INCH-POUND
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PERFORMANCE SPECIFICATION

INTEGRATED POWER NODE CENTER (IPNC)

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

1. SCOPE

1.1 Scope. This specification covers the Integrated Power Node Center (IPNC), herein referred to as the IPNC. The IPNC can provide distribution, switching, control, and conditioning for electrical power systems.

2. APPLICABLE DOCUMENTS

2.1 General. The documents listed in this section are specified in sections 3, 4, or 5 of this specification. This section does not include documents cited in other sections of this specification or recommended for additional information or as examples. While every effort has been made to ensure the completeness of this list, document users are cautioned that they must meet all specified requirements of documents cited in sections 3, 4, or 5 of this specification, whether or not they are listed.

2.2 Government documents.

2.2.1 Specifications, standards, and handbooks. The following specifications, standards, and handbooks form a part of this document to the extent specified herein. Unless otherwise specified, the issues of these documents are those cited in the solicitation or contract.

DEPARTMENT OF DEFENSE SPECIFICATIONS

MIL-S-901	-	Shock Tests, H.I. (High-Impact), Shipboard Machinery, Equipment, and Systems, Requirements for
MIL-E-917	-	Electric Power Equipment Basic Requirements
MIL-E-2036	-	Enclosures for Electric and Electronic Equipment, Naval Shipboard
MIL-DTL-15024	-	Plates, Tags, and Bands for Identification of Equipment, General Specification for
MIL-T-16366	-	Terminal, Electrical Lug and Conductor Splices, Crimp Style

DEPARTMENT OF DEFENSE STANDARDS

MIL-STD-108	-	Definition of and Basic Requirements for Enclosure for Electric and Electronic Equipment
MIL-STD-167-1	-	Mechanical Vibration of Shipboard Equipment (Type I – Environmental and Type II – Internally Excited)
MIL-STD-202	-	Electronic and Electrical Component Parts
MIL-STD-461	-	Requirements for the Control of Electromagnetic Interference Characteristics of Subsystems and Equipment

Comments, suggestions, or questions on this document should be addressed to: Commander, Naval Sea Systems Command, ATTN: SEA 05M3, 1333 Isaac Hull Avenue, SE, Stop 5160, Washington Navy Yard DC 20376-5160 or emailed to CommandStandards@navy.mil, with the subject line “Document Comment”. Since contact information can change, you may want to verify the currency of this address information using the ASSIST Online database at http://assist.daps.dla.mil.

MIL-STD-681	-	Identification Coding and Application of Hookup and Lead Wire
MIL-STD-740-2	-	Structureborne Vibratory Acceleration Measurements and Acceptance Criteria of Shipboard Equipment
MIL-STD-1310	-	Standard Practice for Shipboard Bonding, Grounding, and Other Techniques for Electromagnetic Compatibility and Safety
MIL-STD-1399	-	Interface Standard for Shipboard Systems
DOD-STD-1399-070	-	Interface Standard for Shipboard Systems Section 070-Part 1 D.C. Magnetic Field Environment (Metric)
MIL-STD-1399-300	-	Interface Standard for Shipboard Systems, Section 300A Electric Power, Alternating Current (Metric)
MIL-STD-1472	-	Human Engineering
MIL-STD-1474	-	Noise Limits
MIL-STD-1686	-	Electrostatic Discharge Control Program for Protection of Electrical and Electronic Parts, Assemblies and Equipment (Excluding Electrically Initiated Explosive Devices)

DEPARTMENT OF DEFENSE HANDBOOKS

MIL-HDBK-454	-	General Guidelines for Electronic Equipment

(Copies of these documents are available online at http://assist.daps.dla.mil or from the Standardization Document Order Desk, 700 Robbins Avenue, Building 4D, Philadelphia, PA 19111-5094.)

2.2.2 Other Government documents, drawings, and publications. The following other Government documents, drawings, and publications form a part of this document to the extent specified herein. Unless otherwise specified, the issues of these documents are those cited in the solicitation or contract.

NAVSEA TECHNICAL PUBLICATION

S0400-AD-URM-010/TUM	-	Tag-Out Users Manual

(Copies of this document are available online at http://www.submepp.navy.mil/jfmm/tum/tag_out.pdf.)

2.3 Non-Government publications. The following documents form a part of this document to the extent specified herein. Unless otherwise specified, the issues of these documents are those cited in the solicitation or contract.

INSTITUTE OF ELECTRICAL AND ELECTRONICS ENGINEERS, INC. (IEEE)

IEEE 1012	-	Standard for Software Verification and Validation
IEEE 1394	-	Standard for a High Performance Serial Bus

(Copies of these documents are available online at www.ieee.org or from the Institute of Electrical and Electronics Engineers, Inc., 445 Hoes Lane, P.O. Box 1331, Piscataway, NJ 08855-1331.)

2.4 Order of precedence. In the event of a conflict between the text of this document and the references cited herein, the text of this document takes precedence. Nothing in this document, however, supersedes applicable laws and regulations unless a specific exemption has been obtained.

3. REQUIREMENTS

3.1 First article. When specified (see 6.2), a sample shall be subjected to first article inspection in accordance with section 4.

3.2 Power quality performance requirements.

3.2.1 Power input requirements.

3.2.1.1 AC input power compatibility. The IPNC shall be compatible with AC power sources having characteristics as given in MIL-STD-1399-300 and Table I where characteristics exceed MIL-STD-1399-300.

TABLE I. AC input power characteristics exceeding MIL-STD-1399-300.

Characteristic	Requirement
Frequency	
1. Frequency Tolerance	±5.0%
2. Frequency Modulation	2.0%
3. Frequency Transient Tolerance	±8.0%
4. Worst-Case Frequency Excursion	±10.0%
Voltage	
5. Line Voltage Tolerance	
– Average of Three Line-to-Line Voltages	±10.0%
– Any One Line-to-Line	±15.0%
6. Maximum Departure Voltage	±10.0%
Voltage Waveform	
7. Maximum Total Harmonic Distortion	10.0%
8. Maximum Single Harmonic	7.0%
9. Maximum Deviation Factor	10.0%

3.2.1.2 DC input power compatibility. The IPNC shall be compatible with DC power inputs having characteristics provided in Table II.

TABLE II. DC input power compatibility.

Characteristic	Requirement
Type	Two-Wire DC Ungrounded
1. Steady-State Voltage	
– Nominal	750 V
– Adjustable Range	734–800 V
2. Transient Voltage with 0.2-Sec Recovery	654–880 V
3. Voltage Ripple (p-p)	12 V
4. Voltage Spike Withstand (peak value)	2.5 kV

3.2.2 Output power.

3.2.2.1 Output power – 440 V. The IPNC output power quality requirements for 440 V loads shall meet the characteristics listed in Table III.

TABLE III. Output power quality characteristics as measured at the output terminals, 440 V.

Characteristic	Requirement
Output Type	Three-phase, three-wire, ungrounded
Frequency	
1. Frequency	
– Nominal	60 Hz
– Adjustable Range	50–400 Hz
2. Frequency Tolerance	±0.5%
3. Frequency Modulation	0.5%
4. Frequency Transient Tolerance	
– on circuit creating transient	±2.0%
– on adjacent circuits	±1.0%
5. Frequency Excursion, Worst-Case	±1.5%
6. Frequency Transient and Excursion Recovery Time	0.25 sec
Voltage	
7. Nominal User Voltage (V_{rms})	440 V
Adjustable Range	440–460 V
8. Voltage Unbalance	2.0%
9. Voltage Tolerance	
– Average of Three Line-to Line	±2.0%
– Any One Line-to-Line	±3.0%
10. Voltage Modulation	1.0%
11. Maximum Departure Voltage	±2.5%
12. Voltage Transient Tolerance	
– on circuit creating transient	±5.0%
– on adjacent circuits	±3.0%
13. Voltage Excursion, Worst-Case	±5.5%
14. Voltage Transient and Excursion Recovery Time	0.25 sec
15. Voltage Phase Displacement	±1 degree under balanced load condition
Voltage Waveform	
16. Maximum Total Harmonic Distortion	3.0%
17. Maximum Single Harmonic	2.0%
18. Maximum Deviation Factor	3.0%
Load Current Programmability	
19. Adjustable	10-100%

3.2.2.2 Output power quality – 115 V and 115/200 V. The IPNC output power characteristics for 115 V and 115/200 V loads shall be in accordance with Table IV.

TABLE IV. Output power quality characteristics as measured at the output terminals, 115 V and 115/200 V circuits.

Characteristic	Requirement	
	115 V	115/200 V
Output Type	Single or three-phase, three-wire, ungrounded (Delta Connected)	Single or three-phase, four-wire, neutral or grounded (WYE Connected)
Frequency		
1. Frequency	60 Hz	60 Hz
– Nominal	60 Hz	60 Hz
– Adjustable Range	50–400 Hz	50–400 Hz
2. Frequency Tolerance	±0.5%	±0.5%
3. Frequency Modulation	0.5%	0.5%
4. Frequency Transient Tolerance	±1.0%	±1.0%
5. Frequency Excursion, Worst-Case	±1.5%	±1.5%
6. Frequency Transient and Excursion Recovery Time	0.25 sec	0.25 sec
Voltage		
7. Voltage		
– Nominal	115 V	115/200 V
– Adjustable Range	115–120 V	115/200–120/208 V
8. Voltage Unbalance	2.0%	2.0%
9. Voltage Tolerance		
–Average of Three Line-to Line Voltages	±2.0%	±2.0%
–Any One Line-to-Line	±3.0%	±3.0%
10. Voltage Modulation	1.0%	1.0%
11. Maximum Departure Voltage	±2.5%	±2.5%
12. Voltage Transient Tolerance	±5.0%	±5.0%
13. Voltage Excursion, Worst-Case	±5.5%	±5.5%
14. Voltage Transient and Excursion Recovery Time	0.25 sec	0.25 sec
15. Voltage Phase Displacement	±3 degrees	±2 degrees
Voltage Waveform		
16. Maximum Total Harmonic Distortion	3.0%	3.0%
17. Maximum Single Harmonic	2.0%	2.0%
18. Maximum Deviation Factor	5.0%	5.0%
Load Current Programmability		
19. Adjustable	10–100%	10–100%

3.2.2.3 DC output power quality. The IPNC DC output power quality characteristics shall be in accordance with Table V.

TABLE V. DC output power characteristics as measured at the output terminals – two-wire ungrounded.

Characteristic	Requirement			
	375 V	120 V	48 V	24 V
Voltage				
1. Nominal Voltage	375 V	120 V	48 V	24 V
2. Adjustable Range	370–380 V	115–125 V	46–52 V	22–28 V
3. Voltage Tolerance	±1.0%	±1.0%	±2.0%	±2.0%
4. Voltage Regulation	±1.0%	±1.0%	±2.0%	±2.0%
5. Voltage Transient	±10.0%	±10.0%	±20%	±20%
6. Voltage Transient Recovery	0.2 sec	0.2 sec	0.2 sec	0.2 sec
7. Voltage Ripple (P-P) – Maximum	2.0%	2.0%	3.0%	3.0%
Load Current Programmability				
8. Adjustable Range	50–100%	50–100%	50–100%	50–100%

3.2.3 Special load characteristics. Provisions shall be made to feed loads that do not comply with MIL-STD-1399 and have special input requirements and/or special fault management requirements as specified (see 6.2).

3.3 Supervisory control and data acquisition (SCADA).

3.3.1 Supervisory control. The IPNC, utilizing multi-functional programmable module (MFPM), shall provide supervisory control from a local human-machine interface (HMI) at the IPNC. HMI functions are available for remote control stations.

3.3.1.1 Input control. The IPNC shall have provisions to accept power from multiple sources. The following control features shall be provided when two or more sources are utilized:

a. Power source selection mode – seamless transfer (see 6.3.1)
   (1) Select normal or alternate source
   (2) Select transfer criteria to include normal seeking or power seeking, transfer time, and over and under voltage

b. Power source sharing mode
   (1) Select normal or alternate
   (2) Select power sharing percentage (the ratio of power sharing shall be adjustable)
   (3) Disable/enable source power sharing via the HMI controls

3.3.1.2 Control. The IPNC shall provide the following controls:

3.3.1.2.1 IPNC control.

a. Local/remote (control selection shall be exercised from the local HMI). The local/remote control shall be available to turn the IPNC outputs on or off and make the following adjustments:
   (1) Output voltage setting
   (2) Output current setting
   (3) Selection of which source is normal and which is alternate when dual sources are provided

(4) Selection of source transfer criteria when dual sources are provided

b. Select load shedding criteria – the setting shall select the priority sequence of automatically shedding loads upon the receipt of a signal from the electric power system control. The operator shall be able to select the load priorities.

c. Emergency shutdown – the IPNC shall have the ability to shutdown all the output circuits via an emergency shutdown control.

d. Select load reenergization criteria – the setting shall select the priority sequence for automatically reenergizing the loads upon receipt of a signal from the electric power system control. The operator shall be able to select the load priorities.

3.3.1.2.2 Output MFPM control.

a. Output power module ON/OFF

b. Select 440 Vrms output module for voltage source or current source mode if 440 V output modules are used

c. Select voltage output level – the output voltage level shall be adjustable within the range given in Table III, Table IV, and Table V.

d. Select load current level – the load current maximum limit setting shall be adjustable within the range given in Table III, Table IV, and Table V.

e. Select motor speed setting between 25 percent speed to 100 percent speed in 5-percent increments for motor loads – motor speed is monitored at the motor and a signal sent to the IPNC. The IPNC shall accommodate industry standard control signals.

f. Select output frequency – The frequency shall be adjustable within the range given in Table III, Table IV, and Table V.

3.3.1.3 Display data. The IPNC shall have provisions to display the following information (If remote is provided, identical data shall be available for local and remote):

a. Input parameters (Voltage (V), current (A), frequency (Hz), power factor (pf), power (kW))

b. Individual output MFPM parameters (V, A, Hz, pf, kW)

c. Individual output MFPM status (ON/OFF or Faulted)

d. Input MFPM settings

e. System configuration (mimic)

f. Source selection

g. Transfer from normal to alternate settings and re-transfer settings

h. Selection for power sharing

i. Percentage of input power sharing

j. Load shedding priority

k. Motor speed setting

l. Equipment Performance Monitoring (EPM) (see 3.4.6)

m. System faults and types of faults

n. Control status (Status of primary user control (local or remote) when remote control exists)

o. Reenergization settings

p. Emergency shutdown

3.3.1.3.1 Indicator and audible alarm. Indicator and audible alarms shall be provided and designed in accordance with MIL-STD-1472.

3.4 Fault management.

3.4.1 System faults. The IPNC shall detect, isolate, and report downstream faulted circuits, including:

a. Overloads
b. Three-phase faults and line-to-line faults
c. Line-to-ground faults
   (1) Three-phase, three-wire continuous monitoring
   (2) Three-phase, four-wire monitoring and interrupt
d. Open conductor
e. Motor locked rotor current
f. Motor single phasing

3.4.2 Fault management characteristics – 440 V. For 440 V applications, the IPNC shall provide fault management characteristics listed in Table VI for output power.

TABLE VI. Fault management characteristics.

Characteristic	Requirement
Fault Type	Three-phase, three-wire, ungrounded
1. Overload Protection	Adjustable delay and interruption
2. Line-to-Line and Three-Phase Fault Protection	Adjustable delay and interruption
3. Line-to-Ground Fault Detection	Continuous monitoring and indication

3.4.3 Fault management characteristics – 115 V and 115/200 V. The IPNC fault management output characteristics for 115 V and 115/200 V applications shall be in accordance with Table VII.

TABLE VII. Fault management characteristics, 115 V and 115/200 V circuits.

Characteristic	Requirement	
	115 V	115/200 V
Output Type	Single or three-phase, three-wire, ungrounded (Delta Connected)	Single or three-phase, four-wire, neutral or grounded (WYE Connected)
1. Overload Protection	Adjustable delay and interruption	Adjustable delay and interruption
2. Line-to-Line and Phase Fault Protection	Adjustable delay and interruption	Adjustable delay and interruption
3. Line-to-Ground Fault Detection	Continuous monitoring and indication	Continuous monitoring and indication and interruption

3.4.4 DC fault management characteristics. IPNC DC fault management characteristics shall be in accordance with Table VIII.

TABLE VIII. DC fault management characteristics – two-wire ungrounded.

Characteristic	Requirement
Output Type	24 V, 48 V, 120 V, 375 V
1. Overload Protection	Adjustable delay and interruption
2. Short-circuit Protection	Adjustable delay and interruption
3. Line-to-Ground Fault Detection	Continuous monitoring and indication

3.4.5 Fault protection settings. When specified (see 6.2), specific fault protection setting coordination sheets shall be provided.

3.4.6 Equipment performance monitoring (EPM). Equipment performance monitoring capabilities shall be provided to support operation and maintenance. Monitoring shall be capable of monitoring the normal mode of operation of the IPNC for the purpose of detecting and reporting faults of the types identified in 3.4.6.1.

3.4.6.1 IPNC faults. The IPNC shall detect and display the following equipment faults at the HMI panel and provide output for remote monitoring.

a. Loss of cooling fan
b. Loss of output power of operating MFPM
c. Over temperature of each MFPM
d. Failure of MFPMs to respond to operating control command
e. Communications failure – internal
f. Communications failure – remote

3.5 Electrical requirements.

3.5.1 Continuous current. The IPNC shall carry the full continuous current rating without exceeding the temperature rise limit of any internal component and without exceeding the enclosure external temperature of 149 °F (65 °C). The unit shall meet the continuous-current requirements based on a 122 °F (50 °C) ambient external to the enclosure. See test condition in 4.8.1.

3.5.2 Emergency conditions (input power emergency conditions). Unless otherwise specified (see 6.2), the two-minute emergency condition required by MIL-STD-1399-300 shall have a start-up time of not greater than two seconds.

3.5.2.1 Shutdown. Sources are not available and loads will not be supplied.

3.5.2.2 Input over-voltage and over-frequency. Loads will be supplied, but input current harmonics may exceed MIL-STD-1399-300.

3.5.3 Source impact. The IPNC impact on the source shall be as given below:

a. Pf Control >0.97 for loading >75% of rating
>0.96 for loading >50% of rating
>0.95 for loading >25% of rating
>0.80 for loading >10% of rating
b. Current Harmonics (Waveshape) 3% maximum for 2^{nd} to 32^{nd} harmonic
100/n – 32^{nd} to 20 kHz
c. Current Unbalance Control (Average) 3%

3.5.4 Insulation integrity.

3.5.4.1 Insulation resistance. The IPNC shall meet equipment insulation resistance of at least 10 megohms at 77 °F (25 °C).

3.5.4.2 Dielectric withstand. The IPNC shall meet the requirements of MIL-STD-202, Test Method 301, for dielectric withstanding voltage.

3.5.4.3 Voltage spike withstand. The IPNC modules and the enclosure shall withstand the voltage spike as given in MIL-STD-1399-300.

3.5.4.4 Creepage and clearance distances. Electrical creepage and clearance distances for cable connections shall be in accordance with MIL-E-917.

3.5.5 Leakage current.

3.5.5.1 Ground fault leakage current. Ground leakage current shall be as specified in MIL-E-917.

3.5.5.2 Safety leakage current. The leakage current (input to output) at 122° F (50°C) ambient shall not exceed 0.5 milliamps at 60 Hz to 700 Hz when tested in accordance with Appendix B.

3.5.6 Line filter capacitors to ground. Unless otherwise specified (see 6.2), each line-to-ground filter capacitance on the input and output side for each input and output circuit shall not exceed 0.1 µF per phase.

3.5.7 Source-to-load impedance. The source-to-load impedance shall not be less than 1.3 megohms at 68 °F (20 °C) and shall be not less than 0.8 megohms at 122 °F (50 °C). Both tests are to be performed with the output MFPM in the OFF state.

3.5.8 Source-to-source impedance. Unless otherwise specified (see 6.2), the source-to-source impedance shall not be less than 1.3 megohms at 68 °F (20 °C) and shall be not less than 0.8 megohms at 122 °F (50 °C) with a minimum load of 25 A on one source and the other source in standby.

3.5.9 Electromagnetic interference (EMI). The IPNC shall meet the surface ship and submarine requirements specified in MIL-STD-461 for CE101, CE102, CS101, CS114, CS116, RE101, RE102, RS101, and RS103; and, when specified, CS115 (see 6.2).

3.5.10 Endurance. Unless otherwise specified (see 6.2), the IPNC shall meet endurance requirements when tested in accordance with 4.9.7.

3.5.11 Grounding, bonding, and shielding. The IPNC shall incorporate the electrical grounding, bonding, and shielding provision in accordance with MIL-STD-1310. Provision shall be available for terminating the ground shields on incoming and outgoing cables. MIL-HDBK-454 may be used for guidance.

3.5.11.1 Chassis grounding. All external parts capable of electrical conduction shall be at ground potential at all times in accordance with MIL-STD-1310. The DC resistance measured from the conductive frame of any assembly receiving primary power and the unit electrical bond point shall not exceed 0.1 ohm.

3.5.12 DC magnetic field emission. The DC magnetic field emission shall not exceed the limits specified in DOD-STD-1399-070.

3.5.13 MFPM rating. MFPM ratings shall be the maximum usable current rating.

3.5.14 Efficiency. Input to output total efficiency shall be 85 percent or better with loads greater than 80 percent of the input rating. See Appendix A.

3.6 Mechanical/physical requirements.

3.6.1 Recycled, recovered, or environmentally preferable materials. Recycled, recovered, or environmentally preferable materials should be used to the maximum extent possible, provided that the material meets or exceeds the operational and maintenance requirements, and promotes economically advantageous life cycle costs.

3.6.2 Prohibited materials. Prohibited materials as specified in MIL-E-917 shall not be used.

3.6.3 Electrical insulation. Electrical insulating materials shall be in accordance with the requirements of MIL-E-917.

3.6.4 Nameplates. Manufacturer identification other than that allowed for the nameplates shall not appear on the equipment. Markings shall be in accordance with MIL-DTL-15024.

3.6.5 Data connections. If the IPNC has embedded software (firmware) that is capable of being communicated by external means, then communications shall be by an RS-232, USB2.0, or firewire IEEE 1394 (or similar, if supported by industry standards) port for the purpose of controlling the IPNC electrical parameters and to allow programming of setpoints via a local or hand held computer. A software program shall be provided to interface with the IPNC for the purpose of establishing these parameters and setpoints during shipboard installation and operation. No infrared or RF communications are allowed.

3.6.6 Plating. Preparation of busbar connection surface areas shall prevent degradation from corrosion and other environmental conditions so as to minimize the resistivity and heating over the 50-year life of the equipment. Tin is a prohibited material for plating busbar connection surface areas. MIL-E-917 may be used for guidance.

3.6.7 Certification data (CD) sheets. When specified (see 6.2), if the IPNC has adjustable configuration settings, those settings shall be included with the delivery of the IPNC along with a copy of the CD sheet affixed in or on the IPNC in accordance with MIL-DTL-15024. The IPNC shall also have a unique manufacturer's part number for every different configuration that is ordered. The CD sheet shall also contain the model number, serial number, and the part number of the IPNC.

3.6.8 Paint. Painting techniques used on the IPNC shall be in accordance with the requirements of MIL-E-917. Color shall be as specified in MIL-DTL-15090.

3.6.9 Electrical interfaces.

3.6.9.1 Power interface. The IPNC shall have source and load power cables that enter and exit from the top or bottom of the IPNC cabinet. Terminals shall be rated for cable sizes. The cable size shall at least match the MFPM size (i.e., if the input module is rated at 100 A, the terminals shall be suitable for 100 A cables). Terminals shall be accessible from the front of the IPNC cabinet. The cable entrance plates shall be blank to facilitate terminals or stuffing tubes for passage of cables. The plates shall be sealed to the level of effectiveness of the enclosure.

3.6.9.2 Cable lug terminals. Where used, cable lug terminals shall be in accordance with MIL-T-16366 and MIL-E-917.

3.6.9.3 Wire identification. Wire identification shall be in accordance with MIL-E-917.

3.6.9.4 Wire, wiring methods, and marking. Wire, wiring methods, and marking shall be in accordance with the requirements of MIL-E-917. Color-coded wire may be used in accordance with MIL-STD-681.

3.6.10 Control interface.

3.6.10.1 Local control. Personnel shall be able to operate the IPNC from HMI accessible on the front of the cabinet.

3.6.10.2 Remote control. Personnel shall be able to operate the IPNC remotely. Remote interface cable(s) shall enter from the top or bottom of the IPNC cabinet. Communications shall be via an industry standard port, such as RS232 or Ethernet (see 6.2), suitable for interconnecting with a Machinery Control System (MCS).

3.6.11 Electrostatic discharge (ESD) protection requirements. When specific parts, modules, connectors/receptacles or subassemblies sensitive to damage by ESD are used, the devices shall be clearly marked with ESD labeling in accordance with MIL-STD-1686. The symbol shall be located in a position readily visible to personnel when that assembly is incorporated into its next higher assembly.

3.6.12 Enclosure integrity. Unless otherwise specified (see 6.2), enclosures shall meet the performance requirements of MIL-STD-108.

3.6.13 Acoustic requirements.

3.6.13.1 Airborne noise. The IPNC airborne noise requirements shall be in accordance with MIL-STD-1474 and the grade level shall be as specified (see 6.2).

3.6.13.2 Structureborne noise. The IPNC structureborne noise requirements shall be in accordance with MIL-STD-740-2 and the grade level shall be as specified (see 6.2).

3.6.14 Accessibility. The IPNC should meet the accessibility requirements of MIL-HDBK-454.

3.6.15 MFPM replacement. The IPNC shall provide a means to detect if MFPM of a different rating is inserted into a slot programmed for a specific MFPM rating. A warning signal at the local HMI panel shall be provided and the inserted MFPM will fail to energize.

3.7 Environment requirements.

3.7.1 Operating climate conditions.

3.7.1.1 Ambient temperature. The IPNC shall operate and endure storage in accordance with MIL-E-917.

3.7.1.2 Humidity. The IPNC shall operate in a 95 percent relative humidity environment in accordance with MIL-E-917.

3.7.2 Shock. The IPNC shall meet the Grade A shock acceptance requirements of MIL-S-901 when tested in accordance with 4.10.1. Mechanical switches shall not change state during shock.

3.7.3 Vibration. The IPNC shall meet the Type I vibrations requirement of MIL-STD-167-1 when tested as specified in 4.10.2.

3.7.4 Inclined operation. The IPNC shall perform satisfactorily when in inclined operation in accordance with MIL-E-917.

3.8 Electrical safety. Electrical safety requirements for the IPNC shall be in accordance with MIL-E-917 and MIL-STD-1472. Safety features of the IPNC should be in accordance with MIL-HDBK-454 to allow for tag-out protection using S0400-AD-URM-010/TUM.

3.8.1 High voltage protection. Personnel protection from voltages above 30 V shall be provided in accordance with NSTM Chapter 300. The maximum discharge time shall be 10 seconds to discharge components or assemblies from their operating voltages to 30 VAC rms or less.

3.8.2 Source-to-source galvanic isolation for maintenance. Each input MFPM shall have means to provide a convenient, visual, galvanic isolation (air gap) to protect personnel required to work on the supply circuit of the IPNC. Effective and safe means shall be provided to test the voltage on the input connection.

3.8.3 Source-to-load galvanic isolation for maintenance. Each output MFPM shall have a means to provide convenient, visual galvanic isolation to protect personnel who are required to work on the downstream circuits. Effective and safe means shall be provided to test the voltage on the output connection.

3.8.4 Warning labels. Warning labels shall be in accordance with MIL-E-917.

3.9 Instruction sheets. When specified (see 6.2), instruction sheets for installation shall be in accordance with MIL-E-2036.

3.10 Diagrams for customer interface. Each IPNC shall include a wiring diagram and a schematic diagram. The information shall be protected in accordance with Method 1 of MIL-E-2036 and shall be attached to the inside of the enclosure door in accordance with MIL-E-2036. Wiring diagrams shall include wire numbers, component identification, and fuse size and type, if applicable.

3.11 Embedded software. Embedded software (firmware) used in the IPNC shall appear on the nameplate by name and/or part number, the version number or designator. Equipment furnished with embedded software and/or calibration software shall have software certified by independent V&V (Verification and Validation) testing to IEEE 1012.

4. VERIFICATION

4.1 Classification of inspections. The inspection requirements specified herein are classified as follows:

a. First article inspection (see 4.2).

b. Conformance inspection (see 4.3).

4.2 First article inspection. First article inspection shall be accomplished on a complete IPNC in accordance with Table IX.

4.3 Conformance inspection. Conformance inspection shall be performed to verify that the IPNC meets specification requirements prior to acceptance and shall include the tests specified in Table IX.

4.4 Inspection conditions. All inspections shall be performed in accordance with the test conditions specified in the general requirements of MIL-STD-202.

TABLE IX. First article inspections and conformance inspections.

Tests	Requirement Paragraph	First Article Inspection	Conformance Inspection
Power Input Capability	3.2.1	4.6 tests 1-6	--
Output Power Quality	3.2.2	4.6 tests 8-10	4.6 tests 8-10
SCADA	3.3	4.6	4.6
Input Control –Source Selection-Seamless Transfer	3.3.1.1	4.6 test 13	4.6 test 13
Input Power Source Sharing	3.3.1.1	4.6 test 14	--
Input Power Factor Control	3.3.1.1	4.6 tests 7.a-7.c	--
Motor Speed Control	3.3.1.2.2e	4.6 test 12	4.6 test 12
Load Shed – Reenergization	3.3.1.2.1b and 3.3.1.2.1d	4.6 test 11	4.6 test 11
Overloads	3.4.1a, 3.4.2, and 3.4.3	4.7.1.1	4.7.1.1
Line Faults	3.4.1 thru 3.4.4	4.7.1.2	4.7.1.2
Line to Ground Fault	3.4.1 thru 3.4.4	4.7.1.3 and 4.7.1.4	4.7.1.3 and 4.7.1.4
Three-Phase Motor Loss of Phase (protection against single phase operation)	3.4.1 thru 3.4.3	4.7.1.5	--
Motor Locked Rotor	3.4.1e	4.7.1.6	--
Incoming Line to Ground Fault	3.4.3	4.7.1.7	--
Equipment Performance Monitoring	3.4.6	4.7.2	4.7.2
Continuous Current	3.5.1	4.8.1	--
Examination	4.5	4.5	4.5
Input Current Harmonics	3.5.3b	4.6	--
Input Current Unbalance	3.5.3c	4.6	--
Insulation Resistance	3.5.4.1	4.8.2	4.8.2
Dielectric Withstand Voltage	3.5.4.2	4.8.3	4.8.3
Voltage Spike	3.5.4.3	4.8.4	--
Ground Fault Leakage Current	3.5.5.1	4.8.5.1	--
Safety Leakage Current	3.5.5.2	4.8.5.2	4.8.5.2
Electromagnetic Interference (EMI)	3.5.9	4.8.6	--
DC Magnetic Field Emission	3.5.12	4.8.7	--
Source to Load Impedance	3.5.7	4.8.8	4.8.8
Source to Source Impedance	3.5.8	4.8.9	4.8.9
Efficiency	3.5.14	4.8.11	--
Enclosure Integrity	3.6.12	4.9.1	--
Airborne Noise	3.6.13.1	4.9.2	--

TABLE IX. First article inspections and conformance inspections. Continued.

Tests	Requirement Paragraph	First Article Inspection	Conformance Inspection
Structureborne Noise	3.6.13.2	4.9.2	--
Power Module Withdraw, Insertion	3.6.15	4.9.3	--
Grounding, Bonding, Shielding	3.5.11	4.9.4	--
Module Replacement Test	3.6.15	4.9.5	--
Accessibility	3.6.14	4.9.6	--
Endurance	3.5.10	4.9.7	--
Shock	3.7.2	4.10.1	--
Vibration	3.7.3	4.10.2	--
Inclined Operation	3.7.4	4.10.3	--
Humidity	3.7.1.2	4.10.4	--
Galvanic Isolation	3.8.2 and 3.8.3	4.11.1	--
Accidental Contact Voltage Protection	3.8.1	4.11.2	--

4.5 Examination. Each IPNC shall be examined for compliance with the requirements specified in Table IX. This element of inspection shall encompass all visual examinations and dimensional measurements. The examination shall be conducted using the classifications of defects as specified in Table X as applicable. Noncompliance with any specified requirements or presence of one or more defects preventing or lessening maximum efficiency shall constitute cause for rejection.

TABLE X. Classification of defects.

Categories	Defects	Related Requirements Paragraph
001	Prohibited materials are used.	3.6.1
002	Insulating material not as specified or not provided as required.	3.6.3
004	Instruction sheets not as specified.	3.9
005	Warning labels not as specified	3.8.4
006	Interface diagrams not as specified.	3.10
007	Data connections not as required.	3.6.5
008	CD sheets not as required.	3.6.7
010	Power interface not as required.	3.6.9.1
011	Cable lug terminals not as required.	3.6.9.2
012	HMI not located as required.	3.3.1.1
013	Remote control not provided as required.	3.3.1
102	Devices not marked with ESD as required.	3.6.11
104	Information plates, identification plates, and marking not as specified.	3.6.4
105	Cable entrances not as specified.	3.6.9.1

TABLE X. Classification of defects. Continued.

Categories	Defects	Related Requirements Paragraph
106	Wire, wiring methods, and marking not as specified.	3.6.9.4
107	Diagrams and descriptions of operation not provided as specified.	3.10
109	Connection points not accessible and identifiable.	3.6.9.4
110	Degree of enclosure not as specified.	3.6.12
201	Creepage and clearance distances not as specified.	3.5.4.4
202	Painting not as specified.	3.6.8

4.6 Power quality testing. Using the setup shown in Figure 1, perform the tests listed in Table XI using the corresponding settings in Table XII. For each test, record the ambient temperature, the input parameters, and the output parameters. Tests may be conducted in any convenient order.

TABLE XI. Power quality test conditions.

Test Number	Test Objective	Test Condition	Result
1	Tolerate input V & F (+ tolerance)	Input V: +10% (484 V) Input F: +5% (63 Hz) Input V THD: 10%	Output loads shall be within the tolerance listed in Table III, Table IV, and Table V.
2	Tolerate input V & F (– tolerance)	Input V: –10% (396 V) Input F: –5% (57 Hz) Input V THD: 10%	Output loads shall be within the tolerance listed in Table III, Table IV, and Table V.
3	Tolerate input V & F worst-case (+ excursion)	Input V: +20% (525 V) Input F: +10% (66 Hz) Duration: 2 seconds	Output loads shall be within the tolerance listed in Table III, Table IV, and Table V.
4	Tolerate input V & F worst-case (– excursion)	Input V: –20% (352 V) Input F: –10% (54 Hz) Duration: 2 seconds	Output loads shall be within the tolerance listed in Table III, Table IV, and Table V.
5	Tolerate emergency condition (–)	Input V: –100% (0 V) Input F: –100% (0 Hz) Duration: 2 minutes	Output loads shall recover to prior values following restoration of power (see 3.5.2).
6	Tolerate emergency condition (+)	Input V: +35% (594 V) Input F: +12% (67 Hz) Duration: 2 minutes	Output loads shall be within the tolerances of Table III, Table IV, and Table V.
7.a	Input pf control	Input V: 100% (440 V) Input F: 100% (60 Hz) Reduce Load 1 to 3.6 kVA (approx. 5 A)	Shall be in accordance with 3.5.3 for loads greater than 75%.

TABLE XI. Power quality test conditions. Continued.

Test Number	Test Objective	Test Condition	Result
7.b	Input pf control	Input V: 100% (440 V) Input F: 100% (60 Hz) De-energize Load 1, reduce Load 2 to 2.4 kVA (approx. 3.2 A)	Shall be in accordance with 3.5.3 for loads greater than 50%.
7.c	Input pf control	Input V: 100% (440 V) Input F: 100% (60 Hz) De-energize Load 1, reduce Load 2 to 1.2 kVA (approx. 1.6 A)	Shall be in accordance with 3.5.3 for loads greater than 25%.
8	Output V & F tolerance under transient condition	Input V: 100% (440 V) Input F: 100% (60 Hz) Vary Load 2 from full load to no-load, and no-load to full load with pf 0.8 lagging, unity, and 0.9 leading. Set Load 1 for 15 A.	Shall be within tolerances listed in Table III, Table IV, and Table V.
9	Input current harmonics Input current unbalance Output V tolerance Output V unbalance Output V phase displacement Output voltage modulation Output frequency tolerance Output frequency modulation Output voltage waveform control Output frequency transient control Output voltage/frequency worst-case excursion Output voltage range adjustment Output voltage, maximum departure Output voltage, transient tolerance	Input V: 100% (440 V) Input F: 100% (60 Hz) (Set Load 1 for 15 A. Set output voltages for Loads 2 and 3 to 440 V, and 460 V from zero load to full load.)	Output parameters shall be within tolerances listed in Table III, Table IV, and Table V.
10	Frequency programmability control	Input V: 100% (440 V) Input F: 100% (60 Hz) Adjust output frequency on Load 1 from 50 Hz to 400 Hz.	Frequency shall be 400 Hz after adjustment.
11	Load shed control	Input V: 100% (440 V) Input F: 100% (60 Hz) Set load shed control in six steps.	Loads shall be shed in priority order and re-energize in reverse order.

TABLE XI. Power quality test conditions. Continued.

Test Number	Test Objective	Test Condition	Result
12	Motor starting and speed control	Input V: 100% (440 V) Input F: 100% (60 Hz) Change load to a 10 hp motor.	Motor speed shall be adjustable to 25% in 5% increments and be observable at the HMI panel.
13	Seamless transfer control	Input V: 100% (440 V) Input F: 100% (60 Hz) Set criteria for transfer from normal to alternate and re-transfer from alternate to normal.	Output load parameters shall be within tolerances listed in Table III, Table IV, and Table V.
14	Power-sharing control	Input V: 100% (440 V) Input F: 100% (60 Hz) Set sharing criteria for 70% / 30% then reset for 50% / 50%.	Output load parameters shall be within tolerances listed in Table III, Table IV, and Table V.

TABLE XII. Power quality test setups.

Test Number	Input 1	Input 2	Output 1	Output 2	Output 3	Output 4	Output 5	Output 6
1	ON	OFF	ON	ON	ON	ON	ON	ON
2	ON	OFF	ON	ON	ON	ON	ON	ON
3	ON	OFF	ON	ON	ON	ON	ON	ON
4	ON	OFF	ON	ON	ON	ON	ON	ON
5	ON/ OFF/ ON	OFF	ON	ON	ON	ON	ON	ON
6	ON/ OFF/ ON	OFF	ON	ON	ON	ON	ON	ON
7.a	ON	OFF	Reduced	ON	ON	ON	ON	ON
7.b	ON	OFF	OFF	Reduced	ON	ON	ON	ON
7.c	ON	OFF	OFF	Reduced	OFF	ON	ON	ON
8	ON	OFF	ON	Varying	ON	ON	ON	ON
9	ON	OFF	ON	ON	ON	ON	ON	ON
10	ON	OFF	ON	ON	ON	ON	ON	ON
11	ON	OFF	ON	ON	ON	ON	ON	ON
12	ON	OFF	ON	ON	ON	ON	ON	ON
13	ON	ON	ON	ON	ON	ON	ON	ON
14	ON	ON	ON	ON	ON	ON	ON	ON

4.7 Fault management.

4.7.1 System faults.

4.7.1.1 Overloads. Connect the IPNC as shown in Figure 1. Connect the resistive load of approximately 75 percent of the MFPM rating. Change the load impedance so that it could draw current of 1.5 times the MFPM rated current rating. Apply similar tests on output 4, 5, and 6 (refer to Figure 1). Overload protective function shall be in accordance with Table VI, Table VII, or Table VIII for the voltage specified.

4.7.1.2 Line faults. Connect the IPNC as shown in Figure 1. Create a line-to-line fault on outputs 1, 4, 5, and 6. The MFPM shall limit the current to the MFPM rating and disconnect the load in accordance with Table III, Table IV, or Table V for the voltage specified.

4.7.1.3 Line-to-ground fault (three-phase, three-wire, and DC). Connect the IPNC as shown in Figure 1. Create a line-to-ground fault on outputs 1, 4, and 6. The IPNC shall continue to function and the HMI panel shall indicate that a line-to-ground fault has occurred.

4.7.1.4 Line-to-ground fault (three-phase, four-wire). Connect the IPNC as shown in Figure 1. Create a line-to-ground fault on one of the IPNC three-phase, four wired grounded circuit on one phase (output 5). The IPNC shall disconnect the faulted output in accordance with characteristics provided in Table VII.

4.7.1.5 3-phase motor – loss of phase (protection against single-phase operation). Connect the IPNC as shown in Figure 1. Connect a 3-phase motor to output 2 and energize the motor. Drop one phase (disconnect one of the motor terminals). The load shall disconnect and all adjacent loads shall remain energized within the voltage tolerances provided in Table III, Table IV, and Table V.

4.7.1.6 Motor locked rotor. Connect the IPNC as shown in Figure 1. Connect a motor to output 2, with the rotor clamped such that it cannot rotate, and attempt to start the motor. The IPNC shall disconnect the motor and the current rating shall not exceed the rating of the MFPM and all adjacent loads shall remain energized within the voltage tolerances provided in Table III, Table IV, and Table V.

4.7.1.7 Incoming line-to-ground fault. Connect the IPNC as shown in Figure 1 and with two loads connected. Program the IPNC so that each input will supply 50 percent of the total load. Place a line-to-ground fault on one phase of one of the input supply lines. The IPNC shall continue to function and supply the connected loads within the characteristics provided in Table III, Table IV, and Table V for the voltage type.

4.7.2 Equipment performance monitoring.

a. The MFPM shall shutdown when the over-temperature condition exists (see 3.5.1) and the MFPM shutdown shall be displayed at the HMI panel.

b. Simulate an MFPM failure. The IPNC shall indicate the failure on the HMI panel.

c. The IPNC shall indicate failure at the HMI panel when a fan failure occurs.

4.7.3 Software. Software shall be verified by the method given in IEEE 1012.

4.8 Electrical testing.

4.8.1 Continuous current. Connect the IPNC as shown in Figure 1. The test shall be conducted with maximum rated continuous current on the source module and again with half rated continuous current on the source module. The observed temperature rise shall not exceed the allowable limit, i.e., the enclosure skin temperature shall not exceed 149 °F (65 °C) and the internal components are operating within safe limits when tested in 122 °F (50 °C) ambient. Temperature measurement devices shall be placed on the cable connections to the backplane to measure the temperature to ensure that the cables do not exceed their allowable limit. The continuous current test shall continue until the temperature changes at the cable locations do not exceed 3.56 °F (2 °C) in 30 minutes. The testing shall be conducted without force ventilation within the test chamber. The test shall be conducted with cabling attached to the IPNC for the inputs and the outputs.

4.8.2 Insulation resistance. The insulation resistance shall be measured in accordance with MIL-E-917. The insulation resistance shall be measured on the main power circuit between the line ports and the IPNC ground stud.

4.8.3 Dielectric withstand voltage. Dielectric withstanding voltage tests shall be conducted in accordance with MIL-STD-202, Test Method 301. Test conditions shall be in accordance with MIL-E-917.

4.8.4 Voltage spike test. The test shall be performed in accordance with the voltage spike test requirements of MIL-STD-1399-300.

4.8.5 Leakage current.

4.8.5.1 Ground fault leakage current. Measure ground fault leakage current in accordance with MIL-E-917.

4.8.5.2 Safety leakage current. The safety leakage current test shall be in accordance with Appendix B.

4.8.6 Electromagnetic interference (EMI). The IPNC shall be subjected to the EMI tests specified in 3.5.9. Acceptance criteria shall be as specified in 3.5.9.

4.8.7 DC magnetic field emission. DC magnetic field emissions shall be in accordance with DOD-STD-1399-070.

4.8.8 Source-to-load impedance. The IPNC shall be tested for source-to-load impedance at 68 °F (20 °C) and at 122 °F (50 °C) in accordance with paragraph 3.5.7 for First Article testing. Conformance testing only requires the 20-degree setting.

4.8.9 Source-to-source impedance. The IPNC shall be tested for source-to-source impedance at 68 °F (20 °C) and at 122 °F (50 °C) in accordance with paragraph 3.5.8 for First Article testing. Conformance testing only requires the 20-degree setting.

4.8.10 Active ground detector test. When specified (see 6.2), the IPNC shall be tested with an active ground fault detector circuit utilizing a 500-VDC power supply in accordance with MIL-STD-1399.

4.8.11 Efficiency test. The efficiency test shall be performed with the IPNC connected as shown in Figure 1, with all loads operating at the value of output current as given in Figure 1. Efficiency shall be calculated by means of the following formula:

$$\text{Overall percent efficiency} = \frac{\text{Output power} \times 100}{\text{Input power}}$$

4.9 Mechanical/physical testing.

4.9.1 Enclosure integrity. The IPNC shall be tested for enclosure integrity in accordance with MIL-STD-108.

4.9.2 Acoustics. The IPNC shall be tested for airborne acoustics in accordance with MIL-STD-1474, and for structureborne in accordance with MIL-STD-740-2. When specified, see 6.2 for additional specific requirements.

4.9.3 MFPM withdrawal/insertion test. With the IPNC de-energized and test set-up in accordance with Figure 1, withdraw and re-insert one of the power modules (such as the 15 A module). When the MFPM is removed, immediately measure the voltage on the output power pins of the MFPM. The voltage between power pins and from the power pins to ground shall not exceed 30 V. Withdraw and insert a different module of the same rating 20 times without failure (Failure means that the module either cannot be inserted or that the module after insertion does not meet its requirements.). After the final insertion, energize the IPNC. Verify the voltage to the loads is in accordance with the characteristics of Table III, Table IV, and Table V.

4.9.4 Grounding, bonding, and shielding. Measure the ohmic resistance between the IPNC enclosure case and the ground stud in accordance with MIL-STD-1310.

4.9.5 Module replacement test. Using the test setup shown in Figure 1, replace a higher-rated MFPM with a lower-rated unit (for example, remove a 50 A MFPM and insert a 15 A MFPM). The IPNC shall indicate on the HMI panel that an incorrect module is inserted and the incorrect module shall not energize.

4.9.6 Accessibility. Accessibility should be in accordance with MIL-HDBK-454.

4.9.7 Endurance. The IPNC shall be subjected to the following endurance test:

a. Ambient temperature cycling - Operate equipment at 122 °F (50 °C) for 15 hours. Then reduce temperature to ambient of 77 °F (25 °C) for 5 hours. Repeat the cycle 10 times continuously.

b. Output load cycling - When the equipment is operating at 122 °F (50 °C), as required by 4.9.7a, the rated-load shall be applied continuously for 13 hours followed by 2 hours at no-load. When the equipment is operating at 77 °F (25 °C) as required by 4.9.7a, the rated load shall be applied continuously for 3 hours followed by 2 hours at no-load.

c. Output voltage and frequency - See Figure 1.

d. Input voltage and frequency – 440 V AC nominal, 60 Hz.

e. Data - The input current, input voltages, input frequency, output current, output voltage, output frequency and output power, test chamber ambient temperature, outside chamber ambient temperature, and operating time shall be recorded every hour.

f. If a failure should occur during the first 130 hours of operation, the cause of failure shall be recorded, corrected, and the test continued. The equipment shall operate the final 70 hours without failure. If any failure occurs, the final 70 hours shall be repeated without failure.

4.10 Environmental tests.

4.10.1 Shock. The IPNC shall be subjected to a Class 1, Type A shock test in accordance with MIL-S-901. The IPNC shall be qualified hull mounted, back mounted, and for unrestricted orientation. When tested with the input and two output MFPM energized and supplying loads that are at least 25 percent of the respective MFPM ratings and the third MFPM de-energized with the galvanic isolation switch open, verify that the voltages on the two energized output MFPM terminals remain within the specified limits of Table III, Table IV, and Table V and that the voltages on the terminals of the de-energized MFPM remain at zero. The IPNC shall meet the acceptance criteria specified in 3.7.2 during and after the test.

4.10.2 Vibration. The IPNC vibration test in the energized condition shall be in accordance with the Type I requirements of MIL-STD-167-1. The IPNC shall meet the requirements of 3.7.3 after the test and there shall be no evidence of electrical or mechanical damage or loosening of parts.

When tested with the input and two output MFPM energized and supplying loads that are at least 25 percent of the respective MFPM ratings and the third MFPM de-energized with the galvanic isolation switch open, verify that the voltages on the two energized output MFPM terminals remain within the specified limits of Table III, Table IV, and Table V and that the voltages on the terminals of the de-energized MFPM remain at zero.

4.10.3 Inclined operation. The IPNC shall be subjected to an inclined operation test per MIL-E-917 and configured as shown in Figure 1. The voltage and current shall remain within the specified limits of Table III, Table IV, and Table V. The test shall be conducted at 122 °F (50 °C) at a 30-degree angle for each inclined position for a duration of one hour.

4.10.4 Humidity. The IPNC shall be subjected to humidity testing in accordance with MIL-STD-810.

4.11 Safety.

4.11.1 Galvanic isolation (loads). The test setup shall be in accordance with Figure 1. The unit shall be energized and supplying power to the loads. De-energize one of the loads and open the galvanic isolation switch on the front of the unit. No voltage shall be present on the outgoing connected cable.

4.11.2 Accidental contact. With the IPNC set up as shown in Figure 1 and all loads energized such that the input module is drawing 90 percent or more of its full rated current with all removable panels in place and hinged doors closed. The voltage measured from accessible metal surfaces, including the door, to ground shall not exceed 30 V (AC, rms, or DC).

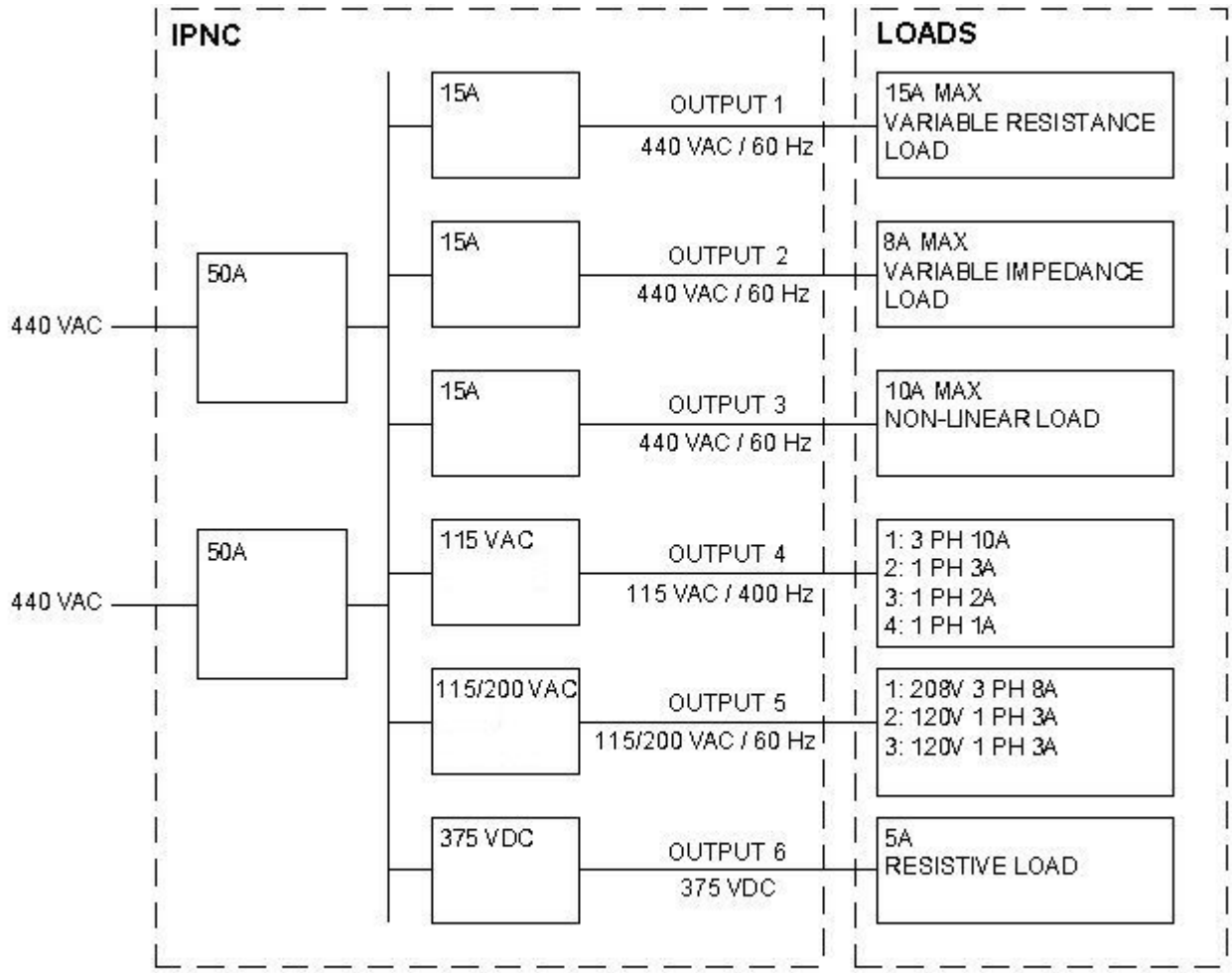


FIGURE 1. Notional test setup.

5. PACKAGING

5.1 Packaging. For acquisition purposes, the packaging requirements shall be as specified in the contract or order (see 6.2). When packaging of material is to be performed by DoD or in-house contractor personnel, these personnel need to contact the responsible packaging activity to ascertain packaging requirements. Packaging requirements are maintained by the Inventory Control Point's packaging activities within the Military Service or Defense Agency, or within the military service's system commands. Packaging data retrieval is available from the managing Military Department's or Defense Agency's automated packaging files, CD-ROM products, or by contacting the responsible packaging activity.

6. NOTES

(This section contains information of a general or explanatory nature that may be helpful, but is not mandatory.)

6.1 Intended use. This specification covers the Integrated Power Node Center (IPNC), herein referred to as the IPNC. The IPNC can provide distribution, switching, control, and conditioning for electrical power systems.

6.2 Acquisition requirements. Acquisition documents should specify the following:

a. Title, number, and date of the specification.

b. Specific issue of the individual documents referenced, if required (see 2.2 and 2.3).

c. First article test (see 3.1).

d. Identify special input and/or special fault management requirements for unusual load characteristics (see 3.2.3).

e. Fault protection settings (see 3.4.5).

f. Emergency conditions (see 3.5.2).

g. Line-to-ground filter capacitance (see 3.5.6).

h. When a higher source-to-source impedance is required (see 3.5.8).

i. Whether CS115 requirements apply (see 3.5.9).

j. Special endurance and overload requirements, if required (see 3.5.10).

k. Certification data (CD) sheets (see 3.6.7).

l. Identify industry standard communication port RS232 or Ethernet (see 3.6.10.2).

m. Degree of enclosure (see 3.6.12).

n. Airborne noise grade level (see 3.6.13.1).

o. Structureborne noise grade level (see 3.6.13.2).

p. Instruction sheets (see 3.9).

q. Active ground fault detection requirement (see 4.8.10).

6.3 Definitions. Definitions are in accordance with MIL-STD-1399, unless listed below.

6.3.1 Seamless transfer. Seamless transfer is the automatic switchover from normal to alternate power sources with quality of power supplied to the loads remaining within the power quality limits.

6.4 Acronyms.

EMI Electromagnetic Interference

EPM Equipment Performance Monitoring

ESD Electrostatic Discharge

F Frequency

FL Fault Localization

HMI Human Machine Interface

IPNC Integrated Power Node Center

MCS Machinery Control System

MFPM Multi-functional Programmable Module

Pf Power Factor

PM Performance Monitoring

RMS Root Mean Square

SCADA Supervisory Control and Data Acquisition

THD Total Harmonic Distortion

V Voltage

6.5 Subject term (key word) listing.

Switch gear

Switching mechanism

MULTI-FUNCTIONAL PROGRAMMABLE MODULE (MFPM) RATINGS

A.1 SCOPE

This Appendix covers multi-functional programmable module (MFPM) ratings. This Appendix is a mandatory part of the specification. The information contained herein is intended for compliance.

A.2 MULTI-FUNCTIONAL PROGRAMMABLE MODULE RATING REQUIREMENTS

Multi-functional programmable module rating requirements shall be in accordance with Table A-I.

TABLE A-I. MFPM ratings.

Power Modules	**Ratings (Ratings are based on maximum continuous current. Overload ratings are not required.)**
Input Power Modules:	
1. 440 V, 60 Hz, 3-phase	15 A, 30 A, 50 A, 100 A, 200 A, 400 A
2. 750 V, DC	50 A
Output Power Modules:	
1. 440 V, 60 Hz, 3-phase (Adjustable for higher frequency – de-rating may be necessary)	5 A, 15 A, 30 A, 50 A, 100 A, 200 A, 400 A
2. 115 V, 60 Hz, 3-phase, 3-wire – MFPM (Adjustable for higher frequency – de-rating may be necessary)	35 A, 60 A
3. 115/200 V, 60 Hz, 3-phase, 4-wire – MFPM (Adjustable for higher frequency – de-rating may be necessary)	25 A, 35 A, 50 A
4. 115 V, 3-phase fast switch modules	10 A
5. 375 V, DC	15 A, 30 A
6. 120 V, DC	10 A, 20 A, 40 A, 60 A
NOTE: Output power is equivalent to input power minus losses (see 3.5.14 for efficiency).	

SAFETY LEAKAGE CURRENT

B.1 SCOPE

This Appendix covers safety leakage current requirements. This Appendix is a mandatory part of the specification. The information contained herein is intended for compliance.

B.2 SAFETY LEAKAGE CURRENT REQUIREMENTS

B.2.1 Human body leakage current limits for personnel safety. In order to evaluate leakage current for potential equipment shock hazards, a leakage current test using an impedance network simulating human body experience shall be conducted on all equipment that requires a dedicated ground conductor or connection path to the ship's hull. Therefore, the leakage current test is not necessarily conducted at the ship's interface but on all equipment requiring a ground conductor or connection path to the ship's hull. Single-phase leakage current shall be measured using the test method described in B.2.2. If equipment is powered from one single-phase transformer, then the total leakage current shall be computed as the difference between the measured values of each single-phase line. If the equipment is powered from a single-phase of a three-phase source, then the leakage current shall be measured as the vector sum resulting from the two power lines, using the test method described in B.2.2. Three-phase leakage current shall be measured as the vector sum of all three-phases using the test method described in B.2.2. Leakage current test limits are defined for two frequency ranges.

B.2.2 Personnel safety leakage current test. Leakage current shall be measured at nominal line voltage and frequency.

B.2.2.1 Apparatus. The following apparatus is recommended for performing this test:

a. Power source (wye-configured) of required capacity and range of voltage and frequency adjustments. A power source with a capability of having an independently programmable voltage and frequency output is recommended.

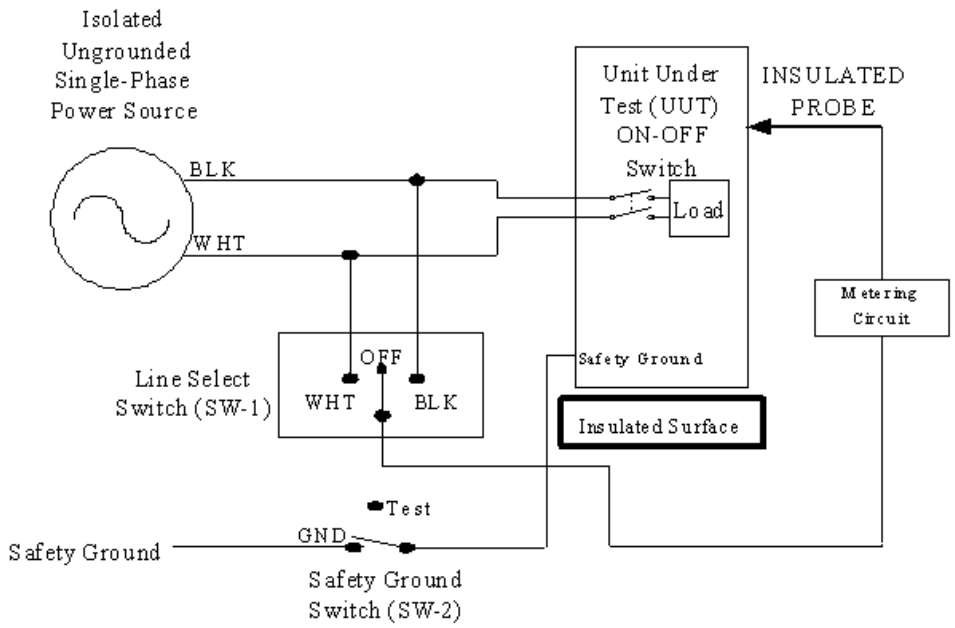
b. Voltmeters (true rms) - ±0.5 percent accuracy; frequency response should satisfy measurement requirements.

c. Circuit as defined by Figures B-1, B-2, and B-3 for single- and three-phase systems, as required.

d. Circuit as defined by Figure B-4 for either high or low frequency metering circuit.

B.2.2.2 Procedures. With power disconnected, place the user equipment on an insulated surface. User equipment shall be insulated from any earth, power, or instrument ground.

WARNING: THIS TEST MAY BE HAZARDOUS DUE TO THE UNGROUNDED CONDITION OF THE EQUIPMENT DURING THE TEST. DO NOT TOUCH EXPOSED METAL SURFACES. Single-phase user equipment shall be connected as shown in Figure B-1 if it is connected to one single-phase transformer (in the shipboard configuration) and Figure B-2 if it is connected to a single-phase of a three-phase source (in the shipboard configuration). Three-phase user equipment shall be connected as shown in Figure B-3. The appropriate metering circuit shall be used for the intended frequency range measurement, shown in Figure B-4. Leakage current shall be measured on equipment while operating at nominal line voltage and frequency. The operating mode that utilizes the maximum power shall be used during leakage current measurements. The leakage current shall be determined by the voltage-drop method. A true rms voltmeter shall be used with adequate frequency response to facilitate the high and low frequency range measurements. The voltage measured across the metering circuit when equal to 1.0 Vrms, represents 2.0 milliamperes of leakage current. The overall measurement error shall not exceed 5 percent. Where risk exists for leakage current paths to any control or external surface component, the probe shall be used on all external conducting parts, such as case, connector housings, recessed calibration or adjustment controls and control shafts with knobs removed. For single-phase user equipment, two types of leakage current conditions can exist. If, in the shipboard configuration, equipment is powered from one single-phase transformer, then the total leakage current shall be computed as the difference between the measured values of each single-phase line using the test circuit shown in Figure B-1. If, in the shipboard configuration, the equipment is powered from a single-phase of a three-phase source, then the leakage current shall be measured as the vector sum resulting from the two power lines. This is accomplished by referencing the metering circuit to the neutral as shown in Figure B-2. For three-phase user equipment, leakage current shall be measured as the vector sum resulting from the three power lines by referencing the metering circuit to the neutral as shown in Figure B-3. The voltage is measured from each part to the source side of open safety ground for every combination of switch positions available in the test diagram. The open safety ground connector shall be reconnected after the test is completed. The following Methods of Test shall be followed for each applicable configuration.



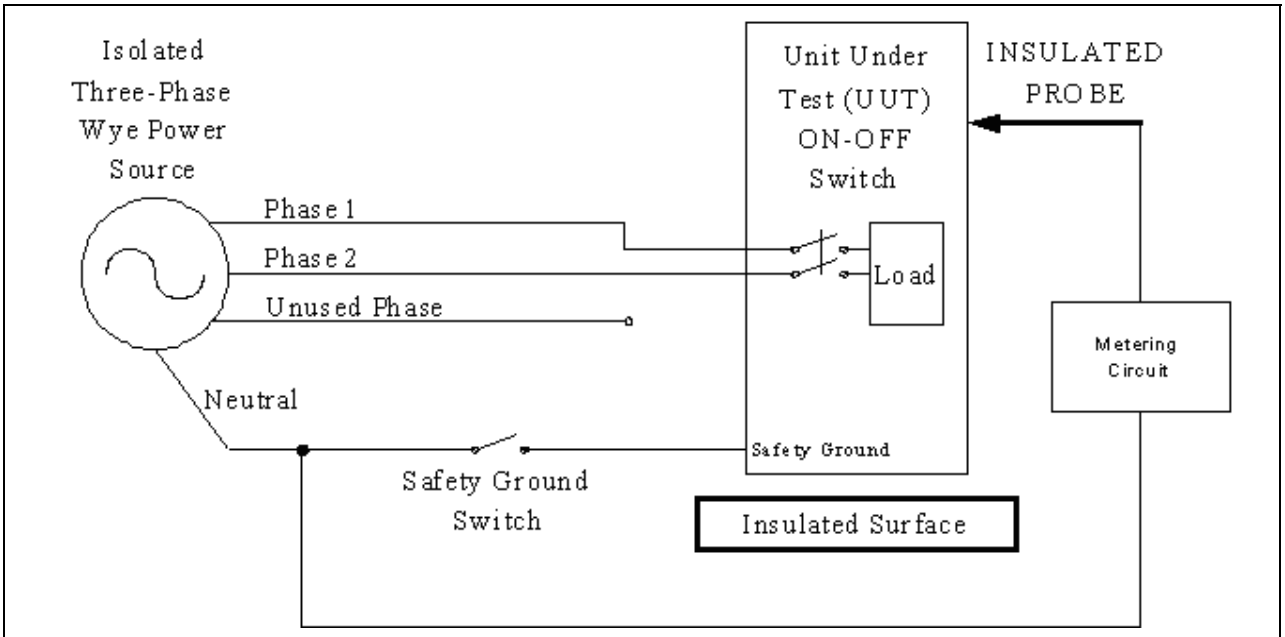
Method of Test:

1. The power source shall be de-energized. Connect the UUT per Figure B-1 utilizing the high or low frequency metering circuit as required. Leave the power source unconnected.
2. Place the UUT ON-OFF switch in the OFF position. Place SW-1 in the OFF position. Place SW-2 in the GND position. Connect and energize the power source.
3. OBSERVE WARNING. Place SW-2 in the TEST position. Place the UUT ON-OFF switch in the ON position. Place SW-1 in the BLK position.
4. Record the voltmeter reading.
5. Place SW-1 in the WHT position.
6. Record the voltmeter reading.
7. Place SW-1 in the OFF position.
8. Place the UUT ON-OFF switch in the OFF position. Place SW-2 in the GND position.
9. Repeat steps 3 through 8 for each and every mode of operation.
10. De-energize and remove the power source. Disconnect the equipment.

NOTES:

1. The safety ground shall be connected to one line of the ungrounded source.
2. For single-phase systems derived from an isolated source, the safety ground shall be connected to each corner of the delta source providing the single phase.
3. The total leakage current is the difference between the currents measured at each line.

FIGURE B-1. Single-phase leakage current test setup if user equipment is connected to one single-phase transformer.



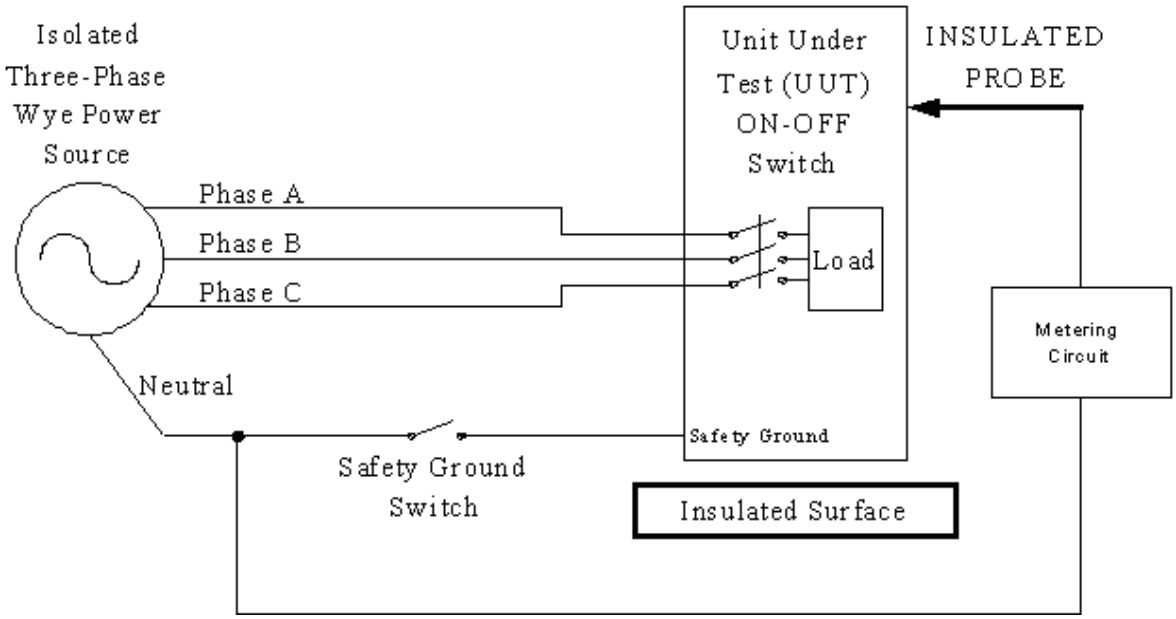
Method of Test:

1. The power source shall be de-energized. Connect the UUT per Figure B-2 utilizing the high or low frequency metering circuit as required. Leave the power source unconnected.
2. Place the UUT ON-OFF switch in the OFF position. Place the Safety Ground switch in the CLOSED position. Connect Phases 1 and 2 of the 3-phase power source.
3. OBSERVE WARNING. Place the Safety Ground switch in the OPEN position. Place the UUT ON-OFF switch in the ON position.
4. Record the voltmeter reading.
5. Place the UUT ON-OFF switch in the OFF position. Place the Safety Ground switch in the CLOSED position.
6. Repeat steps 3 through 5 for each and every mode of operation.
7. De-energize and remove the 3-phase power source. Disconnect the equipment.

NOTES:

1. The safety ground conductor shall not carry load current.
2. Tests for delta loads shall use a wye power source providing balanced line-to-line voltages.

FIGURE B-2. Single-phase leakage current test setup if user equipment is connected to a single-phase of a three-phase source.



Method of Test:

1. The power source shall be de-energized. Connect the UUT per Figure B-3 utilizing the high or low frequency metering circuit as required. Leave the power source unconnected.
2. Place the UUT ON-OFF switch in the OFF position. Place the Safety Ground switch in the CLOSED position. Connect the 3-phase power source.
3. OBSERVE WARNING. Place the Safety Ground switch in the OPEN position. Place the UUT ON-OFF switch in the ON position.
4. Record the voltmeter reading.
5. Place the UUT ON-OFF switch in the OFF position. Place the Safety Ground switch in the CLOSED position.
6. Repeat steps 3 through 5 for each and every mode of operation.
7. Remove the 3-phase power source. Disconnect the equipment.

NOTES:

1. All three-phases shall be connected during the measurement.
2. The safety ground conductor shall not carry load current.
3. Tests for delta loads shall use a wye power source, which provides balanced line-to-line voltages.

FIGURE B-3. Three-phase user equipment leakage current test setup.

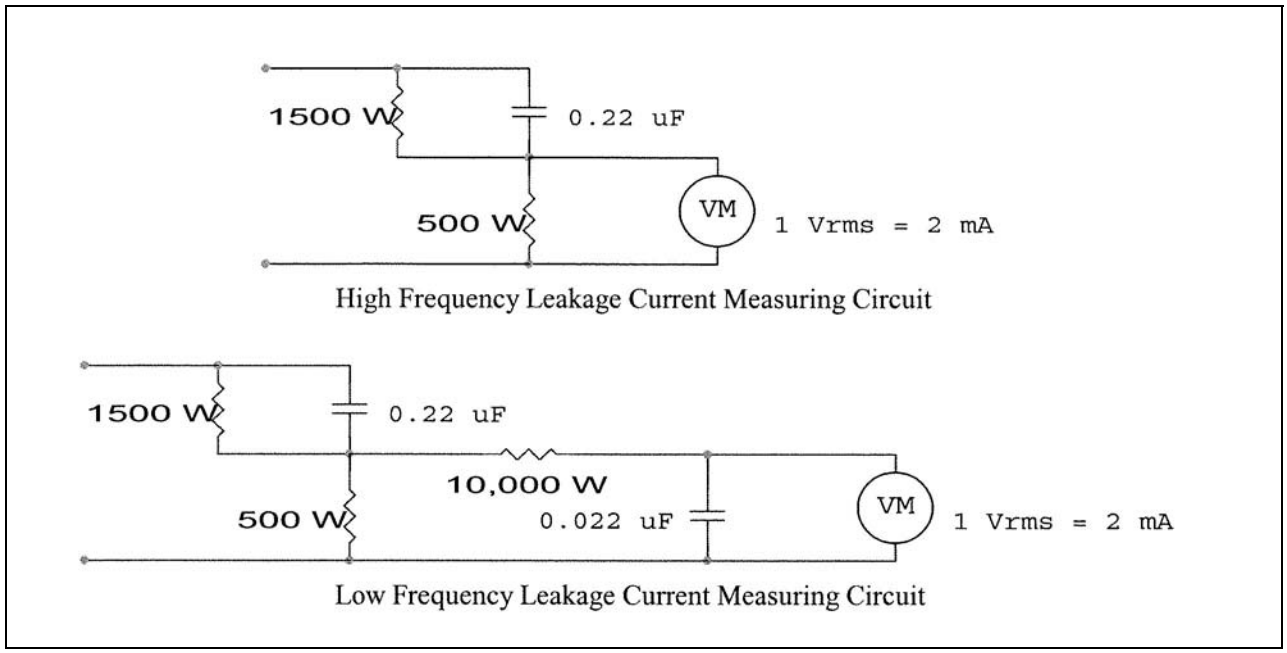


FIGURE B-4. Metering circuits for high and low frequency leakage current tests.

Custodians:
Army – CR4
Navy – SH
Air Force – 99

Preparing Activity:
Navy – SH
(Project 6110-2007-001)

Review Activities:
Navy – AS, CG
Air Force – 03, 19
DLA – GS, GS2

NOTE: The activities listed above were interested in this document as of the date of this document. Since organizations and responsibilities can change, you should verify the currency of the information above using the ASSIST Online database at http://assist.daps.dla.mil.