formerly known as the Computer &Business Equipment Manufacturers Association). It is available at http://www.itic.org.technical/iticurv.pdf

1 Scope

The ITI (CBEMA) Curve and this Application Note describe an AC input voltage envelope which typically can be tolerated (no interruption in function) by most Information Technology Equipment (ITE). The Curve and this Application Note comprise a single document and are not to be considered separately from each other. They are not intended to serve as a design specification for products or AC distribution systems. The Curve and this Application Note describe both steady-state and transitory conditions.

2 Applicability

The Curve and this Application Note are applicable to 120V nominal voltages obtained from 120V, 208Y/120V, and 120/240V 60 Hz systems. Other nominal voltages and frequencies are not specifically considered and it is the responsibility of the user to determine the applicability of these documents for such conditions.

3 Discussion

This section provides a brief description of the individual conditions which are considered in the Curve. For all conditions, the term " voltage" implies an ideal condition of 120V RMS, 60Hz. Seven types of events are described in this composite envelope. Each event is briefly described in the following sections, with two similar line voltage sags being described under a single heading. Two regions outside the envelope are also noted. All conditions are assumed to be mutually exclusive at any point in time, and with the exception of steady-state tolerances, are assumed to commence from the nominal voltage. The timing between transients is assumed to be such that the ITE returns to equilibrium (electrical, mechanical, and thermal) prior to commencement of the next transient.

3.1 Steady-State Tolerances

The steady-state range describes an RMS voltage which is either very slowly varying or is constant. The subject range is +/-10% from the nominal voltage. Any voltages in this range may be present for an indefinite period, and are a function of normal loading and losses in the distribution system.

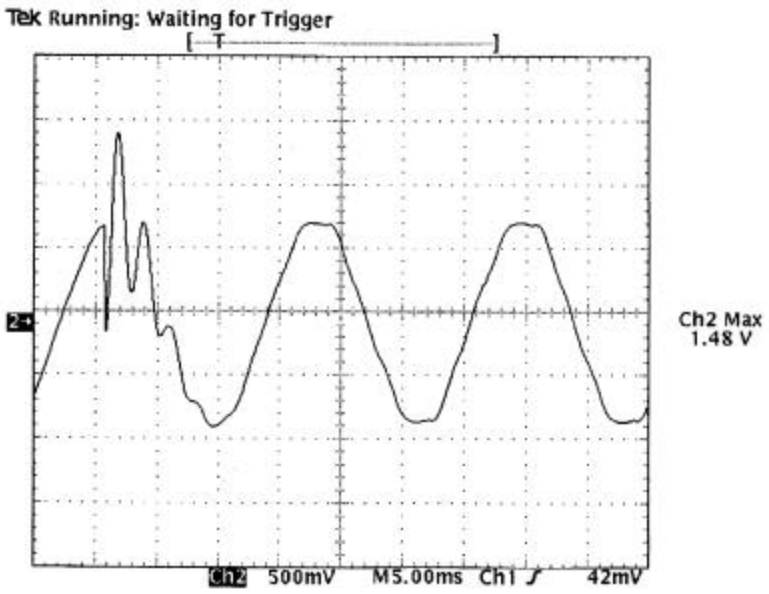
3.2 Line Voltage Swell

This region describes a voltage swell having an RMS amplitude of up to 120% of the RMS nominal voltage with a duration of up to 0.5 seconds. This transient may occur when large loads are removed from the system or when a voltage is supplied from sources other than the electrical utility.

3.3 Low-Frequency Decaying ringwave

This region describes a decaying ringwave transient which typically results from the connection of power factor correction capacitors to an AC distribution system. The frequency of this transient may range from 200 Hz to 5 kHz, depending upon the resonant frequency of the AC distribution system. The magnitude of the transient is expressed as a percentage of the *peak* 60 Hz nominal voltage (not RMS value). The transient is assumed to be completely decayed by the end of the half-cycle in which it occurs. The transient is assumed to occur near the peak of the nominal voltage waveform. The amplitude of the transient varies from 140% for 200 Hz ringwaves to 200% for 5 kHz ringwaves, with linear increase in amplitude with increasing frequency. Refer to Figure 1 for a typical waveform.

FIGURE 1



TYPICAL LOW FREQUENCY DECAYING RINGWAVE

3.4 High-Frequency Impulse and Ringwave

This region describes the transients which typically occur as a result of lightning strikes. Wave shapes applicable to this transient and general test conditions are described in ANSI/IEEE62.41-1991. This region of the curve deals with both amplitude and duration (energy), rather than RMS amplitude. The intent is to provide an 80 Joule minimum transient immunity.

3.5 Voltage Sags

Two different RMS voltage sags are described. Generally, these transients result from the application of heavy loads, as well as fault conditions, at various points in the AC distribution system. Sags to 80 % of the nominal (maximum deviation of 20%) are assumed to have a typical duration of up to 10 seconds, and sags to 70% of nominal (Maximum deviation of 30%) are assumed to have a duration of up to 0.5 seconds.

3.6 Dropout

A voltage dropout includes both severe RMS voltage sags and complete interruptions of applied voltage, followed by immediate re-application of the nominal voltage. The interruption may last up to 20 Milliseconds. This transient typically results from the occurrence and subsequent clearing of faults in the distribution system.

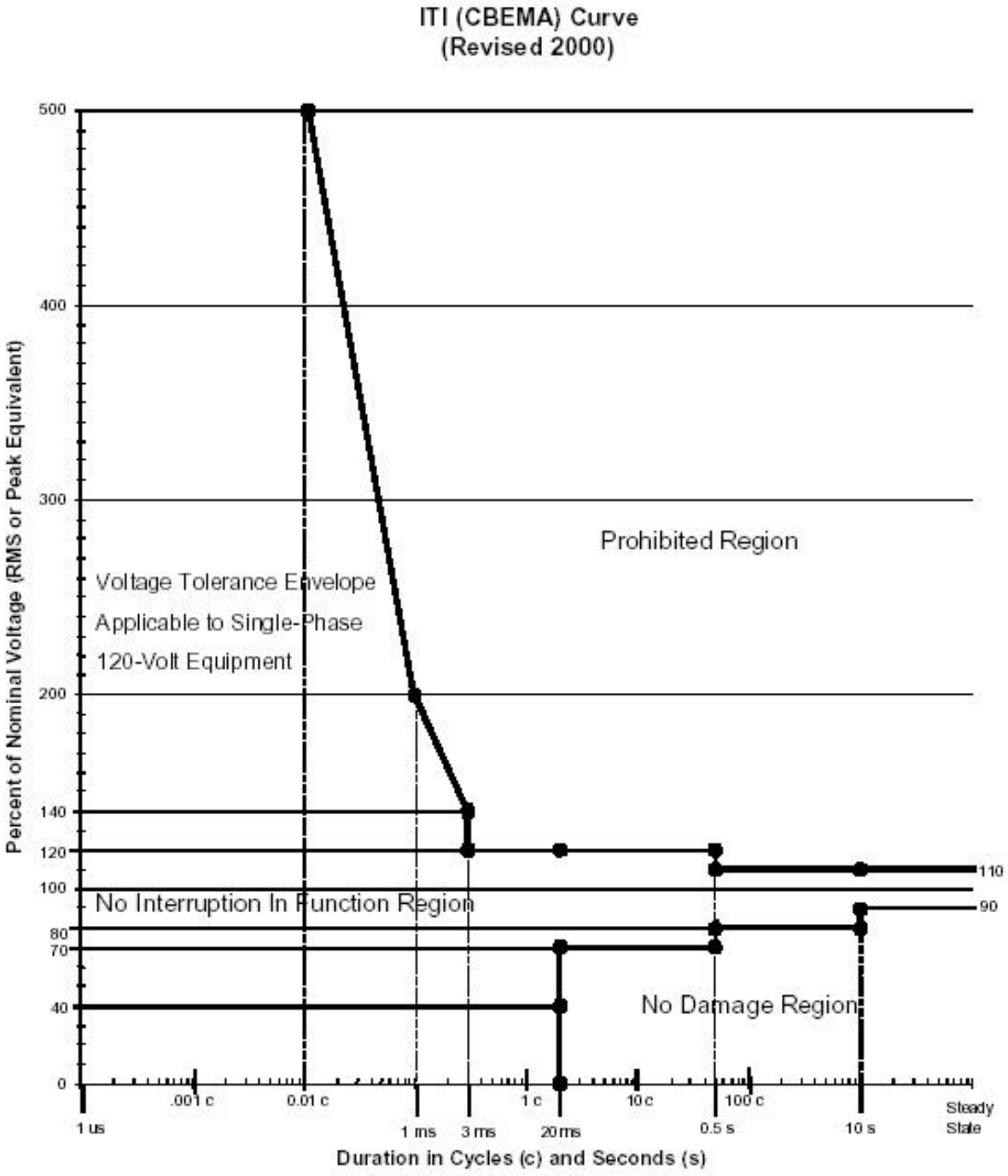
3.7 No-Damage Region

Events in this region include sags and dropouts which are more severe than those specified in the preceding paragraphs, and continuously applied voltages which are less than the lower limit of

the steady state tolerance range. The normal functional state of the ITE is not typically expected during these conditions, but no damage to the ITE should result.

3.8 Prohibited Region

This region includes any surge or swell which exceeds the upper limit of the boundary. If ITE is subjected to such conditions, damage to the ITE may result.



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202-737-8888
http://www.itic.org
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FAA Input Power Tolerance Envelope Application Notes.

SCOPE

This envelope is applicable to single phase, 120V nominal voltage equipment whose input power is obtained from 120V, 120/240V and 208/120V, 60 Hz systems. 120V nominal voltage implies an ideal sinusoidal voltage of $120V_{rms}$ value at 60 Hz. This envelope is not intended as a design specification for AC power systems.

The FAA Input Power Tolerance Envelope defines the input power voltage and time boundaries in which equipment shall have no loss of function. Loss of function includes, but is not limited to, loss of data, inability to communicate with other system components, need to reset or restart, and loss of control of controlled system components. The system level specification shall define the critical functions that shall not be lost.

DEFINITIONS

Distribution system as used herein means the system owned, operated, and maintained by utilities to furnish electrical power to the primary of transformers supplying electrical power to customers.

Site system as used herein means the system, owned, operated, and maintained by the customer to distribute electrical power within and throughout the customer's facility.

When system is used without being preceded by distribution or site it means the events can be caused by both distribution and site systems.

DISCUSSION

The boundaries of voltage-time events defined by this envelope provide protection from loss of function for 94% of the low voltage-time events that occur on the distribution systems of the electrical power network in the United States.

Steady state tolerances are considered as beginning at zero time and continuing indefinitely. The low voltage tolerance of 85% of nominal voltage shown beginning at one (1) second is a region caused by normal load changes on the distribution system and may include the intentional lowering of system voltage (a brownout) to avoid system overload. The high voltage tolerance of 110% of normal is the region resulting from such normal events as system load changes and transformation taps not being reset, or system voltage regulation.

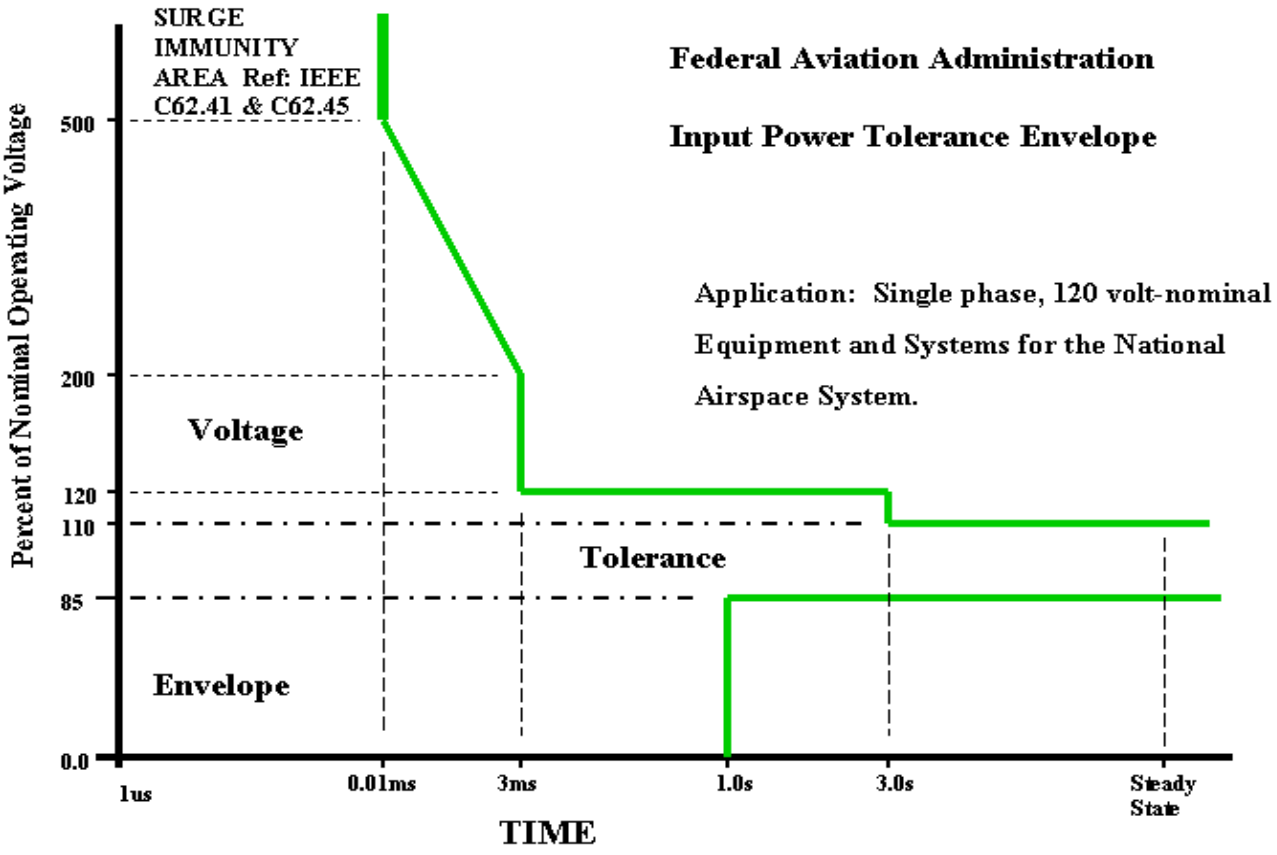
The high voltage event shown beginning at three milliseconds (3ms) and ending at three seconds (3.0s) is the result of either, or both, distribution system capacitor switching and voltage regulating change times.

The surge immunity area above 500% of nominal voltage is typically associated with lightning strikes. This area requires devices designed to both limit the voltage applied to the equipment and dissipate the energy associated with the event. ANSI/IEEE C62.41 and ANSI/IEEE C62.45 provide guidance and testing procedures for events in this region.

The area defined by the time of one microsecond (1us) to three milliseconds (3ms), voltage from zero (0) to 500% of nominal are best defined by IEEE Std 1100-1999 in sections 3.4.2, 3.4.3, and illustrated in Figure 3-9. Normal utility recloser switching produces low and zero voltage events in this area. Over voltage events in this area may occur at any time. These events may be caused by equipment connected to a site system as well as distribution system events.

The digital device is the most susceptible to short-term low voltage events. These devices are almost universally powered by a switching power supply. Energy storage, providing what the industry terms holdup time, may be accomplished on the input or the output side of the discrete device that transforms high voltage direct current to low voltage direct current.

When additional holdup time is provided on the discrete device output a slight increase in basic power supply size is required. This is an application of standard product change, not a design change.



APPENDIX II

GOVERNMENT DOCUMENTS

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

SPECIFICATIONS:

Federal

A-A-1419D	Filter Element, Air Conditioning (Viscous-Impingement and Dry Types, Replaceable)
W-C-596/12E	Connector, Receptacle, Electrical, General Purpose, Duplex, Hospital Grade Grounding, 2 Pole, 3 wire, 15 Amperes, 125 Volts, 50/60 Hertz
W-C-596/13C	Connector, Plug, Electrical, General Purpose, Hospital Grade Grounding, 2 Pole, 3 Wire, 15 Amperes, 125 Volts, 50/60 Hertz

Federal Aviation Administration

FAA-C-1217F	Electrical Work, Interior, February 1996
FAA-D-2494	Instruction Book Manuscript Technical: Equipment and Systems, Part 4

Military

MIL-T-152B(2)	Treatment, Moisture and Fungus-Resistant of Communications, Electronic and Associated Electrical Equipment

STANDARDS:

FAA

FAA-STD-001B-76	Color and Texture of Finishes for National Airspace System (NAS) Equipment, 1976
FAA-STD-019C	Lightning Protection, Grounding, Bonding and Shielding Requirements for Facilities, June 1999
FAA-STD-020B-92	Transient Protection, Grounding, Bonding and Shielding Requirements for Equipment
FAA-STD-032-96	Design Standards for National Airspace System (NAS) Physical Facilities
FAA-STD-049-94	Fiber Optics Standard for Telecommunications Systems and Equipment

Military

MIL-STD-129M Marking for Shipment and Storage, June 1993

MIL-STD-461E Requirements for the Control of Electromagnetic Interference Characteristics of Subsystems and Equipment

MIL-STD-810F DOD Test Method Standard for Environmental Engineering Considerations and Laboratory Tests

MIL-STD-889B(3) Dissimilar Metals

MIL-STD-2073-1D DOD Materiel, Procedures for Development and Application of Packaging Requirements

DRAWINGS:

DESC (Defense Electronics Supply Center)

87204 Connector Plug, Electrical, Midget Locking, Specific Purpose. General Grade, Grounding, 2 Pole, 3 Wire, 15 Amperes, 125 Volts, 50/60 Hertz (Female)

OTHER PUBLICATIONS:

FAA

DOT/FAA/CT-961 FAA Human Factors Design Guide, January 16, 1996

FEMA

FEMA 302 NEHRP Recommended Provisions for Seismic Regulations for New Buildings and Other Structures, Chapter 6

FEMA 356 Prestandard and Commentary for the Seismic Rehabilitation of Buildings, Chapter 11

United States Code

42 USC 4901 Noise Control Act of 1972

Code of Federal Regulations

Title 10 Nuclear Regulatory Commission Regulations, Part 20, Standards for Protection Against Radiation

Title 21 Food and Drug Administration Regulations, Department of Health and Human Services, Part 1000, General

Title 21 Food and Drug Administration Regulations, Department of Health and Human Services, Part 1040 - Performance Standards for Light-Emitting Products

Title 29	Occupational Safety and Health Administration Regulations, Parts 1900-1999
Title 47	Telecommunications, Federal Communications Commission, Part 2 Frequency Allocations and Radio Treaty Matters: General Rules and Regulations
Title 47	Telecommunications, Federal Communications Commission, Part 15, Radio Frequency Devices
Title 47	Telecommunications, Federal Communications Commission, Part 68 Connection of Terminal Equipment to the Telephone Network
Title 47	Telecommunications, Federal Communications Commission, Part 300, National Telecommunications and Information Administration Manual of Regulations and Procedures for Radio Frequency Management (NTIA Manual)

Handbooks

MIL-HDBK-251	Reliability/Design Thermal Applications
MIL-HDBK-1516	Unified Code for Coatings and Finishes for DOD Materiel

(Copies of specifications, standards, drawings, and publications should be obtained from the government program office or as directed by the contracting officer).

APPENDIX III

NON-GOVERNMENT DOCUMENTS

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

STANDARDS:

ANSI

ANSI J-STD-001B	Requirements for Soldered Electrical and Electronic Assemblies (1997)
ANSI N2.1-1989	Radiation Symbol
ANSI/NCSL Z540-1	Calibration -- Calibration Laboratories and Measuring and Test Equipment -- General Requirements (1994)
ANSI Z535.1-1998	Safety Color Code
ANSI/IEEE C95.1-1995	Standard for Safety Levels with Respect to Human Exposure to Radio Frequency Electromagnetic Field, 3 kHz to 300 GHz

(American National Standards Institute. Copies of ANSI standards can be obtained through Global Engineering Documents.)

ASCE

Manual 74	Guidelines for Electrical Transmission Line Structural Loading, 1991

ASTM

ASTMD295-94	Standard Test Methods for Varnished Cotton Fabrics Used for Electrical Insulation
ASTM B766-86	Standard Specification for Electrodeposited Coatings of Cadmium
ASTM D1868	Standard Test Method for Detection and Measurement of Partial Discharge (Corona) Pulses in Evaluation of Insulation Systems
ASTM D3951-98	Standard Practices for Commercial Packaging
ASTM D3955-99	Standard Specification for Electrical Insulating Varnishes

(American Society for Testing Materials. 100 Barr Harbor Drive, West Conshohocken, Pennsylvania, 19428-2959.)

EIA

EIA-310-D	Cabinets, Racks, Panels, and Associated Equipment

(Electronics Industry Association, 2001 Pennsylvania Avenue, N.W., Washington, D.C. 20006, TIA, EIA, JEDEC and Global Engineering Documents have joined forces in an agreement appointing Global as the primary distributor of TIA/EIA/JEDEC standards and related publications.)

IEEE

IEEE 100-1996	The New IEEE Standard Dictionary of Electrical and Electronics Terms
IEEE 141-1993	Recommended Practice for Electric Power Distribution for Industrial Plants (Red Book)
IEEE 200-1975	IEEE Standard Reference Designations for Electrical and Electronics Parts and Equipment (R1989)
IEEE 519-1993	Harmonic Control and Reactive Compensation of Static Power Converters, Guide for
IEEE C62.41-1991	Surge Voltages in Low-Voltage AC Power Circuits, Recommended Practice for
IEEE C62.45	IEEE Guide on Surge Testing for Equipment Connected to Low-Voltage AC Power Circuits
IEEE 1100-1999	Recommended Practice for Powering and Grounding Sensitive Electronic Equipment.

(IEEE Customer Service 445 Hoes Lane, PO Box 1331 Piscataway, NJ 08855-1331, USA.)

IPC

ANSI/IPC-A-610	Acceptability of Printed Board Assemblies
IPC-CM-770	Guidelines for Printed Board Component Mounting
ANSI/IPC-CM-780	Component Packaging and Interconnecting with Emphasis on Surface Mounting
ANSI/IPC CC-830	Electrical Insulating Compound for Printing Board Assemblies, Qualifications and Performance of -1984 (R1990)

(Institute for Interconnecting and Packaging Electronic Circuits (IPC), Dept. 77-3491 Chicago, IL 60678-3491).

IBC

IBC 2000 International Building Code 2000

(International Code Council, 5203 Leesburg Pike, Suite 600 Falls Church, VA 22041.)

ISO

ISO 9000 Quality Management and Quality Assurance Standards

(International Organization for Standardization (ISO) standards can be ordered through ANSI.)

NEMA

NEMA MG 1-1998 Motors and Generators, Revision 1

NEMA WD 6-96 Wiring Devices - Dimensional Requirements

NEMA 250 Enclosures for Electrical Equipment (1000 Volts Maximum)

(Purchasing NEMA Standards. Global Engineering Documents (Global) and Information Handling Services (IHS) handles the sale of NEMA standards and many other publications.)

NFPA

NFPA 70 National Electrical Code

(National Fire Protection Association, One Batterymarch Park, PO Box 9101, Quincy, MA 02269-9101.)

UL

UL62-97 Flexible Cord and Fixture Wire

UL489-96 Molded-Case Circuit Breakers, Molded-Case Switches, and Circuit-Breaker Enclosures

UL943-93 Ground-Fault Circuit Interrupters

UL 1418-92 Cathode-Ray Tubes

UL 1449-96 Transient Voltage Surge Suppressors

UL 1950-98 Safety of Information Technology Equipment Including Electrical Business Equipment

(Underwriters Laboratories, Inc., Publications Stock. 333 Pfingsten Road, Northbrook, IL 60062-2096. Contact Global Engineering Documents to purchase UL standards at: Global Engineering Documents, 15 Inverness Way East, Sales - C303B Englewood, CO 80112-9649).

APPENDIX IV.

Requirements Verification Matrix		
Requirement	**Paragraph Number**	**Verification Method**
Requirements	3.	N/A
General	3.1	N/A
Electrical Power	3.1.1	N/A
Internal wiring to meet section 3.3.1.3.10	3.1.1.a.	N/A
Interface wiring	3.1.1.b.	I
Electrical enclosures meet NRTL	3.1.1.c.	I
Physical requirements	3.1.1.1	N/A
Physical construction	3.1.1.1.1	N/A
Accessibility for use of equipment	3.1.1.1.1 a.(1)	I,D
Access comply with Section 3.1.2.4	3.1.1.1.1.a.(2)	N/A
Front panel controls and indicators	3.1.1.1.1 b.(1)	I
Disconnection by cord	3.1.1.1.1.b.(2)	D
Plugs and receptacles conform to W-C-596	3.1.1.1.1 c.	I
Power cords conform to UL62	3.1.1.1.1 d	I
125v, 15A detachable power cords	3.1.1.1.1e	I
Plug in accordance with W-C-596/100a	3.1.1.1.1 e.(1)	I
Female plug in accordance with DESC 87204	3.1.1.1.1.e.(2)	I
Convenience outlets	3.1.1.1.1.f	I
Test equipment outlets IAW W-C-596/12-3	3.1.1.1.1g	I
Electrical Power Measurements	3.1.1.2.	N/A
Measurement at power input source	3.1.1.2.a.	T
Measure at distribution feeder breaker	3.1.1.2.b.	T
Measure at Input breaker for system level test	3.1.1.2.c.	T
Load power characteristics	3.1.1.3	N/A
Power factor	3.1.1.3.1 a., b., c., d.	T
Inrush current	3.1.1.3.2 a., b., c., d, e, f, g	T/I
Measured within 10 degrees of peak	3.1.1.3.2 a.	T
RMS Current values used	3.1.1.3.2 b.	T
Test voltage source 5X load rating of device	3.1.1.3.2 c.	T
Use cord provided to connect to voltage source	3.1.1.3.2 d.	T
RMS current loads up to 40 Amps	3.1.1.3.2 e.	T
RMS current loads over 40 Amps	3.1.1.3.2 f.	T
RMS Loads over 80 Amps	3.1.1.3.2 g.	T
Electrical load balance – 3 phase equipment	3.1.1.4	T
Harmonics	3.1.1.5	N/A
Harmonics, individual	3.1.1.5.a.	T
Harmonics, 40 KW total	3.1.1.5.b.	T
Circuit Overload protection	3.1.1.6	N/A
Overload protection	3.1.1.6.a.	D
Protection by fuses, circuit breakers, etc	3.1.1.6.a.(1)	I,T

Requirements Verification Matrix		
Requirement	**Paragraph Number**	**Verification Method**
10000 AIC rating	3.1.1.6.a.(2)	I
Loss of one or more phases	3.1.1.6.b.	T/D
Overcurrent device selective fault isolation	3.1.1.6.c.	T
Available fault current calculation	3.1.1.6.d.	A
No series combination protection	3.1.1.6.e.	A
Transient protection	3.1.1.6.f.	T
Input power conditions	3.1.1.7	N/A
Voltage	3.1.1.7.a.	T
Voltage unbalance	3.1.1.7.b.	T
Frequency, steady state	3.1.1.7.c.(1)(a)	T
Frequency, rate of change	3.1.1.7.c.(1)(b).	T
Frequency, steady state variation	3.1.1.7.c.(1)(c)	T
Frequency, momentary variations	3.1.1.7.c.(2)(a)	T
Frequency, momentary rate of change	3.1.1.7.c.(2)(b)	T
Voltage Harmonic Distortion	3.1.1.7.d	N/A
10% Voltage total harmonic distortion	3.1.1.7.d. (1)	T
3% any one harmonic	3.1.1.7.d. (2)	T
Voltage/time events	3.1.1.7.e.	T
120v single phase, Voltage/time events	3.1.1.7.f.	N/A
ITI (CBEMA) Curve (20 ms)	3.1.1.7.f (1)	T
FAA Power Input Tolerance Envelope (1 sec.)	3.1.1.7.f (2)	T
Performance upon fault condition on radio frequency equipment	3.1.1.8	N/A
RF output circuit protection	3.1.1.8.a.	D
RF output short circuit survivability	3.1.1.8.b.	D
Transmitter shutdown	3.1.1.8.c.	D
Grounding and bonding	3.1.1.9	N/A
Ground type selection	3.1.1.9.a.	I,A
Shielding and bonding	3.1.1.9.b.	I
Rack mounted equipment	3.1.1.9.c.	I
Grounding straps on doors	3.1.1.9.d.	I
Isolated ground receptacles	3.1.1.9.e.	T
Resistance to ground	3.1.1.9.f.	T
Corona prevention (High voltage/high current)	3.1.1.10	N/A
EMI compatibility requirement	3.1.1.10.a.(1)	T
Corona degradation of material	3.1.1.10.a.(2)	T
Corona extinction voltage >150% peak circuit voltage	3.1.1.10.a.(3)	T
Corona inception and extinction voltages conform to ASTM D1868	3.1.1.10.a.(4)	T
Corona no sharp edges or points	3.1.1.10.a.(5)	I
Electrical breakdown	3.1.1.10.b.(1)	T
Breakdown prevention methods	3.1.1.10.b.(2)	I
Transformer Isolation, DC Power Supplies	3.1.1.11	N/A
Isolated from AC line	3.1.1.11.a.	I
DC resistance greater than 1 megohm	3.1.1.11.b.	T

Requirements Verification Matrix		
Requirement	**Paragraph Number**	**Verification Method**
Mechanical	3.1.2	N/A
Removable parts and mating connectors	3.1.2.1	N/A
All parts in place	3.1.2.1 a.	I
Parts packing	3.1.2.1 b.	I
Mating connectors provided	3.1.2.1 c.	I
Mating connectors (interconnection required)	3.1.2.1 d.	I
Circuit card guides retain card	3.1.2.1.e.	D
Installation - No special tools	3.1.2.2	D
Construction	3.1.2.3	N/A
No fixed part comes loose	3.1.2.3.a.	D
Floor-loading not to exceed 125 pounds per square feet	3.1.2.3.b.	T,A
Floor loading may exceed 125 pounds per square foot if supported	3.1.2.3.c.	A, I
Equipment Racks	3.1.2.3.1	N/A
Pullout drawers	3.1.2.3.1.1	N/A
Full suspension rollout drawers	3.1.2.3.1.1.a.	I, D
Rigid slides	3.1.2.3.1.1.b.	I,D
Drawer handles and latches	3.1.2.3.1.1.c.	I,D
Cabinet shall not tip over	3.1.2.3.1.1.d.	D
Rack panels	3.1.2.3.1.2	N/A
ANSI/EIA 310 Rack Panels	3.1.2.3.1.2.a.	I
Universal spacing of panel slot/holes	3.1.2.3.1.2.b.	I
3/16 in. aluminum panel thickness	3.1.2.3.1.2.c.	I
1/8 in. steel panel thickness	3.1.2.3.1.2.d.	I
Shelf-life	3.1.2.3.2	A
Moisture	3.1.2.3.3	N/A
No moisture collection	3.1.2.3.3.a.	D
Drain holes	3.1.2.3.3.b.	I
MTTR includes moisture removal time	3.1.2.3.3.c.	A
Windows	3.1.2.3.4	N/A
Shatterproof windows	3.1.2.3.4.a.	T
Windows do not move	3.1.2.3.4.b.	D
Adhesives approved by FAA	3.1.2.3.4.c.	I,D
Accessibility	3.1.2.4	N/A
General	3.1.2.4.1	N/A
Equipment design	3.1.2.4.1.a.	A,D
Captive fasteners on non-hinged shields/plates	3.1.2.4.1.b.	I
Captive fastener placement	3.1.2.4.1.c.	I
Connections to parts inside removable container	3.1.2.4.2	D
Lowest Replaceable Units (LRUs)	3.1.2.4.3	N/A
LRU shall be replaceable and removable	3.1.2.4.3.a.	D
No permanent type fasteners	3.1.2.4.3.b.	D
LRU removal and replacement without damage	3.1.2.4.3.c.	D
Fit only in correct slot	3.1.2.4.3.d.	D

Requirements Verification Matrix		
Requirement	**Paragraph Number**	**Verification Method**
Enclosures	3.1.2.4.4	N/A
No combustion exceeding NEMA 250	3.1.2.4.4.a.	D
NEMA Type 4 or 4X outdoor enclosures	3.1.2.4.4.b.	D
NEMA Type 12 or 13 indoor enclosures	3.1.2.4.4.c.	D
NEMA Type 1 indoor enclosures	3.1.2.4.4.d.	I
NEMA Type 7 indoor enclosures	3.1.2.4.4.e.	D
NEMA Type 8 indoor enclosures	3.1.2.4.4.f.	D
NEMA Type 9 indoor enclosures	3.1.2.4.4.g	D
Accessibility to parts	3.1.2.4.4.h	D
Mounting parts on movable slides/doors	3.1.2.4.4.i	D
Locks	3.1.2.4.4.j.	D
Withdrawal slides	3.1.2.4.4.k.	D
Front or rear access to parts	3.1.2.4.4.l.	D,I
Guide pins for mechanical alignment	3.1.2.4.4.m.	D
Thermal Design	3.1.2.5	N/A
Operates in operating environment	3.1.2.5.a.	T
Air filters with forced air cooling	3.1.2.5.b.	I
Cabinet temperature rise <15 deg C	3.1.2.5.c.	T
EMI integrity of ventilation openings	3.1.2.5.d.	T
Exhaust air directed away from personnel	3.1.2.5.e.	D
Forbidden cooling methods	3.1.2.5.f.	I
Visual and aural warning	3.1.2.5.g.	D
Damage from forced air cooling failure	3.1.2.5.h	D
Equipment software/firmware	3.1.3	D
Characteristics	3.2	N/A
Environmental conditions	3.2.1	N/A
Operating conditions	3.2.1.1	N/A
Seismic Zone Design	3.2.1.1.1	N/A
IBC 2000 Design Category D	3.2.1.1.1.a	D
Enclosures designed to remain upright	3.2.1.1.1.b	D
Design performed by registered professional	3.2.1.1.1.c	D
Outdoor operating environment	3.2.1.1.2.	T
Elevation	3.2.1.1.2.a	T
Wind	3.2.1.1.2.b	T
Ice Loading	3.2.1.1.2.c	T
Temperature, Humidity	3.2.1.1.2.d	T
Climatic Categories of MIL STD 810f	3.2.1.1.2.e	D,A
Indoor Operating Environment	3.2.1.1.3	N/A
Elevation	3.2.1.1.3.a	T
Temperature, Humidity	3.2.1.1.3.b	T
Temperature, Humidity in unattended facilities	3.2.1.1.3.c	T
SLS define operating environment	3.2.1.1.3.d	N/A
Non-operating environmental conditions	3.2.1.2 (a), (b), (c)	T

Requirements Verification Matrix		
Requirement	**Paragraph Number**	**Verification Method**
Physical characteristics	3.2.2	N/A
Electronic equipment assembly requirements	3.2.2.1	I,T
Component mounting	3.2.2.1.1	I
Printed boards	3.2.2.1.2	I,T
Assembly	3.2.2.1.3	I,T
Wire wrap	3.2.2.2	I
Reliability	3.2.3	T,A
Maintainability	3.2.4	D
Routine servicing and maintenance	3.2.4.a.	I,D
Functional stability of displaced parts	3.2.4.b.	D
No soldering when removing chassis	3.2.4.c.	D
Air filter replacement	3.2.4.d.	D
Automatic return to normal operation after restoration of power	3.2.4.e.	D
BIT equipment stability	3.2.4.f.	T
Access points	3.2.4.g.	T
Test points not located next to 300 volts	3.2.4.h.	I
No personnel shock hazard	3.2.4.i.	I
No damage from grounding test points	3.2.4.j.	D
BIT failures do not impact operational functions	3.2.4.k.	D
Accessible test points on plug-in circuit cards	3.2.4.l.	D
External equipment interfaces	3.2.5	D
Electrostatic discharge	3.2.6	N/A
Non-operating state	3.2.6.a.	T
Operating state	3.2.6.b.	T
Transportability	3.2.7	D,I
Equipment design and construction	3.3	N/A
Materials, processes, and parts	3.3.1	N/A
Materials	3.3.1.1	N/A
Dissimilar metals	3.3.1.1.1.a.	I
Environmental isolation of dissimilar metals	3.3.1.1.1.b.	I
Metals, corrosion and resistance	3.3.1.1.2	N/A
Corrosion resistant coating	3.3.1.1.2.a.	A,I
Materials and processes for metallic parts	3.3.1.1.2.b.	I
Corrosion resistant coating selection	3.3.1.1.2.c.	I
Non-corrosion resistant steel alloys	3.3.1.1.2.d.	I
Corrosion-resisting ferrous alloys	3.3.1.1.2.1	N/A
Use of austenitic corrosion-resisting steel	3.3.1.1.2.1.a.	I
Passivation treatment of corrosion-resistant steels	3.3.1.1.2.1.b.	I
Other protective finishes	3.3.1.1.2.1.c.	I
Flammable materials	3.3.1.1.3	A,T
Additives	3.3.1.1.3.1	N/A
Fire retardant additives	3.3.1.1.3.1.a.	A,I
Permanence of fire deterrence additives	3.3.1.1.3.1.b.	A

Requirements Verification Matrix		
Requirement	**Paragraph Number**	**Verification Method**
Equipment manufacturing processes	3.3.1.2	N/A
Strain relief	3.3.1.2.1	I
Painted finish on metal surfaces	3.3.1.2.2.a.	I
Environmental characteristics of painted surfaces	3.3.1.2.2.b.	A
Paint finish iaw FAA-STD-001	3.3.1.2.2.c.	I
Hazardous contents in paints	3.3.1.2.2.d.	A
Cadmium plating	3.3.1.2.3	N/A
Use of cadmium plating	3.3.1.2.3.a.	I
Cadmium on surfaces subject to frictional wear	3.3.1.2.3.b.	I
Plating to be in accordance with ASTM B766	3.3.1.2.3.c.	I
Cadmium plating of bolts, nuts, etc	3.3.1.2.3.c.(1)	I
Cadmium plating of limited tolerance items	3.3.1.2.3.c.(2)	I
Cadmium plating of areas where controlled deposit cannot be	3.3.1.2.3.c.(3)	I
Use of lubricants on cadmium plated parts	3.3.1.2.3.c.(4)	I
Electrical parts	3.3.1.3	N/A
Batteries	3.3.1.3.1	N/A
Not to be used unless required by SLS	3.3.1.3.1	N/A
Battery defined as secondary or back-up source	3.3.1.3.1.a.	N/A
Batteries comply with industry standard	3.3.1.3.1.b.	I
Two year battery life	3.3.1.3.1.b.(1)	A
Battery replacement in less than 30 min.	3.3.1.3.1.b.(2)	D
Battery back-up time as specified in SLS	3.3.1.3.1.b.(3)	T,D
Battery not leak	3.3.1.3.1.b.(4)	D
Battery compartments	3.3.1.3.1.c.	N/A
Battery compartment secure battery	3.3.1.3.1.c.(1)	I
Battery compartment access	3.3.1.3.1.c.(2)	D
Prevent build-up of heat, gases, liquids, chemicals	3.3.1.3.1.c.(3)	D
Heat, gases, liquids, chemicals avoid electronic compartment	3.3.1.3.1.c.(4)	D
Exclusion for battery compartment	3.3.1.3.1.d.	I
Battery compartment markings	3.3.1.3.1.e	I
Circuit breakers	3.3.1.3.2	N/A
Selection and application	3.3.1.3.2.1	N/A
Circuit breaker selection	3.3.1.3.2.1.a.	A
Circuit breaker conform to UL 489	3.3.1.3.2.1.b.	I
Circuit breakers instantaneous tripping	3.3.1.3.2.1.c.	A,D
Circuit breaker trip/switching mechanism	3.3.1.3.2.1.d.	D
Circuit breaker manual operation	3.3.1.3.2.1.e.	I
Circuit breaker use as switch prohibited	3.3.1.3.2.1.f.	D,I
Circuit breaker status indication	3.3.1.3.2.1.g.	I
Coordination with power system breakers	3.3.1.3.2.1.h.	I
Continuous overcurrent protection	3.3.1.3.2.1.i.	I,D
Circuit breakers are full size units	3.3.1.3.2.1.j.	I
Permanent marking for Ampere rating	3.3.1.3.2.1.k.	I

Requirements Verification Matrix		
Requirement	**Paragraph Number**	**Verification Method**
Standard trip curve circuit breakers	3.3.1.3.2.1.l.	I
Circuit breakers in UL approved equipment	3.3.1.3.2.1.m.	I
No circuit breaker functioning as thermal overload relay	3.3.1.3.2.1.n.	A,D
Electrical connectors – Environmental compatibility of connectors	3.3.1.3.3	A
Selection	3.3.1.3.3.1	N/A
Connector UL listed	3.3.1.3.3.1.a	I
Consideration of intended use connector data in specification sheets	3.3.1.3.3.1.b	A
Connector maintenance tools	3.3.1.3.3.1.c	I
FAA tool list	3.3.1.3.3.1.c.(1)	I
Connectors with thermocouple contacts	3.3.1.3.3.2	N/A
Thermocouple connector identifiers	3.3.1.3.3.2.a.(1)&(2)	I
Thermocouple marker location	3.3.1.3.3.2.b	I
Thermocouple material identifiers	3.3.1.3.3.2.c	I
Power connectors	3.3.1.3.3.3	N/A
NEMA power connectors	3.3.1.3.3.3.a	I
Polarized power connectors	3.3.1.3.3.3.b	I,D
Protective measures	3.3.1.3.3.4	N/A
Dust caps on unmated connectors	3.3.1.3.3.4.a	I
Moisture and vapor proof caps on live connectors	3.3.1.3.3.4.b	I
Protective caps linked to equipment	3.3.1.3.3.4.c.	I
Fuses, fuse holders, and associated hardware	3.3.1.3.4	N/A
Selection	3.3.1.3.4.1	N/A
Branch circuits open before main circuit	3.3.1.3.4.1.a.	D
Fuses as thermal overload devices	3.3.1.3.4.1.b.	A,I
Fuse rating compatible with currents encountered	3.3.1.3.4.1.c.	D
Fuses replaceable within 5 min.	3.3.1.3.4.1.d.	D
Extractor post type fuse holders	3.3.1.3.4.1.e.	I
Interrupting capacity of 10000Amps	3.3.1.3.4.1.f	D,I
Indicating meters IAW applicable standards	3.3.1.3.5	N/A
Meter accuracy no less than 10%	3.3.1.3.5. a	I,T
Analog meters indicate in upper half of scale	3.3.1.3.5.a (1)	I
Digital meters indicate in center of scale	3.3.1.3.5.a (2)	I
Calibration meters 10 times more accurate	3.3.1.3.5. b	I
Printed wiring board modifications	3.3.1.3.6	I
Conformal coating of PCB	3.3.1.3.7	N/A
When in extreme environmental conditions	3.3.1.3.7.a.	I
ANSI/IPC CC-830 coating	3.3.1.3.7.b.	I
Electromagnetic shielding	3.3.1.3.8	N/A
Shield sensitive devices	3.3.1.3.8.a.	I
Effectiveness of EMI shielding	3.3.1.3.8.b.	T
Shielding in accordance with FAA-STD-020	3.3.1.3.8.c.	I
Switches maintain indicated state	3.3.1.3.9	D
Wiring	3.3.1.3.10	N/A

Requirements Verification Matrix		
Requirement	**Paragraph Number**	**Verification Method**
Clearance and leakage (creepage) distances	3.3.1.3.10.1	I
Marking/labeling	3.3.1.3.10.2	N/A
Signal, control and power wiring	3.3.1.3.10.2.a.	I
Marking locations	3.3.1.3.10.2.b.	I
Wiring protection	3.3.1.3.10.3	N/A
Chafing protection	3.3.1.3.10.3.a.	I
Cable retractors near pull-out drawers	3.3.1.3.10.3.b.	I
Cable clamps	3.3.1.3.10.3.c.	I
Insulation cold flow	3.3.1.3.10.4	I
Cable ducts	3.3.1.3.10.5	I
Bend radius	3.3.1.3.10.6	I
Sleeving	3.3.1.3.10.7	N/A
Type sleeving used	3.3.1.3.10.7.a.	I
Sleeving secured	3.3.1.3.10.7.b.	I
Cable anchored and formed	3.3.1.3.10.7.c.	I
Additional protection where abrasion not avoidable	3.3.1.3.10.7.d.	I
Panel door cables	3.3.1.3.10.8	N/A
Minimum flexible wiring on hinged doors	3.3.1.3.10.8.a.	I
Cable arrangement for maintenance	3.3.1.3.10.8.b.	I
Through hole protection	3.3.1.3.10.9	N/A
Thin bulkhead (<1/8 in.)	3.3.1.3.10.9.a.	I
Thick bulkhead (>1/8 in.)	3.3.1.3.10.9.b.	I
Grommet for wires carrying RF above 500 VRMS	3.3.1.3.10.9.c.	I
Grommet exceptions in clearance areas	3.3.1.3.10.9.d.	I
Wiring arrangement	3.3.1.3.10.10	N/A
Wiring arranged for maintenance and access	3.3.1.3.10.10.a.	I
Placement of wire bundles	3.3.1.3.10.10.b.	I
Compatibility of lacing, etc. with cable jackets	3.3.1.3.10.10.c.	I
Wiring arranged for bundles or cable ducts	3.3.1.3.10.10.d.	I
Slack	3.3.1.3.10.11	I
Prevent cable stress	3.3.1.3.10.11.a.	I
Enable parts to be moved during maintenance	3.3.1.3.10.11.b.	I
Facilitate field repair of broken wiring	3.3.1.3.10.11.c.	I
Opening slide out drawers and racks	3.3.1.3.10.11.d.	D
Maintain bend radii when drawers and slides are fully open	3.3.1.3.10.11.e.	I
Bend radii for flat cable	3.3.1.3.10.11.f.	I
Ensure movement of cables and connections intended to move	3.3.1.3.10.11.g.	I
Exception for RF leads	3.3.1.3.10.11.h	I
Wiring in terminal boxes	3.3.1.3.10.12	I
Entrance cable and wiring	3.3.1.3.10.13	I
Wire	3.3.1.3.10.14	N/A
Stranded wire is preferred	3.3.1.3.10.14.a.	I
Uninterrupted wire is preferred	3.3.1.3.10.14.b.	I

Requirements Verification Matrix		
Requirement	**Paragraph Number**	**Verification Method**
Support	3.3.1.3.10.15	N/A
Cable and wire supported to avoid undue stress and motion	3.3.1.3.10.15.a.	I
Ensure separation of unprotected wiring	3.3.1.3.10.15.b.	I
No twine or tape	3.3.1.3.10.15.c.	I
Connectors, insulation sleeving UL listed	3.3.1.3.10.16	I
Fungus protection	3.3.1.3.10.17	N/A
In accordance with system level specification	3.3.1.3.10.17.a.	A,I
Cable-end fungus treatment	3.3.1.3.10.17.b.	I
Aluminum conductors	3.3.1.3.10.18	I
Termination of signal and control wiring	3.3.1.3.10.19	I
Fiber optics	3.3.1.3.10.20	I
Raised floor cabling	3.3.1.3.10.21	I
Mechanical parts	3.3.1.4	N/A
Bearings	3.3.1.4.1	N/A
Bearing Lubricant	3.3.1.4.1.1	N/A
Provide lubricant	3.3.1.4.1.1.a.	I
Lubricant replenishment	3.3.1.4.1.1.b.	I
Preservative coating	3.3.1.4.1.1.c.	I
Seals and shields	3.3.1.4.1.2	I
Self lubricating bearings	3.3.1.4.1.3	I
Unlubricated bearings	3.3.1.4.1.4	I
Electrical grounding	3.3.1.4.1.5	I
Alignment	3.3.1.4.1.6	I
Controls and switches	3.3.1.4.2	D,I
Direction of Movement	3.3.1.4.2.1	N/A
Direction of movement	3.3.1.4.2.1.a.	D
Response to movement	3.3.1.4.2.1.b.	D
Operating controls	3.3.1.4.2.2	I
Adjustment controls	3.3.1.4.2.3	N/A
Alignment and calibration control locations	3.3.1.4.2.3.a.	I
Use of common screwdriver adjustment	3.3.1.4.2.3.b.	I
Long term adjustment location	3.3.1.4.2.3.c.	I
Adjustment range	3.3.1.4.2.3.d.	I
Operation	3.3.1.4.2.4	N/A
Play and backlash in controls	3.3.1.4.2.4.a.	D
Operates freely and without binding	3.3.1.4.2.4.b.	D
Physical range of adjustment	3.3.1.4.2.4.c.	D
Stops	3.3.1.4.2.5	N/A
Mechanical stops	3.3.1.4.2.5.a.	D,I
Stops on flexible control shafts	3.3.1.4.2.5.b.	I
Locking devices	3.3.1.4.2.6	N/A
Retain controls in any setting	3.3.1.4.2.6.a.	D
Ease of lock and unlock without affecting setting	3.3.1.4.2.6.b.	D

Requirements Verification Matrix		
Requirement	**Paragraph Number**	**Verification Method**
Control interaction in unlocked position	3.3.1.4.2.6.c.	D
Locks on vernier controls	3.3.1.4.2.6.d.	D
Non-turn devices	3.3.1.4.2.7	I
Shafts and couplings	3.3.1.4.2.8	N/A
Adequate strength	3.3.1.4.2.8.a.	D
Shaft couplings	3.3.1.4.2.8.b.	I
Shaft Couplings under 2 HP	3.3.1.4.2.8.c.	I,D
Use of flexible couplings	3.3.1.4.2.8.d.	I
Couplings in frequency determining circuits	3.3.1.4.2.8.e.	I
Taper Locking bushing type coupling	3.3.1.4.2.8.f	I
Gears, sheaves, sprockets, clutches, brakes	3.3.1.4.2.9	NA
Taper locking type bushing design	3.3.1.4.2.9.a	I
SLS exemption for 1 horsepower or less	3.3.1.4.2.9.b	I
Fastener hardware	3.3.1.4.3	N/A
General	3.3.1.4.3.1	N/A
Install & remove without damage	3.3.1.4.3 1.a.	D
Remain secure in normal operation	3.3.1.4.3.1.b.	D
More than one fastener	3.3.1.4.3.1.c.	I
Use of friction for connections	3.3.1.4.3.1.d.	I
Minimize number of standard tools	3.3.1.4.3.1.e.	I
Special tools	3.3.1.4.4	D,A
Miscellaneous items	3.3.1.5	N/A
Glass	3.3.1.5.1	I,T
Motors	3.3.1.5.2	N/A
One Horsepower and larger	3.3.1.5.2.1	N/A
NEMA Design B, E Rating	3.3.1.5.2.1.a	I
Permanently Lubricated ball bearings	3.3.1.5.2.1.b	I
Open drip-proof frame	3.3.1.5.2.1.c	I
Totally enclosed, fan cooled	3.3.1.5.2.1.d	I
Epoxy encapsulated winding	3.3.1.5.2.1.e	I
Contactor and thermal overload relay	3.3.1.5.2.1.f	I
Single phase 230 volt or 3 phase 208 volts	3.3.1.5.2.1.g	I
115 volt single phase, 16 amp max full load	3.3.1.5.2.1.h	I
Fractional Horsepower	3.3.1.5.2.2	N/A
Single phase, 16 amp max full load	3.3.1.5.2.2.a	I
Permanently Lubricated ball bearings	3.3.1.5.2.2.b	I
NEMA Design E rating	3.3.1.5.2.2.c	I
Overload protection	3.3.1.5.2.2.d	I
Open frame Construction	3.3.1.5.2.2.e	I
Enclosed frame construction	3.3.1.5.2.2.f	I
UL Rating	3.3.1.5.2.2.g	I
Ventilating fan motors	3.3.1.5.2.3	N/A
Ball bearing	3.3.1.5.2.3.a	I

Requirements Verification Matrix		
Requirement	**Paragraph Number**	**Verification Method**
Overload protection	3.3.1.5.2.3.b	I
Energy Efficiency	3.3.1.5.2.3.c	I
Frame construction	3.3.1.5.2.3.d	I
Electromagnetic compatibility	3.3.2	N/A
RF Emitters (transmitters)	3.3.2.a	T
Equipment meets Part 2 and 15 of FCC regulations, Title 47	3.3.2.b	T
EMI requirements	3.3.2.c	T
Equipment meets Part 68 of FCC regulations	3.3.2.d	T
Nameplates and marking	3.3.3	N/A
Nameplates	3.3.3.1	N/A
One or more nameplates required	3.3.3.1.a.	I
Nameplate in accordance with Fig 2	3.3.3.1.b.	I
4-40 panhead screws to attach	3.3.3.1.c.	I
Equipment titles	3.3.3.1.1	N/A
Titles approved by Government	3.3.3.1.1.a.	I
Titles in equipment specifications not to be assumed to be correct	3.3.3.1.1.b.	I
Serial Numbers	3.3.3.1.2	D,I
Sequential from 1	3.3.3.1.2.a.	I
No duplicates for a part number	3.3.3.1.2.b.	I
Marking	3.3.3.2	N/A
Permanent and legible	3.3.3.2.a.	T,I
As specified in ANSI/IEEE-200	3.3.3.2.b.	I
Visibility of parts labels	3.3.3.2.1	I
Fuse positions	3.3.3.2.1.1	I
Terminal strips, blocks and wafer switches	3.3.3.2.1.2	I
Controls and indicating devices	3.3.3.2.1.3	N/A
All indicators, fuses and controls marked	3.3.3.2.1.3.a.	I
Correct relationship of markings to controls, fuses, indicators	3.3.3.2.1.3.b.	I
Interchangeability of parts	3.3.4	D
Personal safety and health	3.3.5	N/A
Safe clearances, workspaces, and other safety in accordance with NFPA-70	3.3.5.a.	A,D,I,T
Seismic anchors	3.3.5.b.	A,T
Equipment design for personnel safety equal to or better than ANSI/IEEE C95.1-1991	3.3.5.c.	I
Equipment conforms to UL 1950	3.3.5.d.	T
Personal protection when replacing filters	3.3.5.e.	D
Personnel protected from injury by sharp edges	3.3.5.f.	I
Electrical safety	3.3.5.1	N/A
Personal protection from excess of 30 v in normal operation	3.3.5.1.a.(1)&(2)	I,D
Physical protection for power input side of switches and connections	3.3.5.1.b	I
Ground potential	3.3.5.1.1	N/A

Requirements Verification Matrix		
Requirement	**Paragraph Number**	**Verification Method**
Everything exposed except antennas and transmission line terminals are at ground potential	3.3.5.1.1.a.	T
External and interconnecting wire terminated at both ends	3.3.5.1.1.b.	I
Shields will not carry ground except for coax cable	3.3.5.1.1.c.	I
Antenna and transmission lines at ground potential except for RF	3.3.5.1.1.d.	T
Plugs and convenience outlets provide ground to cable first and	3.3.5.1.1.e.	I
Casings of all components at ground potential except for	3.3.5.1.1.f.	T
External casing encloses original case except for terminal sides	3.3.5.1.1.g.	I
Conductive chassis servesas common connection for safety and	3.3.5.1.1.h.	I
Hinged or slide mounted panels and doors	3.3.5.1.2	N/A
Hinges shunted by ground strap	3.3.5.1.2.a.	I
System tie point to door or panel less that 0.1 ohm	3.3.5.1.2.b.	T
Shielding	3.3.5.1.3	N/A
Shielding grounded on chassis or frame	3.3.5.1.3.a.	I
Sufficient distance from exposed conductors to ground	3.3.5.1.3.b.	I
Bonding in hazardous areas IAW NFPA-70	3.3.5.1.4	I
Guarding of radio frequency voltages	3.3.5.1.5	I
Interlocks	3.3.5.1.6	N/A
None required if all potentials of 70 volts or more are totally	3.3.5.1.6.a.	I
Interlocks required when exposure to 70 volts or high is possible	3.3.5.1.6.b.	I
Bypassable interlock switches permit operation with doors open for	3.3.5.1.6.c.	D,I
Bypassable interlocks allowable where voltages are not open to	3.3.5.1.6.d.	I,D
Proper location of bypass switches	3.3.5.1.6.e.	D
Non-bypassable interlocks for voltages over 500 volts	3.3.5.1.6.f.	I
Shorting rods	3.3.5.1.7	N/A
Provided when transmitting equipment voltages exceed 70 volts	3.3.5.1.7.a.	I
Stored within the equipment	3.3.5.1.7.b.	I
Meter safety	3.3.5.1.8	N/A
Provision for overload bypass in event of failure	3.3.5.1.8.a.	I
1500 volt peak between terminals	3.3.5.1.8.b.	I
High voltage protection	3.3.5.1.9	N/A
Potentials above 500 volts enclosed and interlocked	3.3.5.1.9.a.	I
Holes for test probes	3.3.5.1.9.b.	I
High voltage measurement via test points at less than 300 volts	3.3.5.1.9.c.	T
Proper test point hardware for voltages above 30 volts	3.3.5.1.9.d.	I
Provide dual path from test point to ground	3.3.5.1.9.e.	I
Details of test point circuitry in manuals	3.3.5.1.9.f.	I
High current protection	3.3.5.1.10	I
Discharging devices	3.3.5.1.11	N/A
Provide discharge devices for capacitors and high voltage circuits	3.3.5.1.11.a.	I,T
Automatically activated when case is opened	3.3.5.1.11.b.	D
Shorting bars actuated by mechanical release or solenoid	3.3.5.1.11.c.	D
Bleeder resistor provides dual path to ground	3.3.5.1.11.d.	I

Requirements Verification Matrix		
Requirement	**Paragraph Number**	**Verification Method**
Devices will discharge circuits within 2 sec.	3.3.5.1.11.e.	T
Connectors, electrical	3.3.5.1.12	N/A
Operate protected on connector disconnect	3.3.5.1.12.a.	D
Pins on connectors will not be hot after disconnection	3.3.5.1.12.b.	D
Laser radiation limits	3.3.5.2	N/A
Laser Radiation	3.3.5.2.1	I,T
Switches	3.3.5.3	N/A
Safety Switches	3.3.5.3.1	N/A
Knife switches iaw NEMA KS-1	3.3.5.3.1.a.	D
Contacts to signal accidental opening damage	3.3.5.3.1.b.	D
Rated for maximum available fault current	3.3.5.3.1.c.	D
Knife switch for mechanical drive units	3.3.5.3.1.d.	D,I
Momentary override switches	3.3.5.3.2	D
Mechanical hazards	3.3.5.4	N/A
Low center of gravity	3.3.5.4.a.	D
Protection from moving fans, belts, etc	3.3.5.4.b.	D
Smooth corners on cabinets and doors with stops	3.3.5.4.c.	I
Prevent damage from pulling out doors or racks	3.3.5.4.d.	D
Power switches protected from accidental switching	3.3.5.4.e.	D
Mechanical interconnection	3.3.5.4.1	N/A
Means to prevent mismatching of mechanical parts	3.3.5.4.1.a.	I,D
Coding of mechanical parts where mismatches are possible	3.3.5.4.1.b.	I
Cathode ray tubes	3.3.5.4.2	I,T
Glass fibers	3.3.5.4.3	I
Markings, signs, tags, and symbols	3.3.5.5	N/A
Markings	3.3.5.5.1	N/A
Hazard marking on doors, guards, covers, etc	3.3.5.5.1.a.	I
Location of marking	3.3.5.5.1.b.	I
Internal markings	3.3.5.5.1.c.	I
ANSI Z535.1 color codes	3.3.5.5.1.d.	I
Center of gravity marking	3.3.5.5.1.e.	I,T
Accident prevention signs and labels	3.3.5.5.2	N/A
When to use signs and labels	3.3.5.5.2.a.	I
Permanence of marking	3.3.5.5.2.b.	A
Sign Design	3.3.5.5.2.1	N/A
Three panels	3.3.5.5.2.1.a.	I
Upper panel height to width ratio	3.3.5.5.2.1.a.(1)	I
Lower panel width	3.3.5.5.2.1.a.(2)	I
Lower panel height	3.3.5.5.2.1.a.(3)	I
Optional symbol panel size	3.3.5.5.2.1.a (4)	I
Content of upper panel	3.3.5.5.2.1.a.(5)	I
Lower panel content	3.3.5.5.2.1.a.(6)	I
Sign classifications and detailed design	3.3.5.5.2.2	N/A

Requirements Verification Matrix		
Requirement	**Paragraph Number**	**Verification Method**
Class 1 (danger)	3.3.5.5.2.2.1	N/A
When used	3.3.5.5.2.2.1.a.	I
Content of upper panel	3.3.5.5.2.2.1.b.	I
Content of lower panel	3.3.5.5.2.2.1.c.	I
Class II (caution)	3.3.5.5.2.2.2	N/A
When to use	3.3.5.5.2.2.2.a.	I
Content of sign	3.3.5.5.2.2.2.b.	I
Class III (General safety)	3.3.5.5.2.2.3	N/A
When to use	3.3.5.5.2.2.3.a.	I
Content of upper panel	3.3.5.5.2.2.3.b.	I
Content of lower panel	3.3.5.5.2.2.3.c.	I
Class IV (Fire and emergency)	3.3.5.5.2.2.4	N/A
When to use	3.3.5.5.2.2.4.a.	I
Content of upper panel	3.3.5.5.2.2.4.b.	I
Content of lower panel	3.3.5.5.2.2.4.c.	I
Sign placement	3.3.5.5.2.3	N/A
Location	3.3.5.5.2.3.a.	D,I
Effects of sign	3.3.5.5.2.3.b.	I
DOT/FAA/CT-961	3.3.5.5.2.3.c.	I
Marking of radio active materials (NRC/OSHA requirements)	3.3.5.5.3	I
Symbols	3.3.5.5.4	N/A
Ionizing radiation hazard	3.3.5.5.4.a.	I
Microwave and RF radiation	3.3.5.5.4.b.	I
Laser	3.3.5.5.4.c.	I
Alerts/warnings	3.3.5.5.5	D
Audio Warning Signals	3.3.5.5.5.1	T
Display warnings	3.3.5.5.5.2	N/A
When used	3.3.5.5.5.2.a.	A
Clearly discriminative features	3.3.5.5.5.2.b.	D,I
Battery warning label	3.3.5.5.5.3	I
Hazardous and restrictive materials	3.3.5.6	N/A
Assessment of potential	3.3.5.6.a.	A
Assessment activities	3.3.5.6.b.	A
Carcinogens	3.3.5.6.1	A,I
Dusts, mists, fumes, and gases	3.3.5.6.2	N/A
Emissions dangerous to humans	3.3.5.6.2.a.	T
Emissions dangerous to plant, etc	3.3.5.6.2.b.	T
Emission of flammable gases	3.3.5.6.2.c.	T
Restricted materials	3.3.5.6.3	I
Radioactive materials	3.3.5.6.4	I
Seismic Safety	3.3.5.7	N/A
Equipment minimum life-safety seismic reqs	3.3.5.7.a	A
Secure to prevent overturning	3.3.5.7.b	I

Requirements Verification Matrix		
Requirement	**Paragraph Number**	**Verification Method**
Support components per IBC 2000/FEMA 302	3.3.5.7.c	I
Facilities in E or F Categories	3.3.5.7.d	A
Enclosures/components remain in place	3.3.5.7.e	A
Human engineering	3.3.6	A,I
Noise criteria requirement	3.3.6.1	N/A
Outside areas	3.3.6.1.a.	T
In operational areas	3.3.6.1.b.	T
In equipment areas	3.3.6.1.c.	T
In special areas/offices	3.3.6.1.d.	T
In high noise/remote areas	3.3.6.1.e.	T
Identification of noise hazard areas	3.3.6.1.1	N/A
When warning signs are needed	3.3.6.1.1.a.	T,I
Visibility of signs	3.3.6.1.1.b.	I
Manuals address noise hazards	3.3.6.1.1.c.	I
Ergonomic considerations	3.3.6.2	I
Weight lifting limits	3.3.6.3	I
Visual displays	3.3.6.4	N/A
Lighting levels	3.3.6.4.a.	T
Lighting levels	3.3.6.4.b.	T
Lighting levels	3.3.6.4.c.	T
Display information	3.3.6.4.1	N/A
Display to operator	3.3.6.4.1.a.	D
Information limited to what is necessary	3.3.6.4.1.b.	D
No exclusive use of numeric digital displays	3.3.6.4.1.c.	D
Use of numeric digital displays	3.3.6.4.1.d.	D
Display Positive feedback	3.3.6.4.2	N/A
Data on status change	3.3.6.4.2.a.	D
Selectable data, minimum amount	3.3.6.4.2.b.	A,D
Light-emitting diodes (LED) Displays	3.3.6.4.3	N/A
May be used	3.3.6.4.3.a.	A
Colors to be used	3.3.6.4.3.b.	D
Flash	3.3.6.4.4	N/A
When to use	3.3.6.4.4.a.	A,D
Flash rate	3.3.6.4.4.b.	T
Synchronization of multiple indicators	3.3.6.4.4.c.	D
Labeling	3.3.6.5	N/A
When to use	3.3.6.5.a.	A
Label orientation	3.3.6.5.b.	I
Label content	3.3.6.5.c.	I
DOT/FAA/CT-961 requirements	3.3.6.5.d.	I
Documentation	3.4	A
Personnel and Training	3.5	D