U.S. Department of Transportation

Federal Aviation Administration

Application Handbook for

FAA-G-2100g

Electronic Equipment, General Requirements

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1 Introduction

The FAA-G-2100g Guide provides assistance to the Integrated Product Teams (IPT) to capture all the necessary/applicable requirements from FAA-G-2100g and to demonstrate how the requirements should be stated in the System Level Specifications (SLS). The requirements set contained in Section 3 of FAA-G-2100g needs to be tailored by the responsible IPT so that the applicable requirements are stated in the SLS. The FAA-G-2100g Guide should improve the acquisition process by:

- Providing a common resource for the IPTs;
- Assisting the IPTs in identifying all necessary requirements;
- Potentially eliminating unforeseen cost increases because all electronic equipment requirements have been specified.

Section 2.0, Guidelines, walks through pertinent sections of FAA-G-2100g and provides information that describes why the section should be addressed and how the section should be addressed in the SLS.

2 Guidelines

The Federal Aviation Administration (FAA) designated the FAA-G-2100g as the general specification for ground based electronic equipment and as the technical baseline used for acquiring electronic equipment throughout the National Airspace System (NAS). The specification provides requirements for electronic equipment regardless of the type of items procured (commercial-off-the-shelf (COTS), non-developmental item (NDI), or developmental). The majority of the documents referenced in FAA-G-2100g are recognized as industry standards. The following sections in FAA-G-2100g state requirements for electronic equipment:

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The requirements of FAA-G-2100g will be addressed in the following sections of this document. Each section will describe the requirements addressed, the importance of the requirement, and the recommended application of the requirement in the SLS.

It is also recommended that the SLS contain a specific section titled “Electronic Equipment General Requirements.” This section in the SLS will be the link to address all the applicable requirements stated in FAA-G-2100g. Specific requirements in FAA-G-2100g that apply should be cited in the SLS (i.e., state the FAA-G-2100g paragraph numbers). It is recommended that all text shown in italics in this document be included in the SLS. All requirements that apply should be given separate requirement statements in the SLS. Requirements in the SLS invoking FAA-G-2100g in its entirety should be avoided.

Most of the requirements stated in FAA-G-2100g apply to all projects. However, it is the responsibility of the IPTs to determine which requirements are applicable to their program. If a program has a more stringent, or a different requirement, the IPT may supercede the requirement stated in FAA-G-2100g by stating the new requirement within the “Electronic Equipment General Requirements” section of the SLS.

2.1 Electrical Power

Section 3.1.1 of FAA-G-2100g, Electrical Power, addresses internal wiring, equipment interface to building wiring, and electrical enclosure wiring/cabling requirements.

Section 3.1.1 provides a set of reference documents to assure building wiring is in accordance with NFPA 70, FAA-C-1217F, and FAA-STD-032. The section also requires electrical enclosures, cabling, and wiring to be approved by a nationally recognized testing laboratory.

Applicable requirements of section 3.1.1 in FAA-G-2100g should be restated in the SLS.

2.1.1 Physical Construction

Section 3.1.1.1.1 of FAA-G-2100g addresses the following requirements:

a. Accessibility
b. Equipment directly connected to line power
c. Plugs and receptacles for Alternating Current (AC)
d. Power cord for AC
e. Detachable Power cords
f. Convenience Outlets
g. Test equipment power source

Accessibility – This section requires test equipment or maintenance equipment to be accessible in accordance with NFPA 70 or OSHA. The section also refers to Section 3.1.2.4, Accessibility for accessibility of electrical components, connections, and wiring.

Equipment directly connected to line power – This section requires the control and indication of the power to be located on the front panel of the equipment. For safety purposes, the power is required to be shut-off immediately where the power enters the equipment enclosure. When the equipment is connected by cord and plug to line power, the power may be disconnected by means of unplugging the cord from the receptacle.

Plugs and receptacles for Alternating Current (AC) – This sections requires that AC plugs and receptacles 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. When Federal Specification W-C-596, is applied it insures that quality plugs and receptacles are used in the electronic equipment. W-C-596 is a general specification that includes both the NEMA and stringent UL specifications as requirements. There are numerous sub specifications within W-C-596 for specific devices.

Detachable power cords – This section specifies that detachable power cords rated 125 volts(V) maximum and 15 amperes(A) maximum be of the SF 3 conductor type. It also requires that the ends be in accordance with W-C-596 and DESC 87204.

Convenience outlets – This section requires convenience outlets in equipment racks to be duplex type in accordance with W-C-596 and wired in accordance with NFPA 70. To maintain the quality of power to operational equipment in racks, convenience outlets must be isolated from the equipment rack power source by powering from a separate source.

Test equipment power source – To prevent sensitive equipment within a rack from stray currents that could cause equipment malfunction, test equipment should be powered from a different source isolating it from the rack power source. To accommodate cases when sensitive test equipment must be powered from the same source as the rack equipment (instead of from a convenience outlet), the IPT should determine whether potential confusion can be averted by clearly identifying the convenience outlet.

The IPT should include the applicable requirements Section 3.1.1.1.1 in the SLS.

2.1.2 Electrical Power Measurements

Section 3.1.1.2 of FAA-G-2100g provides requirements for conducting electrical power measurement, specifying the points where electrical power measurements are to be made. This section should be included in the SLS.

2.1.3 Load Power Characteristics

Section 3.1.1.3.1 of FAA-G-2100g addresses the electrical power factor requirements for electronic equipment.

Power factor is a measurement of how efficiently a commercial facility uses electrical energy. The higher the power factor, the lower the cost of electricity. A low power factor reduces the load handling capability of a facility's electrical system. It can also overload the electrical equipment within a facility, creating large voltage drops and greater line losses. Most importantly, a low power factor increases the total demand charges and the cost per Kilowatt Hour (kWh). In order for the NAS facility power system to properly operate and interface with the electronic equipment, the power factors of the electronic equipment must be within the limits stated in FAA-G-2100g.

It is imperative for the IPT to correctly identify the power factor requirements for the equipment in order to effectively and reliably interface with and operate in the NAS facilities. The IPT should consider the KVA capacity of the facilities where the electronic equipment will be located. For example, if the equipment is to be located in an ARTCC with a large KVA capacity (greater than 1500 KVA), a power factor of 0.6 lag to 0.7 lead may be acceptable. At a small ATCT with a low KVA capacity (less than 200KVA), a more stringent power factor of 0.9 lag to 1.0 would be required. Where equipment is to be located in facilities with varying KVA capacities, the more stringent power factor should be specified.

Power Factor

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)*
KVA<200	*0.9 (lag) – 1.0*

(Note - The IPT should specify only the applicable power factor from the above table)

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.

$$PF = |Pfdisp \times Pfdist|$$

The displacement component of the power factor, Pfdisp, 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).

$$Pfdisp = Cos(theta) = Watts/VA$$

The distortion component of the power factor, Pfdist, 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 519-1993 (Harmonic Control and Reactive Compensation of Static Power Converters, Guide for).

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

2.1.4 Inrush Current

Section 3.1.1.3.2 of FAA-G-2100g addresses the inrush current limit requirements for electronic equipment.

The surge in current when electronic equipment is initially powered is called inrush current. As the electronic equipment continues to operate, the inrush current reduces to the operating current. To keep the circuit from tripping, it is important to keep the inrush current below the threshold of current limiting devices such as circuit breakers.

It is imperative for the IPT to correctly identify the inrush current requirements for the equipment in order to effectively and reliably interface with and operate in NAS facilities. The entire section 3.1.1.3.2 should be restated in the SLS.

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 forty (40) amperes, 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 forty (40) amperes and equal to or less than eighty (80) amperes, 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 eighty (80) amperes shall be defined in the system level specification for that device or load.*

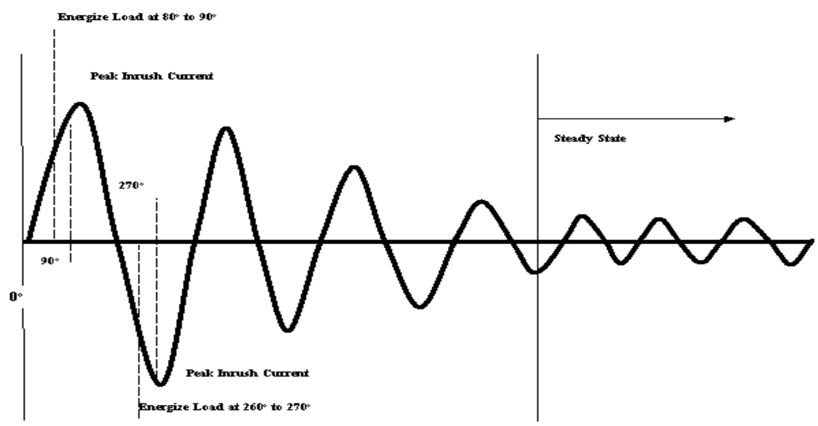

FIGURE 1. Inrush Current Measurements

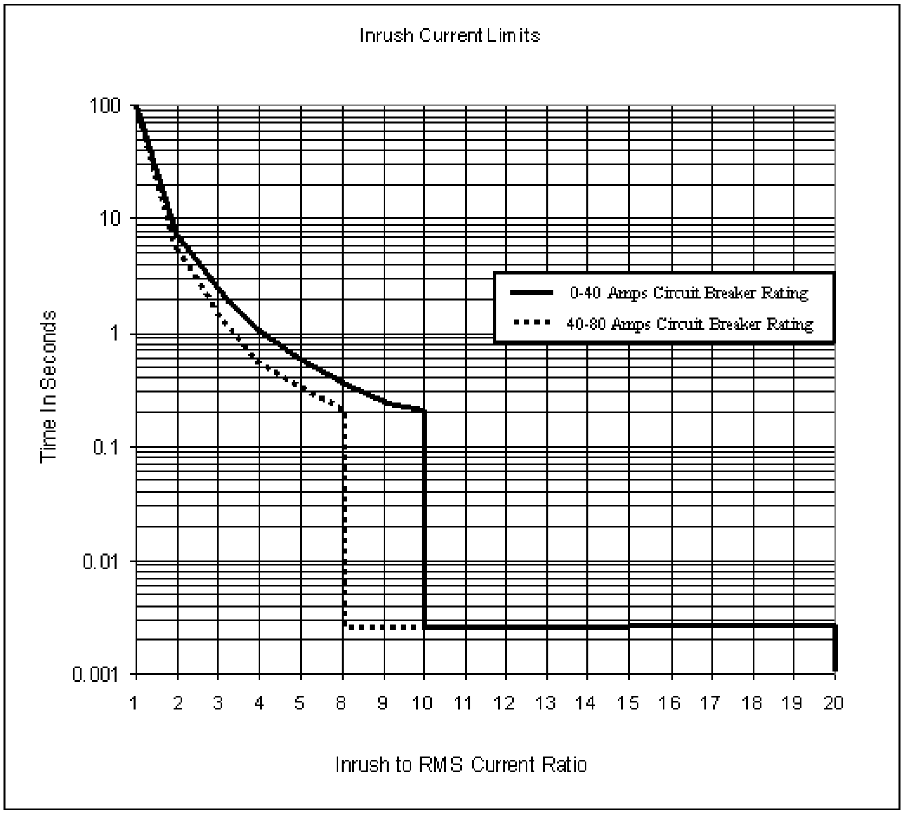

FIGURE 2. Inrush Current Limit Ratios

NOTE: $\text{Overcurrent} = \dfrac{\text{Maximum Peak Current}}{\text{Steady State (rms) Current}}$

The following factors were used generate the Inrush Current Limit Ratio curves in Figure 2. The IPT may, but is not required to, include the following in the SLS:

1. The actual time current curves and tolerances of several manufacturers standard molded case circuit breakers spanning ratings of 15 to 100+ amperes;
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 five milliseconds;
4. Amperes determine the size of circuit breakers and distribution systems. The FAA is responsible for facility distribution system design to support the load requirements. 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, e.g., a

large HVAC fan, may require reduced voltage starting or a facility distribution special circuit breaker application.

2.1.5 Electrical Load Balance

Section 3.1.1.4 of FAA-G-2100g addresses requirements for balancing the electronic equipment current load on each phase of a three-phase power panel.

To prevent an overload on each phase of a three-phase power panel, the loads from the equipment need to be distributed on each leg so that one phase does not deviate for the average of the three phases by more than 10 percent.

When the IPT is procuring equipment requiring three-phase power, the SLS should include the requirements of Section 3.1.1.4.

2.1.6 Harmonics

Section 3.1.1.5 of FAA-G-2100g addresses the current harmonic distortion requirements for electronic equipment.

Harmonic currents are the result of non-linear loads demanding a current waveform different from the shape of the applied voltage waveform. For example, assume that the utility supplies a certain building's electrical distribution system with a pure sinusoidal voltage waveform at 60 hertz (Hz). Equipment such as computers, fax machines, electronic lighting ballasts, welding equipment, battery chargers, variable frequency drives (VFD), and uninterruptible power supplies (UPS) use this utility-provided AC power to run an electronic power converter, using solid state power switching devices such as diodes, thyristors (SCR), or transistors to convert the sources' AC power into DC power by drawing the current in pulses. The result is to generate harmonic currents, which, in combination with source impedances, produce distortion of the line voltages.

Non-linear loads can draw a number of current frequencies. These frequencies are generally multiples of the fundamental frequency (i.e., 60 Hz) and usually decrease in magnitude as their harmonic order increases. Harmonic order is defined as a multiple of the fundamental frequency (e.g., a harmonic frequency of 180 Hz developed on a 60 Hz source is called the 3rd harmonic). The ratio of the total harmonic current (RMS) to the fundamental current is known as a total harmonic current distortion (THD-C) and is expressed as a percentage of the fundamental current. The heating effect of current is a function of the square value of both the fundamental current and the harmonic current and increases with frequency.

American standards base the percentage distortion on the fundamental frequency. Other countries base the percentage distortion on the RMS values. Needless to say, the numbers can vary widely depending on the load and method used. IPTs need to be aware of this distinction.

Until several years ago, harmonics were a problem noticed by utility companies servicing a few isolated customers that used arc furnaces or large battery chargers. Today, however, the proliferation of non-linear loads within many buildings has led to excessive harmonic currents on power distribution networks.

The most common problems caused by excessive harmonics are overheating of neutral conductors and electrical distribution transformers and the malfunctioning of electronic equipment. Harmonic voltages and currents can cause interference effects that are detrimental to electronic equipment not designed to operate in the presence of significant harmonics. Modern power electronic equipment draws current in repetitive pulses from the AC power line. As the frequency of the harmonic increases, so does the impedance of everything in the circuit. High values of harmonic current add heat out of proportion to their absolute value. One common harmful effect is the heating of the trip mechanism of standard molded case circuit breakers.

A load rich in higher order harmonics can actually bias a correctly sized and applied branch circuit breaker to trip at less than desired amperes. The even number harmonics, usually not present, will cause motors to overheat. The impedances of standard motors make them excellent receptors of these harmonics.

Other electronic equipment on the same distribution system may be disturbed by the consequent pulsations of voltage in the supply line. For example, a computer "glitch" may occur during a rising or dropping voltage pulse, and could result in data loss, data corruption, processing interruption, or brown-out. In addition, electromagnetic fields associated with the harmonic currents can interfere with telephone and other communication systems. Harmonic voltage effects are of particular concern in applications where emergency generators are used to maintain services during utility power outages. Emergency generators have an impedance three or more times the impedance presented by conventional utility sources. Thus, for the same harmonic current, the harmonic voltage distortion is three or more times larger; subsequently, there is a much greater potential for operating problems. The generator capacity is also affected by the amount of harmonic current. In severe harmonic environments, emergency UPS generators have difficulty in recognizing the high harmonic waveforms and, in many cases, are unable to activate and provide power to critical loads.

It is imperative that electronic equipment's current harmonic distortion characteristics meet the requirements below. The entire Section 3.1.1.5 should be restated in the SLS as follows:

Harmonics

The individual current harmonic distortion (IN) produced by each individual equipment item or subsystem (consisting of several items combined in a single power circuit) shall not exceed the limits listed in Table I measured from the equipment end of the electrical power branch feed.

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.

TABLE I. Limits of individual harmonics

Harmonic Order	*Maximum Limits (ma) For* $50<W<600$ *(1 phase)*	*Maximum Limits (ma) For* $600<W<40K$ *(1 or 3 phase)*
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 circuits as defined by ANSI/IEEE Standard 100. "IEEE Standard Dictionary of Electrical and Electronics Terms."*
3. *K equals 1000.*

2.1.7 Circuit Overload Protection

Section 3.1.1.6 of FAA-G-2100g addresses the overcurrent protection device requirements.

Current overload circuit protection devices, such as fuses or circuit breakers, are required to prevent circuits from experiencing currents beyond that for which the circuit was designed.

The IPT should include the requirements of Section 3.1.1.6 in the SLS.

2.1.8 Input Power Conditions

Section 3.1.1.7 of FAA-G-2100g addresses the input power operating parameters, including voltage, frequency, and voltage harmonic distortion, required for electronic equipment.

The power operating parameters are important to insure the electronic equipment properly interfaces with the facility power system.

It is imperative that electronic equipment's current harmonic distortion characteristics meet the requirements below. The entire Section 3.1.1.7 should be restated in the SLS:

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

Voltage. (Note: The IPT should state only the applicable 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 ≤ 5%*
DC 25 Volts	*+/- 20%*	*AC Ripple ≤ 5%*
DC 12 Volts	*+/- 20%*	*AC Ripple ≤ 5%*

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))

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

Frequency

Steady State

Steady state 60 Hz +or – 3 Hz

Steady state rate of change 1.5 Hz/sec

Steady state frequency variation + or – 0.5 Hz

Momentary deviations (.5 cycles to 3 seconds)

60 Hz + 5 Hz, - 7 Hz

Rate of change 5 Hz per sec.

Voltage Harmonic Distortion

10% Voltage Total Harmonic distortion (THD)

3% Any one Harmonic

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 and 8.3 – and table 5, earthed neutrals.

Voltage/Time events for 120 volts single phase applications. **(The IPT should choose only one of the following)**

(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.

The data on the following page is part of the data from the EPRI funded Power Distribution Quality (DPQ) study. This multi-million dollar, multi-year effort is the most comprehensive ever performed in this country.

The DPQ study stopped recording low voltages events when the time exceeded one second because most loads would have tripped off lines in far less than a second. The FAA curve provides immunity to over 94 percent of ***all*** low voltage (includes no voltage) events one can expect at the least reliable site in the nation. The events where it cannot prevent outages are those longer than one second. Some of these events will be so long that FAA emergency power has to be made available. The FAA curve will increase the reliability of any load by at least one "9".

IPTs should be aware that the UL specification for power supplies in "office equipment" like items requires a power supply with 200percent full load capability. Twice the minimal "CBEMA" ride through should not be a problem.

The European standards (EU/EN/IEC etc.) have finally been made active for power supplies. Their requirements have led power supply manufacturers to have standard items that comply with the worldwide European requirements. Inrush current, harmonics, and to a lesser degree ride through (holdup time in "power supply") requirements will be satisfied simply by buying the item made for international sales. IPTs can expect some sales oriented misdirection in this area.

Events Affecting Power Quality

Sag and Interruption Rate Magnitude Duration Histogram, One-Minute Aggregation, 6/1/93 to 6

Duration (cycles)

Voltage Magnitude	1	2	3	4	5	6	7	8	9	10	11	12 to 14	15 to 19	20 to 24	25 to 29	30 to 39
>=0.88 and <0.9 p.u.	0.92	0.61	0.65	0.94	0.76	0.69	0.46	0.27	0.19	0.11	0.09	0.18	0.35	0.30	0.25	0.29
>=0.86 and <0.88 p.u.	0.62	0.51	0.41	0.47	0.64	0.55	0.37	0.23	0.14	0.16	0.08	0.22	0.33	0.20	0.11	0.14
>=0.84 and <0.86 p.u.	0.50	0.45	0.35	0.32	0.57	0.38	0.21	0.13	0.12	0.08	0.05	0.13	0.29	0.08	0.06	0.12
>=0.82 and <0.84 p.u.	0.37	0.39	0.28	0.31	0.40	0.34	0.19	0.14	0.07	0.09	0.09	0.09	0.19	0.19	0.06	0.07
>=0.80 and <0.82 p.u.	0.25	0.30	0.20	0.22	0.31	0.32	0.28	0.11	0.10	0.10	0.04	0.12	0.14	0.02	0.06	0.10
>=0.78 and <0.80 p.u.	0.22	0.22	0.30	0.20	0.25	0.22	0.17	0.07	0.10	0.06	0.08	0.06	0.08	0.05	0.05	0.04
>=0.76 and <0.78 p.u.	0.14	0.33	0.14	0.17	0.12	0.13	0.14	0.09	0.33	0.34	0.02	0.04	0.11	0.04	0.05	0.06
>=0.74 and <076 p.u.	0.13	0.34	0.20	0.12	0.13	0.16	0.12	0.06	0.04	0.05	0.05	0.04	0.03	0.02	0.03	0.07
>=0.72 and <0.74 p.u.	0.16	0.30	0.27	0.19	0.14	0.10	0.07	0.11	0.06	0.02	0.02	0.04	0.03	0.01	0.04	0.09
>=0.70 and <0.72 p.u.	0.12	0.18	0.14	0.14	0.08	0.07	0.18	0.08	0.04	0.02	0.02	0.07	0.10	0.03	0.04	0.03
>=0.65 and <0.70 p.u.	0.13	0.35	0.39	0.31	0.24	0.20	0.16	0.16	0.11	0.04	0.03	0.08	0.11	0.11	0.08	0.05
>=0.60 and <0.65 p.u.	0.15	0.24	0.26	0.22	0.21	0.23	0.16	0.18	0.06	0.05	0.05	0.13	0.06	0.06	0.04	0.02
>=0.55 and <0.60 p.u.	0.04	0.17	0.21	0.18	0.15	0.09	0.08	0.03	0.04	0.02	0.00	0.13	0.13	0.03	0.03	0.03
>=0.50 and <0.55 p.u.	0.10	0.16	0.18	0.17	0.18	0.14	0.08	0.07	0.02	0.07	0.04	0.06	0.03	0.07	0.03	0.02
>=0.40 and <0.50 p.u.	0.04	0.18	0.41	0.23	0.11	0.19	0.08	0.04	0.04	0.03	0.02	0.08	0.13	0.04	0.03	0.06
>=0.30 and <0.40 p.u.	0.10	0.16	0.27	0.09	0.12	0.06	0.07	0.04	0.03	0.02	0.02	0.06	0.07	0.06	0.05	0.04
>=0.20 and <0.30 p.u.	0.04	0.03	0.09	0.09	0.04	0.04	0.04	0.01	0.01	0.02	0.02	0.04	0.07	0.01	0.02	0.09
≥0.0 and <0.20	0.05	0.07	0.19	0.11	0.16	0.30	0.12	0.08	0.10	0.11	0.07	0.18	0.15	0.05	0.06	0.14
sum	8%	10%	10%	9%	9%	8%	6%	4%	3%	3%	2%	4%	5%	3%	2%	3%
Key		CBEMA		ITIC/cbema		SEMI		FAA								
% events dropping equipment		92%		32%		20%		6%								
% events equipment survives		8%		68%		80%		94%								

SEMI is the 1999 Semiconductor Industry envelope

Note: Cells show the monthly average number of events based on 28 months at 277 locations, and 326,346 recorded events. Data came from the EPRI Distribution PQ survey. Monitor location were utility feeders selected to be representative of typical quality of power in the US. The actual number of events at low-voltage equipment terminals is expected to be higher.

EPRI Power Quality Survey

2.1.9 Performance Upon Fault Condition of Radio Frequency Equipment Output Circuit

Section 3.1.1.8 of FAA-G-2100g is applicable to Radio Frequency (RF) equipment only and addresses preventing damage to the output circuits when a fault condition occurs.

If a fault condition occurs, the RF equipment should not be damaged. This Section requires that RF output circuits be designed to prevent damage due to fault conditions, voltage standing wave ratio (VSWR), and not to exceed dissipation limits.

If the acquisition of equipment includes RF equipment, the requirements in Section 3.1.1.8 should be included in the SLS.

2.1.10 Grounding and Bonding

Section 3.1.1.9 of FAA-G-2100g addresses the electronic equipment grounding, bonding and shielding in addition to facility grounding, bonding, and shielding requirements.

Grounding is perhaps the single most important power quality consideration. That is not to say grounding alone will eliminate system damage or degradation caused by transients because it will not, nor will it attenuate harmonics. However, grounding is the starting point from which a solid nonlinear power distribution system should be built. An adequate grounding scheme is essential for the proper operation of suppression filter systems, which may be hardwired into the distribution system. This grounding scheme is essential for the data and logic systems that look for a ground reference of 0V. The FAA has developed two standards concerning grounding requirements: electronic equipment, FAA-STD-020, and facilities, FAA-STD-019. Both of these standards should be included in the SLS.

Grounding, bonding, and shielding of data lines is even more critical when stand-alone or distributed data processing is involved.

All mainframe computers have built-in data error detection and correction software. This powerful software, sometimes unknown to the operators, contains the ability to detect and correct errors in the bit stream. A mainframe receiving corrupted data will slow, sometimes to a crawl, but not stop when poorly grounded or shielded data lines corrupt data.

Personal computers in stand-alone applications do not usually contain such powerful software. A false bit or two may cause a glitch; some number of glitches cause a lockup or shutdown. The data lines involved in these applications must be properly grounded, bonded, and shielded.

The IPT should include the requirements of Section 3.1.1.9 in the SLS.

2.1.11 Corona Prevention (High Voltage/High Current)

Section 3.1.1.10 of FAA-G-2100g addresses the Corona prevention and electrical breakdown prevention requirements for electronic equipment.

Partial discharge, as defined by ASTM D1868, is a type of localized discharge resulting from transient gaseous ionization in an insulation system when the voltage stress exceeds a critical value. The partial discharge (Corona) level has a pronounced effect on the life of the electronic equipment transformer. As the voltage stress is increased, anomalies in the insulation system will result in partial discharge or Corona inception. Corona extinction will occur as the voltage stress is reduced.

The partial discharge cycle repeats during the operation of the coil. The excess energy dissipated during these repeating cycles causes deterioration of the insulation system, resulting in premature failure of the coil.

Corona testing requires specialized equipment and cannot be performed with standard dielectric or induced voltage testers.

Choosing a supplier skilled in Corona abatement with extensive design experience, repeatable manufacturing processes, and the proper test equipment and procedures to measure Corona inception and extinction levels can minimize Corona.

For systems that require high voltages and currents, the IPT should include Section 3.1.1.10 in the SLS.

2.1.12 Transformer Isolation and Non-Switching DC Power Supplies

Section 3.1.1.11 of FAA-G-2100g addresses the transformer isolation and non-switching power supply requirements for electronic equipment.

The applicable requirements of Section 3.1.1.11 should be included in the SLS.

2.2 Mechanical

Section 3.1.2 of FAA-G-2100g addresses the electronic equipment requirements for removable parts and connectors, installation, construction, accessibility, and thermal design.

2.2.1 Removable Parts and Mating Connectors

Section 3.1.2.1 of FAA-G-2100g addresses the requirement for the equipment to be delivered completely with replaceable components such as fuses, lamps, and other quick removal and replacement parts. This section also requires that mating connectors be provided with the equipment.

It is necessary to require that the equipment be delivered complete with all mating connectors and quick removal and replacement parts. This complete delivery helps to ensure that the equipment is easily repairable and maintainable.

When the IPT anticipates procuring equipment that will require maintenance actions to replace items such as fuses, lamps, and other quick removal and replacement parts, the requirements of Section 3.1.2.1 should be included in the SLS.

2.2.2 Installation

Section 3.1.2.2 of FAA-G-2100g addresses installation, removal, and reinstallation of equipment without the use of special tools unless approved by the FAA.

Thissection requires the contractor to design the equipment to use standard tools. If the equipment is unique and requires a special tool, the FAA may approve it.

The IPT should include the requirements of Section 3.1.2.2 in the SLS.

2.2.3 Construction

Section 3.1.2.3 of FAA-G-2100g provides general requirements for the construction of the electronic equipment/enclosure, including the following:

a. Connection of fixed parts is maintained throughout the life of the equipment;
b. 125 pounds per square foot maximum equipment/enclosure floor loading;
c. Equipment rack requirements;
d. Equipment will meet the performance requirements after a shelf life of two years in a non-operational state;
e. Requirement for equipment to have drainage or purging capability to prevent the collection of moisture on the equipment;
f. Requirement for equipment windows to be made of shatterproof transparent material.

The maximum 125 pounds per square foot floor loading is needed to prevent raised floors from being overloaded or from bowing.

The IPT should include the applicable construction requirements of Section 3.1.2.3 in the SLS.

2.2.4 Accessibility

Section 3.1.2.4 of FAA-G-2100g addresses the requirements for general accessibility, captive fasteners, Lowest Replaceable Units (LRU), and enclosures.

The accessibility section assures that the electronic equipment is designed to provide a means to remove, install, and maintain all components within the equipment in a manner that is conducive to the operational and maintenance concept of the acquisition program.

The IPT should include the applicable accessibility requirements of Section 3.1.2.4 in the SLS.

2.2.5 Thermal Design

Section 3.1.2.5 of FAA-G-2100g addresses the dissipation requirements for heat generated by the electronic equipment/enclosure.

This section provides standard requirements to insure that the heat generated by the electronic equipment/enclosure is dissipated into the ambient environment in a safe manner to prevent the equipment from overheating.

This section also places restrictions on cooling methods and provides standards for forced cooling and for the failure of cooling devices.

The IPT should include the applicable thermal design requirements of Section 3.1.2.5 in the SLS.

2.2.6 Equipment Software/Firmware

Section 3.1.3 of FAA-G-2100g addresses the electronic equipment software/firmware requirements and the standards for software development.

Section 3.1.3 defines the software/firmware to include 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. This section also requires that firmware/software programs shall be in accordance with the requirements for performance, reliability, and maintainability in the system/subsystem specification.

The IPT should include the software/firmware requirements of Section 3.1.3 in the SLS for acquisitions that include software or firmware.

2.3 Environmental Conditions

Section 3.2.1.1 of FAA-G-2100g provides the operating condition design values and the non-operating design value conditions for the electronic equipment/enclosure.

Section 3.2.1.1 describes all the environmental condition requirements for the electronic equipment. It is imperative for IPTs to identify the environmental conditions for their particular program.

The following environmental condition requirements in FAA-G-2100g should be restated in the SLS:

Operating Conditions

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 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.*

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

The following standards apply to equipment to be used outdoors:

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.*

The following standards apply to equipment used indoors (this applies to the majority of equipment):

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 +85°F with relative humidity of 30% to 80% in the defined temperature range.*
d. *The system level specification shall define the required operating environment(s).*

From MIL-STD-810F:

TABLE C-I. Summary of climatic conditions and daily cycles of temperature, solar radiation, and relative humidity.

CLIMATIC CATEGORY		DAILY CYCLE[1]	OUTDOOR AMBIENT CONDITIONS		
			Air Temperature °C[2] (°F)	Solar Radiation W/m[2] (BPH)[3]	Relative Humidity[4] %
HOT		HOT-DRY (A1)	32 to 49 (90 to 120)	0 to 1120 (0 to 355)	8 to 3
		HOT-HUMID (B3)	31 to 41 (88 to 105)	0 to 1080 (0 to 343)	88 to 59
BASIC	HUMID-TROPIC ZONE	CONSTANT HIGH HUMIDITY (B1)	Nearly Constant 24 (75)	Negligible	95 to 100
		VARIABLE HIGH HUMIDITY (B2)	26 to 35 (78 to 95)	0 to 970 (0 to 307)	100 to 74
	INTERMEDIATE ZONE	BASIC HOT (A2)	30 to 44 (86 to 111)	0 to 1120 (0 to 355)	44 to 14
		MILD COLD (C0)	-19 to –6 (-2 to 21)	Negligible	Tending Toward Saturation
		BASIC COLD (C1)	-32 to –21 (-25 to –5)	Negligible	Tending Toward Saturation
COLD		COLD (C2)	-46 to –37 (-50 to –35)	Negligible	Tending Toward Saturation
SEVERE COLD		SEVERE COLD (C3)	-51 (-60)	Negligible	Tending Toward Saturation

[1] Designations in parentheses refer to corresponding climatic categories in Quadripartite Standardization Agreement 360, "Climatic Environmental Conditions Affecting the Design of Military Materiel," and NATO STANAG 2895, "Extreme Climatic Conditions and Derived Conditions for Use in Defining Design/Test Criteria for NATO Forces Materiel."

[2] °C values (rounded to the nearest whole degree) derived from data obtained/established on °F scale.

[3] BPH represents British Thermal Units per square foot per hour.

[4] Sequence of RH presentation corresponds to sequence of air temperatures shown (e.g., for HOT-DRY daily cycle, 8% RH occurs at 32°C; 3% RH occurs at 49°C).

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 -50C to +56C
(b) Relative humidity 0% to 100% including condensation due to temperature changes
(c) Altitude 0 to 50,000 feet above sea level

2.4 Physical Characteristics

Section 3.2.2 of FAA-G-2100g addresses electronic equipment assembly requirements, such as component mounting, printed circuit boards, and assembly. The requirements in this section will ensure that electronic assemblies are in compliance with industry standards.

Section 3.2.2 references industry standard ANSI/J-STD-001B for the assembly of electronic equipment and appropriate Integrated Printed Circuits (IPC) standards.

Other references in 3.2.2 include IPC-CM-770 (Guidelines for Printed Board Component Mounting), ANSI/IPC-CM-780 (Component Packaging and Interconnecting with Emphasis on Surface Mounting), IPC-A-600E (Acceptability of Printed Boards), and ANSI/IPC-A-610 (Acceptability of Electronic Assemblies).

Section 3.2.2 also prohibits the use of wire wrap on printed circuit boards.

The IPT should include the applicable physical characteristics requirements of Section 3.2.2 in the SLS.

2.5 Reliability

Section 3.2.3 of FAA-G-2100g serves as a reminder to the IPT to include the reliability requirements of the equipment in the SLS.

2.6 Maintainability

Section 3.2.4 of FAA-G-2100g describes standard general requirements to provide access for maintenance. The section prevents unsoldering of wires, harnesses, parts, or assemblies as a means to gain maintenance access. Section 3.2.4 requires the design of the electronic equipment/enclosure to provide maintenance access without extensive movement of wiring and components. Section 3.2.4 also covers the removal of panels and sub-chasses, air filter replacement, built in test equipment, and test points.

The IPT should include the applicable maintainability requirements of Section 3.1.2.5 in the SLS.

2.7 External Equipment Interfaces

Section 3.2.5 of FAA-G-2100g requires that failures of external systems, such as remote maintenance monitoring systems, will not cause a failure of the equipment.

The IPT should include the external interface requirements Section 3.2.5 in the SLS when it is expected that the equipment will be connected to external remote maintenance monitoring systems.

2.8 Electrostatic Discharge

Section 3.2.6 of FAA-G-2100g addresses the electrostatic discharge requirements for equipment in a non-operational state and operational state.

Static electricity is defined as an electrical charge caused by an imbalance of electrons on the surface of a material. This imbalance of electrons produces an electric field that can be measured and that can influence other objects at a distance. Electrostatic discharge is defined as the transfer of charge between bodies at different electrical potentials.

Electrostatic discharge can change the electrical characteristics of a semiconductor device, degrading or destroying it. Electrostatic discharge also may upset the normal operation of an electronic system, causing equipment malfunction or failure. Controlling electrostatic discharge begins with understanding how electrostatic charge occurs in the first place. Electrostatic charge is most commonly created by the contact and separation of two similar or dissimilar materials. For example, a person walking across the floor generates static electricity as his/her shoe soles contact and then separate from the floor surface. An electronic device sliding into or out of a bag, magazine, or tube generates an electrostatic charge as the device's case and/or metal leads make multiple contacts and separations with the surface of the container. While the magnitude of electrostatic charge may be different in these examples, static electricity is indeed generated.

The IPT should include the electrostatic discharge requirements of Section 3.2.6 in the SLS.

2.9 Transportability

Section 3.2.7 of FAA-G-2100g serves as a reminder to the IPT that transportability requirements must be addressed in the SLS.

2.10 Equipment Design and Construction

2.10.1 Dissimilar Metals

Section 3.3.1.1 of FAA-G-2100g addresses the requirements regarding dissimilar metals, corrosion resistant metals, and flammable materials.

This section identifies dissimilar metals and assures that combinations of dissimilar metals are compatible and/or protected from exterior environments. It requires metals to be corrosion resistant, coated, or metallurgically processed to resist corrosion. This section also requires noncombustible or fire retardant materials.

The IPT should include the applicable requirements for dissimilar metals, corrosion resistan metals, and flammable materials of Section 3.3.1.1 in the SLS.

2.10.2 Equipment Manufacturing Processes

Section 3.3.1.2 of FAA-G-2100g addresses the equipment manufacturing process requireme regarding strain relief, painted finishes, and cadmium plating.

To prevent connection points of cables, wiring, or fiber optics from breaking due to tensile or shear stress, strain relief mechanisms are required.

Unprotected metal surfaces are required to be painted. Painted surfaces must withstand the environmental conditions the equipment will be exposed to without degrading the paint surface or allowing any corrosion. FAA-G-2100g requires the paint finish to be in accordance with FAA-STD-001. When COTS equipment meets the acquisition program's requirements, the paint finish can be the standard manufacturer's color. If the manufacturer of the electronic equipment, console, or rack allows a color selection, the acquisition program should select a color. In addition, hazardous paints shall not be used.

The use of cadmium plating has the potential of causing cancer in humans. This section addresses situations when cadmium plating shall not be used and, if used, requires the plating to be in accordance with Type II, Class I of ASTM B766.

The IPT should determine the applicable requirements in Section 3.3.1.2 for strain relief, painted finishes, and cadmium plating and include them in the SLS.

2.10.3 Electrical Parts

Section 3.3.1.3 of FAA-G-2100g addresses the electrical parts requirements for batteries, circuit breakers, electrical connectors, fuses, fuse holders, indicating meters, printed wiring board modifications, conformal coating of printed circuit boards, electromagnetic shielding, switches, and wiring.

Section 3.3.1.3 provides general requirements for the electrical components of the electronic equipment.

Section 3.3.1.3.1 of FAA-G-2100g sets requirements for batteries, which includes minimum battery life, maximum time for replacing batteries, requirements on leaking, ability to maintain, secure fitting, and markings.

Section 3.3.1.3.2 of FAA-G-2100g addresses requirements for circuit breakers. This section sets requirements for selection and application to include provision of complete overcurrent protection, operating by a toggle type handle, non-use as switches unless specifically approved, handle clearly indicated, and restriction from use as a thermal overload relay.

Section 3.3.1.3.10 of FAA-G-2100g addresses requirements for wiring to include the following: clearance and leakage distances, marking, wiring protection, insulation cold flow, cable ducts, bend radius, sleeving, panel door cables, through hole protection, wiring arrangement, slack, wiring in terminal boxes, entrance cabling and wiring, wire, support, conductor's insulation sleeving, fungus protection, aluminum conductors, fiber optics, and raised floor cabling.

The IPT should determine the applicable requirements in Section 3.3.1.3 for electrical parts and include them in the SLS.

2.10.4 Mechanical Parts

Section 3.3.1.4 of FAA-G-2100g addresses the electronic equipment mechanical parts requirements for bearings, controls and switches, fastener hardware, and special tools.

Section 3.3.1.4 of FAA-G-2100g provides general requirements for the mechanical components used in the electronic equipment.

IPTs involved in items where motors, clutches, brakes, and the like should be aware the taper locking bushing requirements of 3.3.1.4.2.8 will dramatically lower their Mean Time To Repair (MTTR). Removal and replacement requires little skill and no more than an Allen wrench and/or an adjustable hand wrench, removes the need for special pulling and pressing tools from the required tool list.

There will be an increase in Mean Time Between Failure (MTBF) by using taper locking items in place of conventionally bored items. The taper lock securely grips the entire shaft circumference, even when neither the shaft nor the item mounted on it is of the correct dimension.

The maintaining staff has been known to use hammers to drive items on and off shafts. This practice assures that MTBF will be lower than necessary and, at some time, after the shaft bearings have failed due to impact, an increase in MTTR.

The IPT should determine the applicable requirements in Section 3.3.1.4 for bearings, controls and switches, fastener hardware, and special tools and include them in the SLS.

2.10.5 Miscellaneous Items

Section 3.3.1.5 of FAA-G-2100g addresses requirements for glass and motor types. The motors covered in this section are one horsepower and larger types, fractional horsepower, and ventilating fan motors.

Section 3.3.1.5.1 requires that all glass used in the equipment, except for cathode ray tubes, be of the shatterproof type and appropriate for the specified environmental conditions.

Section 3.3.1.5.2 of FAA-2100g defines requirements for fractional horsepower motors (less than one horsepower), integral (one horsepower and larger) and ventilating fan motors, commonly called “pancake.”

NEMA Design B is the standard design used for motors. Design B has the next to lowest inrush current and normal starting torque, and is the most standard design for the vast majority of applications.

Design E Energy rating provides the most cost effective energy efficiency currently available. The average KwH cost for the entire government is approximately 5 cents. The “E” energy rating is the lower of two current standards for motor energy efficiency. Of the two, this design is more tolerant of voltage imbalance. IPTs should be aware of this effect if the higher efficiency motors are offered. Cost vs. benefits may be affected by site-specific problems.

The IPT should determine the applicable glass and motor requirements in Section 3.3.1.5 and include them in the SLS.

2.11 Electromagnetic Compatibility

Section 3.3.2 of FAA-G-2100g addresses the electronic equipment electromagnetic compatibility requirements.

The electromagnetic compatibility requirements of this section are applicable to the extent defined in the individual equipment or subsystem specification.

The IPT should determine the applicable electromagnetic compatibility requirements in Section 3.3.2 and include them in the SLS.

2.12 Nameplates and Marking

Section 3.3.3 of FAA-G-2100g addresses the electronic equipment requirements for nameplates, equipment titles, serial numbers, and marking of parts, controls, and indicating devices.

The IPT should determine the applicable nameplates and marking requirements in Section 3.3.3 and include them in the SLS.

2.13 Interchangeability

Section 3.3.4 of FAA-G-2100g requires that the electronic equipment parts be interchangeable in form, fit, and function. This information should be included in the SLS by the IPT.

2.14 Personnel Safety and Health

Section 3.3.5 of FAA-G-2100g addresses personnel safety and health requirements, such as equipment construction (NFPA Code 70), anchoring of equipment (FEMA Publication 302 Section 6.3), safety with respect to RF EMF (ANSI/IEEE C 95-1991), technology equipment (UL 1950), protection from moving parts when replacing filters, and use of edge guards.

Section 3.3.5 of FAA-G-2100g addresses the personnel safety and health requirements. These requirements include electrical safety, laser radiation limits, switches, mechanical hazards, markings, signs, tags and symbols, hazardous and restricted materials, and seismic safety.

2.14.1 Electrical Safety

Section 3.3.5.1 of FAA-G-2100g addresses the requirements regarding electrical safety.

The electrical safety section sets the safety requirements for ground potential, panels/doors, shielding, bonding in hazardous areas, RF, interlocks, shorting rods, meter safety, high voltage protection, high current protection, discharge devices, and electrical connectors.

Section 3.3.5.1.1, ground potential, covers requirements on external parts, surfaces, interconnecting cable, exclusive use of coaxial cables for current-carrying ground connection, antenna, plugs, outer metal cases, and external casing.

Section 3.3.5.1.3, shielding, requires specific grounding of shielding and sets distance requirements.

Section 3.3.5.1.4 covers bonding in hazardous areas. These requirements must conform to NFPA 70 and FAA-STD-019b.

Section 3.3.5.1.6 sets requirements for interlocks, which includes the voltage level required for interlocks, other systems in those voltage ranges that cancel the need for interlocks, bypassable interlock switches, and requirements for these bypass switches.

Section 3.3.5.1.9, high voltage protection, sets requirement for enclosures and other protections at certain voltage levels. It also sets the standards for test probe holes, test points, and the use of voltage dividers.

Section 3.3.5.1.10, high current protection, sets the requirement on power buses and the surrounding equipment and materials potential for short circuiting when current rating is excessive.

Section 3.3.5.1.11 sets the requirements for discharge devices, including standards for discharge time for particular voltage levels given high voltage circuits and capacitors. Also included are requirements protective devices, shorting bars, and resistive bleeder networks.

The IPT should be in accordance with FAA-STD-019 for the following: hinge or slide mounted panels and doors, and bonding in hazardous areas. It should also be in accordance with NFPA 70 for bonding in hazardous areas.

All applicable requirements for electronic safety of Section 3.3.5.1 should be included in the SLS by the IPT.

2.14.2 Laser Radiation Limits

Section 3.3.5.2 of FAA-G-2100g provides limits conforming to 21CFR1040, FDA, DHHS, Part 1040 Performance Standards for Light –Emitting Products. All requirements in this section should be included in the SLS by the IPT.

2.14.3 Switches

Section 3.3.5.3 of FAA-G-2100g addresses the use of safety switches and momentary override switches. This section includes equipment and procedures that must be in accordance with NEMA KS-1 and NFPA-70 or OSHA. All requirements in this section should be included in the SLS by the IPT.

2.14.4 Mechanical Hazards

Section 3.3.5.4 of FAA-G-2100g addresses the design and inspection of equipment to avoid mechanical hazards.

The mechanical hazards section pays particular attention to mechanical interconnections, cathode ray tubes, and glass fibers. The cathode ray tubes should conform to UL 1418.

All applicable requirements for mechanical hazards of Section 3.3.5.5 should be included in the SLS by the IPT.

2.14.5 Markings, Signs, Tags, and Symbols

Section 3.3.5.5 of FAA-G-2100g provides the requirements for creating and setting up the various safety signs and signals.

This section covers proper markings, accident prevention signs and labels, sign design, sign classification (Class I – IV), sign placement marking of radioactive material, symbols, alerts/warnings, audio warning signals, display warnings, and battery warning labels.

The IPT needs to pay particular attention to properly include the various OSHA requirements found in Section 3.3.5.5 in the SLS.

2.14.6 Hazardous and Restricted Materials

Section 3.3.5.6 of FAA-G-2100g limits what materials may be used due to the hazards and health problems attributed to working around such materials.

These restricted materials fall in the one of the following categories: carcinogens (should conform to 29CFR1990); dusts, mists, fumes, and gases; restricted materials; and radioactive materials. Mercury and asbestos are strictly prohibited from use. Restrictions on radium and other radioactive materials must conform to Nuclear Regulatory Commission (NRC) regulations.

All applicable requirements for mechanical hazards of Section 3.3.5.6 should be included in the SLS by the IPT.

2.14.7 Seismic Safety

Section 3.3.5.7 of FAA-G-2100g covers the requirements for work locations near major faults or locations otherwise troubled with seismic activities. Equipment must be in accordance with IBC 2000 techniques in conjunction with FEMA 302, NEHRP (National Earthquake Hazard Reduction Program) Recommended Provisions for Seismic Regulations for New Building and Other Structures, Chapter 6.

All requirements in this section should be included in the SLS by the IPT.

2.15 Human Engineering

Section 3.3.6 of FAA-G-2100g addresses human engineering for design and development of electronics equipment. These requirements include noise criteria requirements (42USC 4901), ergonomic considerations, weight lifting limits, visual displays, and labeling (DOT/FAA/CT-961).

2.15.1 Noise Criteria

Section 3.3.6.1 of FAA-G-2100g addresses the different noise level limits. These limits are governed by location (indoor/outdoor requirements) and hearing protection. Noise limits should conform to local ordinances in accordance with 42 USC 4901 (the Noise Control Act of 1972). It also provides information pertaining to identification of noise hazard areas and equipment.

2.15.2 Ergonomic Considerations

Section 3.3.6.2 of FAA-G-2100g requires that equipment ergonomic considerations conform to with DOT/FAA/CT-961.

2.15.3 Weight Lifting Limits

Section 3.3.6.3 of FAA-G-2100g requires weightlifting limits to be in accordance with DOT/FAA/CT-961.

2.15.4 Visual Displays

Section 3.3.6.4 of FAA-G-2100g addresses the requirement for various visual displays.

The following subjects are discussed in more detail: display information, display positive feedback, light-emitting displays (LED) displays, and flash.

All applicable requirements for visual displays of Section 3.3.5.6 should be included in the SLS by the IPT.

2.15.5 Labeling

Section 3.3.6.5 of FAA-G-2100g provides requirements for various labels. Label characters should conform to DOT/FAA/CT-961.

2.16 Documentation

Section 3.4 of FAA-G-2100g addresses proper documentation and refers to FAA-D-2494 for general requirements.

2.17 Personnel and Training

Personnel and training issues shall be considered in relation to the equipment utilization and maintainability requirements. All applicable requirements for training and personnel should be included in the SLS by the IPT.

3 Acronyms and Definitions

3.1 Acronyms and Abbreviations

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

ANSI	American National Standards Institute
ASCE	American Society for Civil Engineers
ASTM	American Society for Testing Materials
AC	Alternating Current
BPH	British Thermal Unit per square foot
C	Celsius
CBEMA	Computer and Business Equipment Manufacturer's Association
CFR	Code of Federal Regulations
COTS	Commercial off-the-shelf
DC	Direct Current
DESC	Defense Electronics Supply Center
DHHS	Department of Health and Human Services
DOT	Department of Transportation
EMF	Electromagnetic Force
F	Fahrenheit
FAA	Federal Aviation Administration
FDA	Food and Drug Administration
FEMA	Federal Emergency Management Administration
HVAC	Heating, Ventilation, and Air Conditioning
Hz	Hertz
IAW	In Accordance With
IEEE	Institute of Electrical and Electronics Engineers
I_N	Individual Current Harmonic Distortion
IPC	Integrated Printed Circuit
IPT	Integrated Product Team
ITI	Information Technology Industry Council
kV	Kilovolt
kVA	Kilovolt Ampere
kWh	Kilowatt Hour
LED	Light-emitting Diode
LRU	Lowest Replaceable Unit

MIL	Military
NAS	National Airspace System
NATO	North Atlantic Treaty Organization
NEHRP	National Earthquake Hazards Reduction Program
NEMA	National Electronic Manufacturers Association
NDI	Non-Developmental Items
NFPA	National Fire Protection Association
NRTL	Nationally Recognized Testing Laboratory
OSHA	Occupational Safety and Health Administration
PF	Power Factor
PROM	Programmable Read Only Memory
RF	Radio Frequency
RMS	Remote Monitoring Subsystem
SCR	Thyristors
SLS	System Level Specifications
STANAG	Standard Agreements
STD	Standard
TCD	Total Current Distortion
THD	Total Harmonic Distortion
UL	Underwriters Laboratories, Inc.
UPS	Uninterruptible Power Supply
V	Volts
VA	Volt Ampere
VFD	Variable Frequency Drives
W	Watt

3.2 Definitions

3.2.1 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.

3.2.2 Developmental item

A developmental item is 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.

3.2.3 Fail-safe

A failure does not adversely affect the safety of the NAS. This statement 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. It also means that a failure in the equipment shall not create a safety hazard to the personnel who maintain the equipment.

3.2.4 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.

3.2.5 Lowest Replaceable Unit (LRU)

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 that performs a single function or group of closely related functions.

3.2.6 Internal/building wiring

The electronic equipment electrical power interface to the building is shown in Figure 3. 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.

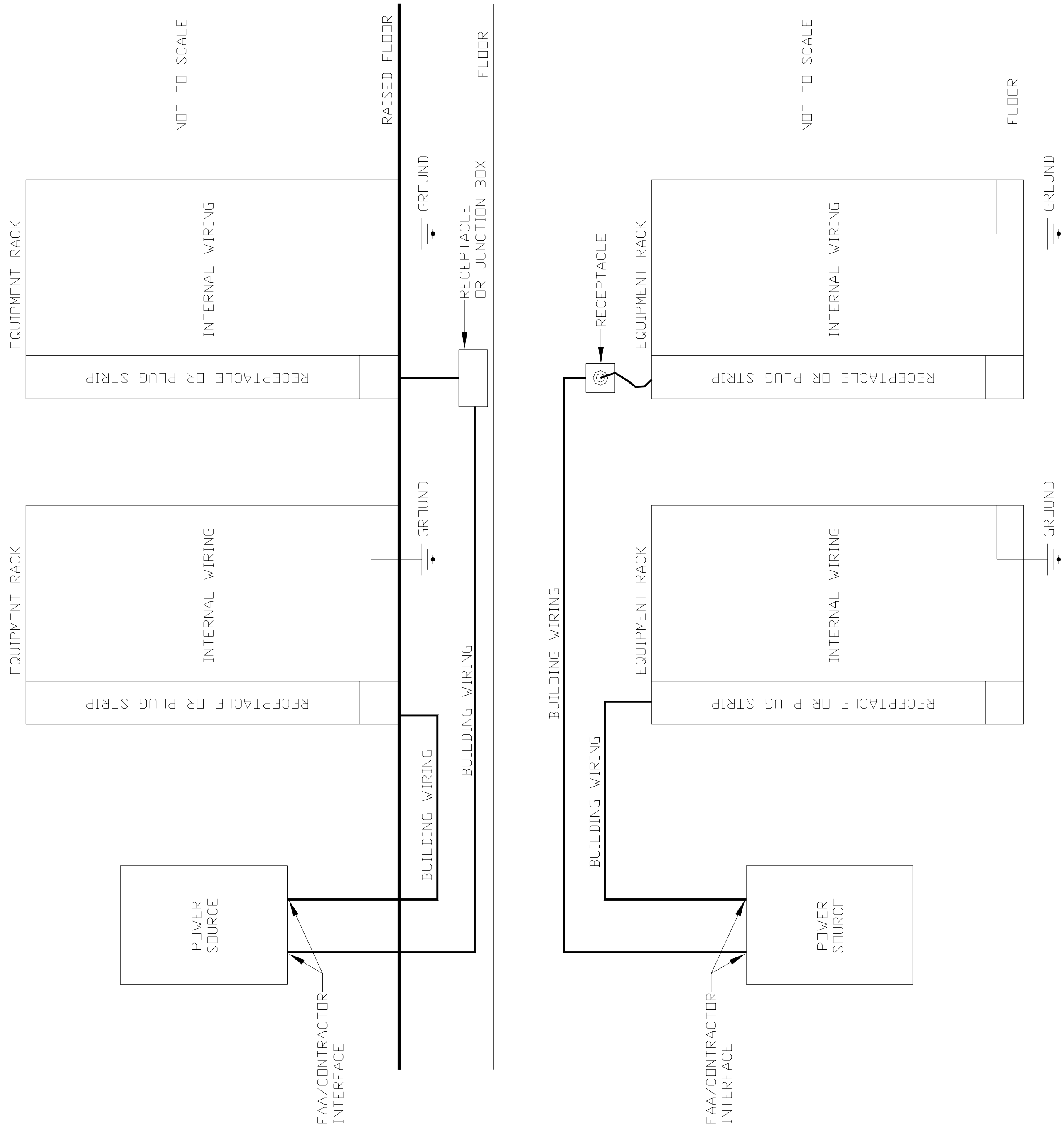

FIGURE 3. Internal/building Electrical Power Wiring Diagram

3.2.7 Modified COTS/commercial type product

Modified COTS/commercial type products is equipment that has been modified to meet functional requirements. It also signifies a commercial product that (a) has been modified to meet some government-specific [illegible] (b) has otherwise been identified differently from its [illegible] arts. Within this document, modified COTS equipment is [illegible]

3.2.8 Nationally Recognized Testing La[illegible]

An NRTL is an organization recognized by [illegible] endix A of Title 29 of the Code of Federal Regulations ([illegible] 910.7).

3.2.9 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, including 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, is not available in the commercial marketplace.

3.2.10 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.

3.2.11 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.

3.2.12 Series Combination System Overcurrent

A series combination system overcurrent consists of two or more overcurrent protection devices wired in series and relied upon as a combination to provide overcurrent protection.