UNIFIED FACILITIES GUIDE SPECIFICATIONS

References are in agreement with UMRL dated January 2021
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DIVISION 26 - ELECTRICAL

SECTION 26 35 43

400-HERTZ (HZ) SOLID STATE FREQUENCY CONVERTER

05/11, CHG 2: 02/18

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USACE / NAVFAC / AFCEC / NASA	**UFGS-26 35 43 (May 2011)** **Change 2 - 02/18**
Preparing Activity: NAVFAC	**Superseding** **UFGS-26 35 43 (April 2006)**

UNIFIED FACILITIES GUIDE SPECIFICATIONS

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SECTION 26 35 43

400-HERTZ (HZ) SOLID STATE FREQUENCY CONVERTER
05/11, CHG 2: 02/18

****

NOTE: This guide specification covers the requirements for the procurement, installation, and testing of 400 Hz solid state frequency converters.

Adhere to UFC 1-300-02 Unified Facilities Guide Specifications (UFGS) Format Standard when editing this guide specification or preparing new project specification sections. Edit this guide specification for project specific requirements by adding, deleting, or revising text. For bracketed items, choose applicable item(s) or insert appropriate information.

Remove information and requirements not required in respective project, whether or not brackets are present.

Comments, suggestions and recommended changes for this guide specification are welcome and should be submitted as a Criteria Change Request (CCR).

****

****

NOTE: These converters are used to supply 400 Hz electrical power to aircraft and ships in shore facility environments. Typical applications include aircraft operating in flight line conditions or in hangars, avionics shops, laboratories, training buildings, flight simulators, and computer rooms. This specification is not to be used for procurement of power converters installed on board aircraft or ships. This specification is not intended for medium-voltage applications.

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****

NOTE: The following information shall be shown on the project drawings:

1. Show location of all equipment including

converter, paralleling panels, remote monitoring and control panel.

2. Provide functional block diagram, single line diagrams, power, and control wiring interconnection diagrams, wiring diagrams, conduit entry diagrams, equipment elevations, limiting dimensions, and equipment ratings which are not covered in the specifications.

3. Design 400 Hz equipment rooms with working spaces as required by NFPA 70. Provide ventilation for equipment rooms based on 400 Hz components heat load generated when operating at 100 percent load. Provide 60 Hz convenience receptacles.

****

****

NOTE: Ensure that the 400 Hz distribution system is properly coordinated including the ratings of the power cables, ground cables, circuit breakers, transformers, filters, rectifiers, and control equipment. When replacing a motor generator set with a solid state converter ensure that the existing feeders circuit protective devices will operate properly without damage to electrical devices including the solid state converter.

****

PART 1 GENERAL

1.1 REFERENCES

****

NOTE: This paragraph is used to list the publications cited in the text of the guide specification. The publications are referred to in the text by basic designation only and listed in this paragraph by organization, designation, date, and title.

Use the Reference Wizard's Check Reference feature when you add a Reference Identifier (RID) outside of the Section's Reference Article to automatically place the reference in the Reference Article. Also use the Reference Wizard's Check Reference feature to update the issue dates.

References not used in the text will automatically be deleted from this section of the project specification when you choose to reconcile references in the publish print process.

****

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

INSTITUTE OF ELECTRICAL AND ELECTRONICS ENGINEERS (IEEE)

IEEE 519	(2014) Recommended Practices and Requirements for Harmonic Control in Electrical Power Systems
IEEE 1159	(2009) Recommended Practice on Monitoring Electric Power Quality
IEEE C2	(2017; Errata 1-2 2017; INT 1 2017) National Electrical Safety Code
IEEE C62.41.1	(2002; R 2008) Guide on the Surges Environment in Low-Voltage (1000 V and Less) AC Power Circuits
IEEE C62.41.2	(2002) Recommended Practice on Characterization of Surges in Low-Voltage (1000 V and Less) AC Power Circuits

INTERNATIONAL ELECTROTECHNICAL COMMISSION (IEC)

IEC 60947-4-1	(2018; INT 1 2020; Corr 1 2020) Low-voltage Switchgear and Controlgear, Part 4-1: Contactors and Motor Starters - Electromechanical Contactor and Motor Starters

NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION (NEMA)

NEMA 250	(2018) Enclosures for Electrical Equipment (1000 Volts Maximum)
NEMA ST 20	(2014) Dry-Type Transformers for General Applications

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 70	(2020; ERTA 20-1 2020; ERTA 20-2 2020; TIA 20-1; TIA 20-2; TIA 20-3; TIA 20-4) National Electrical Code

SOCIETY OF AUTOMOTIVE ENGINEERS INTERNATIONAL (SAE)

SAE AS5756/6	(2013; Rev A; Stabilized (S) 2013) Cable, 3-Phase Power, Electric Portable, Multiconductor, 90 Degree C, 600V, Ozone Resistant, Split Phase

U.S. DEPARTMENT OF DEFENSE (DOD)

MIL-PRF-24021	(1998; Rev K; Notice 1 2014) Electric Power Monitors, External Aircraft
MIL-STD-461	(2015; Rev G) Requirements for the Control of Electromagnetic Interference Characteristics of Subsystems and Equipment
MIL-STD-704	(2004; Rev F; Notice 1 2008; Notice 2

	2013) Aircraft Electric Power Characteristics
MIL-STD-1399-300	(2008; Rev B) Electric Power, Alternating Current

UNDERWRITERS LABORATORIES (UL)

UL 489	(2016) UL Standard for Safety Molded-Case Circuit Breakers, Molded-Case Switches and Circuit-Breaker Enclosures
UL 506	(2017) UL Standard for Safety Specialty Transformers
UL 1012	(2010; Reprint Apr 2016) UL Standard for Safety Power Units Other than Class 2
UL 1449	(2014; Reprint Jul 2017) UL Standard for Safety Surge Protective Devices

1.2 SUBMITTALS

****

NOTE: Review Submittal Description (SD) definitions in Section 01 33 00 SUBMITTAL PROCEDURES and edit the following list, and corresponding submittal items in the text, to reflect only the submittals required for the project. The Guide Specification technical editors have classified those items that require Government approval, due to their complexity or criticality, with a "G." Generally, other submittal items can be reviewed by the Contractor's Quality Control System. Only add a "G" to an item if the submittal is sufficiently important or complex in context of the project.

For Army projects, fill in the empty brackets following the "G" classification, with a code of up to three characters to indicate the approving authority. Codes for Army projects using the Resident Management System (RMS) are: "AE" for Architect-Engineer; "DO" for District Office (Engineering Division or other organization in the District Office); "AO" for Area Office; "RO" for Resident Office; and "PO" for Project Office. Codes following the "G" typically are not used for Navy, Air Force, and NASA projects.

The "S" classification indicates submittals required as proof of compliance for sustainability Guiding Principles Validation or Third Party Certification and as described in Section 01 33 00 SUBMITTAL PROCEDURES.

Choose the first bracketed item for Navy, Air Force, and NASA projects, or choose the second bracketed item for Army projects.

****

Government approval is required for submittals with a "G" or "S" classification. Submittals not having a "G" or "S" classification are [for Contractor Quality Control approval.][for information only. When used, a code following the "G" classification identifies the office that will review the submittal for the Government.] Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-02 Shop Drawings

Frequency Converter Drawings; G[, [_____]]

SD-03 Product Data

Frequency Converter; G[, [_____]]

Aircraft Power Cable Assembly; G[, [_____]]

[Remote Monitoring and Control Panel; G[, [_____]]]

SD-06 Test Reports

Work Plan; G[, [_____]]

Routine Factory Test Plan; G[, [_____]]

Special Factory Test Plan; G[, [_____]]

Performance Test Plan; G[, [_____]]

Test Schedule; G[, [_____]]

Routine Factory Tests; G[, [_____]]

Special Factory Tests; G[, [_____]]

SD-07 Certificates

Qualifications of Manufacturer; G[, [_____]]

UL Listing; G[, [_____]]

SD-09 Manufacturer's Field Reports

Initial Inspection and Tests; G[, [_____]]

Performance Tests; G[, [_____]]

Training Syllabus; G[, [_____]]

SD-10 Operation and Maintenance Data

Frequency Converter, Data Package 5; G[, [_____]]

Preliminary Operation and Maintenance Manuals, Data Package 5; G[, [_____]]

Remote Monitoring and Control Panel, Data Package 5; G[, [_____]]

1.3 QUALITY ASSURANCE

1.3.1 Frequency Converter Drawings

Furnish scaled drawings of enclosure outline including front, top, side views, and overall dimensions. Provide external power and control wiring and cable connections. Provide single line, schematic, and wiring diagrams. Drawings shall include details of input and output circuit breakers, contactors, rectifiers, surge protectors, and control devices. Drawings shall include conduit entry and exit locations. If parallel operation is included, provide an interconnection diagram.

1.3.2 Qualifications of Manufacturer

****

NOTE: The experience clause in this section has been approved by a Level I Contracting Officer in accordance with the requirements of Naval Facilities Acquisition Supplement (NFAS). NFAS can be found a the following link:
https://portal.navfac.navy.mil/portal/page/portal/navfac/navfac_forbusinesse
This clause may be used without further approval or request for waiver.

****

Submit a certification that the manufacturer has a minimum of five (5) years' experience in the design, manufacturing, and testing of 400 Hz solid state frequency converters at the same or equivalent kVA and voltage ratings for direct connection to aircraft electrical loads. When specifications require multiple converters operating in parallel, the manufacturer shall provide specific experience with equal or greater kVA rated converters.

The certification shall state that the manufacturer is experienced in manufacturing and testing solid state converters of an equivalent or greater kVA rating. Experience in manufacturing motor generator sets does not qualify as equivalent. Experience in manufacturing portable engine-driven 400-hertz power units does not qualify as equivalent. The manufacturer shall be experienced in producing units for installation in permanent buildings in environmentally closed spaces or in weatherproof enclosures as applicable. The manufacturer shall also document that converters are designed for connection to non-linear loads typically encountered in the aircraft and shipbuilding industries. The manufacturer shall furnish documented experience with converters in various environmental conditions including exterior flight line, hangar, and environmentally enclosed spaces within buildings.

1.3.3 Work Plan

Submit a written schedule of dates of routine and special factory tests, installation, field tests, and operator training for the converter system. Furnish a list of instrumentation equipment for factory and field test reports.

1.3.4 Routine Factory Test Plan

Submit 7 copies of test plans and procedures at least [21][_____] calendar days prior to the tests being conducted. Provide detailed description of test procedures, including test equipment and setups, to be used to ensure

the converter meets the performance specification and explain the test methods to be used. As a minimum, the test procedures shall include the tests required under the paragraph ROUTINE FACTORY TESTS.

1.3.5 Special Factory Test Plan

Submit 7 copies of test plans and procedures with the Routine Factory Test Plan. Provide detailed description of test procedures, including test equipment and setups, used to ensure the converter meets the performance specification and explain the test methods used. As a minimum, the test procedures shall include the tests required under the paragraph SPECIAL FACTORY TESTS.

1.3.6 Performance Test Plan

Submit 7 copies of test plans and procedures at least [15][_____] calendar days prior to the start of field tests. Provide detailed description and dates and times scheduled for performance of tests, and detailed description of test procedures, including test equipment (list make and model and provide functional description of the test instruments and accessories) and setups of the tests to be conducted to ensure the converter meets the performance specification. Explain the test methods to be used. As a minimum, the test procedures shall include the tests required under the paragraph FIELD QUALITY CONTROL. Test reports shall include power quality measurement data collected in accordance with IEEE 1159.

1.3.7 UL Listing

Submit with the initial submittal to verify qualification of manufacturer. Frequency converter shall be identified with a UL or nationally recognized testing laboratory (NRTL) label prior to shipping.

1.3.7.1 Currently Listed Products

Submit UL or NRTL certification or UL file number for the actual frequency converter to be shipped.

1.3.7.2 Proposed Listed Products

Submit UL or NRTL certification or UL file number for same or similar rating or product size range of like design unit.

1.3.8 Routine Factory Tests Report

Submit within [45][_____] calendar days after completion of tests. Receive approval of test prior to shipping unit. Certify tests were conducted on each converter in accordance with the requirements set forth in paragraph ROUTINE FACTORY TESTS and certify converter satisfactorily operated within specified limits. Report shall include copies of the test procedures, test data, and results.

1.3.9 Special Factory Tests Report

Certify tests were conducted on a converter of the same design, construction and kVA and voltage rating to be provided and in accordance with the requirements set forth in paragraph SPECIAL FACTORY TEST and certify converter operated without malfunctioning within specified limits. Report shall include copies of the test procedures, test data,

and results.

1.3.10 Performance Tests Report

Submit report of test results as specified by paragraph FIELD QUALITY CONTROL within [15][_____] calendar days after completion of tests. Certify tests were conducted on each converter in accordance with the paragraph FIELD QUALITY CONTROL and certify converter satisfactorily operated within specified limits. Report shall include copies of the test procedures, test data, and results.

1.4 MAINTENANCE

1.4.1 Operation and Maintenance Manuals

Submit frequency converter operation and maintenance manuals in accordance with Section 01 78 23 OPERATION AND MAINTENANCE DATA.

1.4.1.1 Additions to Operation and Maintenance Manuals

In addition to requirements of Data Package 5, include the following on the actual frequency converter provided:

a. A "one-line diagram" from service entrance to 400 Hz utilization panel or point.

b. A weatherproof, tear-resistant plastic data sheet with operating instructions for each unit including startup, shutdown[, and paralleling] procedures.

c. Routine and field acceptance test reports.

d. UL or NRTL certification or UL file number.

1.4.1.2 Preliminary Operation and Maintenance Manuals

Prior to scheduling Field Performance Tests, 2 copies of a Preliminary Operation and Maintenance Manual must be submitted to and approved by the Contracting Officer.

1.4.1.3 Extra Material

****

NOTE: Delete ventilation system filters except for frequency converters located outdoors or in areas subject to a high level of airborne contaminants.

****

Furnish recommended manufacturer's spare parts list and schedule of prices for each type of converter and other equipment specified in this section. This list shall include the following:

a. Power semi-conductors

b. Power filter capacitors

c. Plug-in logic cards

d. Output switching modules

e. Fuses

f. Indicator lamp/LED

[g. Ventilation system filters

]PART 2 PRODUCTS

2.1 FREQUENCY CONVERTER

****
NOTE: Do NOT edit this paragraph to specify the type of power supply, rectifier type or switching technology to be utilized. Specifying this type of technology may make this a sole source specification which requires justification and approval per federal contract law.
****

Provide frequency converter consisting of modular construction solid-state components for [50][60] to 400 Hz conversion, input/output devices, and ancillary control devices. Frequency converter shall be a standard product of the manufacturer and shall be the manufacturer's latest design that complies with the specification requirements. The 400 Hz frequency converters provided under this contract shall be products of the same manufacturer. The unit shall have a calculated MTBF exceeding [24,000][_____] hours as calculated when the converter is provided with yearly servicing and maintenance. The converter shall be UL or third party listed to comply with UL 1012. Circuit breakers operating at 400 Hz shall be designed and UL tested for 60 Hz operation and derated for 400 Hz operation. Provide startup and shutdown instructions posted on the front of the unit using engraved plastic plate. Provide a plastic encapsulated schematic diagram attached to the inside of the unit in clear view of maintenance personnel.

2.1.1 Electrical Characteristics

2.1.1.1 Input Voltage

****
NOTE: For units 15 kVA and below the input voltage should be 208 volts and for units over 15 kVA the preferred input voltage is 480 volts. Using input voltage other than 480 volts will increase the cost and weight and decrease the efficiency of the converter. The input voltage shall be shown on the construction drawings.
****

[480Y/277][208Y/120][380Y/220][_____] V, three phase, four wire, grounded, [60][50] Hz. Converter shall provide rated output voltage when input voltage is varied plus or minus [10][_____] percent. Input neutral currents shall not exceed [21][_____] percent of any individual phase current at no load and at full load.

2.1.1.2 Input Power Factor

Between 0.8 lagging and unity, under all conditions of steady state line

and load variations specified herein.

2.1.1.3 Surge Protection

****
NOTE: Select Location Category C for outdoor locations only.
****

The converter shall be capable of sustaining an input surge described in and tested in accordance with UL 1449, and IEEE C62.41.1 and IEEE C62.41.2, Location Category [B][C], and continue to operate with no alarms within the specified tolerance.

2.1.1.4 Inrush Current

The inrush current shall not exceed 100 percent of the rated full load input current. Inrush current limitation is based on a frequency converter that does not require a transformer at the input to the unit. Should the contractor choose to provide a frequency converter with a transformer at the input to the unit, the contractor shall be responsible for increasing the size of the upstream feeder breaker(s) and increasing the size of conductors and raceways in accordance with NFPA 70.

2.1.1.5 Input Current Distortion

****
NOTE: Where total connected frequency converter load is a small percentage (less than 40 percent) of the total connected facility load, use 12 percent THD and 8 percent individual. For large frequency converters (i.e. 312 kVA or larger) or where total connected frequency converter load is a significant percentage of the total connected facility load, use 5 percent THD and 3 percent individual. For installation in shipboard environments, use 5 percent THD and 3 percent individual.
****

Input current THD shall not exceed [12][5]-percent of the fundamental with nominal input voltage at full load. Individual harmonic content shall not exceed [8][3]-percent of the fundamental.

2.1.1.6 Output Voltage

****
NOTE: Use MIL-STD-704, when 400 Hz power is required to power aircraft avionic equipment. Aircraft equipment is normally operated 200Y/115 V, three-phase, 400 Hz, grounded. UFC 3-555-01N, "400 Hertz Medium Voltage Conversion/Distribution and Low Voltage Utilization Systems" contains aircraft electrical demand loads.

Use MIL-STD-1399-300, when 400 Hz power is required to power laboratory test benches simulating shipboard environments. Shipboard equipment in simulated shore laboratory environments normally operated on a 440 V, three-phase, 400 Hz, ungrounded

system.
****

[200Y/115 V, three phase, 400 Hz, grounded][440 V, three phase, 400 Hz, delta connected ungrounded] system. [Adjustable to plus or minus 10 percent of the rated voltage.] The limits overvoltage and undervoltage shall be [as defined in MIL-STD-704][as defined in MIL-STD-1399-300 Type [II][III] power][plus or minus [2][_____] percent]. The phase rotation of the output voltage shall be clockwise sequence of [A-B-C][AB-BC-CA]. Converters shall be designed for compatibility with ship and aircraft power monitors complying with MIL-PRF-24021.

2.1.1.7 Power Output

****
NOTE: Unit that will be used for providing power for aircraft should be sized for the type and number of aircraft to be supplied. The recommended sizes for units supporting aircraft are 45, 60, 90, 120,150, 180 or 312 kVA for legacy systems.
****

[_____] kVA at 0.8 power factor lagging.

2.1.1.8 Load Range

Operate into a linear load with a power factor between 0.5 lagging and 0.8 leading and into a non-linear load with not less than 15 percent current THD, composed of not less than 6 percent of the 3rd harmonic and not less than 7 percent of the 5th harmonic.

2.1.1.9 Efficiency

****
NOTE: Use the table below to fill in the kVA and minimum efficiency.

Minimum Percent Efficiency		
Rating (kVA)	**50 Percent Load**	**100 Percent Load**
5 - 14	**80**	**90**
15 - 39	**86**	**90**
40 - 99	**87**	**91**
100 - up	**89**	**92**

Adding EMI filtering for units with power rating larger than 15 kVA, will reduce the efficiency of the unit. If EMI filtering is specified for units with power rating larger than 15 kVA, reduce minimum efficiency by 2 percent.
****

The [_____] kVA units shall have a minimum efficiency of [_____] at 50

percent load and [_____] at 100 percent load. For a frequency converter that requires a transformer at the input to the unit, reduce the specified efficiencies by 2 percent.

2.1.1.10 No Load Input Losses

****
NOTE: Above 30 kVA, use 7 percent, below 30 kVA, use 9 percent.
****

The frequency converter shall have no-load input losses no greater than [7] [9][_____] percent of the output kW rating. For a frequency converter that requires a transformer at the input to the unit, increase the specified no load input losses by 2 percent.

2.1.1.11 Overload

Satisfactory overload operating time is based on no more than one overload in any 4 consecutive hours of operation:

Percent of Full Load	Satisfactory Operating Time
110 percent	60 minutes
125 percent	5 minutes
150 percent	2 minutes
200 percent	20 seconds

After minimum operating time is achieved, unit shall interrupt output power. Unit shall be capable of sustaining the overload without damage until the protective device interrupts the overload.

2.1.1.12 Short Circuit

When [a bolted line-to-ground fault,] a bolted line-to-line fault, or a bolted three phase fault is applied to the unit, unit shall be capable of sustaining the short circuit current without damage until the protective device interrupts the fault.

2.1.1.13 Output Voltage THD

a. Balanced load:

(1) Output voltage THD: Not to exceed [3][_____] percent line-to-line and line-to-neutral for linear loads as specified in the paragraph LOAD RANGE.

(2) Output voltage THD: Not to exceed [5][_____] percent line-to-line and line-to-neutral for non-linear loads as specified in the paragraph LOAD RANGE.

(3) Maximum single harmonic distortion: Not to exceed [2][_____] percent of the fundamental at the nominal voltage for linear loads as specified in the paragraph LOAD RANGE.

(4) Maximum single harmonic distortion: Not to exceed [3][_____] percent of the fundamental at the nominal voltage for non-linear loads as specified in the paragraph LOAD RANGE.

b. Unbalanced load: Output voltage THD not to exceed 4 percent, line-to-neutral with 15 percent unbalanced linear load.

2.1.1.14 Output Voltage Amplitude Modulation

Output voltage amplitude modulation shall not exceed 1/2 percent of nominal voltage at no load to full load.

2.1.1.15 Frequency Stability

Control output frequency of the 400 Hz converter within plus or minus 0.5 percent for all operating conditions, including maximum and minimum specified input voltages, ambient temperature and relative humidity. The frequency regulation shall operate independent of supply frequency and load changes.

2.1.1.16 Phase Angle Regulation

Displacement angle between adjacent voltage phases shall be 120 degrees plus or minus 2 degrees with balanced load and plus or minus 4 degrees with three phase 15 percent unbalanced load. A 15 percent unbalanced load is defined as:

a. Phase A at full rated single phase load.

b. Phase B at 85 percent of Phase A.

c. Phase C at 85 percent of Phase A.

2.1.1.17 Transient Output Voltage Recovery

****

NOTE: Use MIL-STD-704, when 400 Hz power is required to power aircraft avionic equipment.

Use MIL-STD-1399-300, when 400 Hz power is required to power shipboard equipment.

****

[In accordance with MIL-STD-704.][In accordance with MIL-STD-1399-300 for Type [II][III] power.]

2.1.2 Environmental Rating

****

NOTE: Select 55 degrees C ambient temperature rating unless in areas subject to extreme temperatures (i.e. Middle East, desert environments, etc.)

****

The converter shall operate from no load to rated full load under the following conditions:

a. Ambient temperatures ranging from 0 degrees C to [55][60][65] degrees C.

b. Relative humidity from [0 to 95] [_____] percent noncondensing.

c. Ambient pressures from sea level to [915] [_____] meters [3,000] [_____] feet.

2.1.3 Monitoring and Control Panel

Provide converter with a control panel that is equipped with the following controls, indicators, instrumentation, data logging, diagnostics, and alarm functions.

2.1.3.1 Controls

a. Start/stop pushbutton.

b. Lamp/light emitting diode (LED) test - A push-to-test button or switch to test indicator lamps/LEDs.

c. Alarm reset.

d. Emergency power off - A separate pushbutton for emergency power off.

[e. Circuit breaker.

][f. Output contactor ON/OFF

][g. Output voltage adjust.

]2.1.3.2 Indicators

a. Input power available - Lamp/LED to indicate that the supply voltage is available.

b. Output power On/Off - Lamp/LED to indicate that the converter output voltage is available.

c. System alarm - Lamp/LED to indicate that a fault has been detected. This indicator shall be latched in the "ON" position whenever an alarm condition described in paragraph ALARM ANNUNCIATOR, is detected and shall remain "ON" until the alarm reset pushbutton is pressed.

d. Indicating lamp/LED to indicate that the alarm silence switch is in the disable position.

e. Elapsed time meter (hours)

[f. Output contactor "ON".

][g. Aircraft interlock bypass - Lamp/LED to indicate that the Aircraft Interlock has been bypassed.

]2.1.3.3 Digital Instrumentation

****

NOTE: For delta output frequency converters, delete phase-to-neutral voltage and neutral current display

requirements.
****

Provide true rms, plus/minus one percent accuracy, microprocessor-based meter with a simultaneous three-line LCD display

Provide a digital display that has, at a minimum, the following functions:

a. Output phase-to-phase voltage.

b. Output phase-to-neutral voltage.

c. Output phase current.

d. Output neutral current.

e. Output frequency.

2.1.3.4 Alarm Annunciator

The unit shall be capable of detecting and displaying the following abnormal conditions:

a. Input overvoltage.

b. Input undervoltage.

c. Output undervoltage.

d. Output overvoltage.

e. Output overload.

f. System alarm.

g. Control logic failure.

h. Overtemperature.

i. Logic power supply failure.

2.1.4 Input/Output Devices

Provide fully-rated, three-pole, UL approved devices for control of [50] [60] Hz input and 400 Hz output from the converter. Devices and cables operating at 400 Hz shall be derated in accordance with IEEE 519.

2.1.4.1 Circuit Breaker

Conform to requirements of UL 489. Units operating at 400 Hz shall be derated for 400 Hz operation.

2.1.4.2 Input Circuit Breaker

Provide converter with a UL listed input circuit breaker as an integral part of the converter. Breaker shall be operable from the front of the converter. Breaker shall have a short-circuit current rating of [_____] amperes symmetrical minimum.

2.1.4.3 Output Contactor

Provide converter output with an automatic magnetically-held contactor with interlock circuit. Output contactor shall be of sufficient capacity to handle rated load, overload, and available short circuit current. Contactor shall open when any circuit identified in the paragraph PROTECTIVE CONTROL causes the system to shut down. Output contactor shall be electrically interlocked with ON/OFF circuitry so that when the frequency converter is shut down, the contactor shall open immediately and remain open. [Conform to the requirements of IEC 60947-4-1.]

[2.1.4.4 Output Circuit Breaker

****
NOTE: Add output circuit breaker only if frequency converter is supplying downstream distribution panelboard or multiple outputs with distribution internal to the frequency converter.
****

Provide converter output with a non-automatic manual circuit breaker with appropriate frame size and a shunt trip coil derated for 400 Hz operation. Circuit breaker shall be tripped by the unit's OFF circuit [local or remotely activated] and when any circuit identified in the paragraph PROTECTIVE CONTROL causes the system to shut down. Output breaker shall be operable from the front of the unit.

][2.1.4.5 Aircraft Interlock Circuit

****
NOTE: Coordinate with specified aircraft cable assembly.
****

Interlock circuit shall determine the presence or absence of the 28 VDC feedback signal from the aircraft. Interlock circuit shall not allow the output disconnect to close if the 28 VDC signal is not present. If the output disconnect is closed when the 28 VDC is lost, the disconnect shall open within 2 seconds. Converter shall contain terminal block points for the connection of two 12 AWG wire from the aircraft cable assembly for the interlock circuit. Interlock circuit shall not draw more than 20 milliamperes from the aircraft's 28 VDC circuit. For testing purposes, provide a switch inside the converter with two positions:

a. Normal - For aircraft loads.

b. Bypass - For testing with dummy load or no load, or for use with aircraft with no 28 VDC.

]2.1.5 Protective Controls

Provide circuitry for the following protective controls.

a. Input undervoltage.

b. Input overvoltage.

c. Loss of phase.

d. Loss of input power.

e. Door interlock - When any access door is opened, the interlock circuitry shall open the [60][50] Hz input device [and 400 Hz output device] and not allow the input [or output] device to close. For maintenance purposes, provide a bypass switch to defeat the interlock circuitry.

f. Output overvoltage - Protect by tripping output devices for instantaneous overvoltage of 30 percent or more and for 10 to 30 percent overvoltage lasting more than 0.25 second.

g. Output undervoltage - Protect by preventing the closing of the output disconnect until the output voltage is 95 percent of the rated output. If, after closing, the voltage decreases to below 90 percent for longer than 5 seconds, provide relaying to trip output devices utilizing a field-adjustable time-delayed circuit with a range of 4 to 10 seconds.

h. Output frequency - Protect by tripping output devices for frequency change in excess of plus or minus 5 percent of the rated output frequency (400 HZ).

i. Output overload.

j. Converter overtemperature protection.

[2.1.6 Electromagnetic Interference Limits

****
NOTE: This is an additional cost item and reduces converter efficiency. EMI filtering should not be specified unless specifically requested by the user.
****

Comply with MIL-STD-461 for Class A equipment.

]2.1.7 Automatic Line Drop Compensation

Provide automatic line drop compensation - 0 to 7 percent adjustable internally.

[2.1.8 Paralleling

****
NOTE: This is an additional cost item and should not be specified unless specifically requested by the user.
****

Provide frequency converter capable of being paralleled. Paralleled units shall be same manufacturer and model number. Regulate and control units operated in parallel by a master unit. Design controls associated with paralleling of the units such that each frequency converter can operate as a stand alone unit, or as either a slave or master unit in a parallel system. Units shall parallel and synchronize within a 50 millisecond recovery time. Share the total load equally within plus or minus [_____][5] percent by each unit. [Provide manual paralleling which permits a paralleled unit to be added or removed from the system without

interrupting the operation of other units.]

][2.1.9 Auto Restart

****

NOTE: Auto restart should be considered when the converter is installed in a remote location that is not readily accessible to operating personnel and maintaining 400 Hz power is critical to operations. Use of auto restart should be studied carefully to ensure that it does not create a potential personnel safety hazard. This is an additional cost item and should not be specified unless specifically requested by the user.

****

After a total input power outage the unit shall be capable of automatically restarting and re-energizing loads upon restoration of normal power. Provide units with a manual/auto restart switch. If this requirement requires a backup battery power supply this shall be provided. When interlock circuit has been interrupted or when interlock is in the maintenance position manual restart, the system should not restart.

][2.1.10 Built-In Test Equipment

Frequency converter shall include built-in test equipment which monitors both primary circuits and protection circuits of the unit. Provide visual indication to assist diagnosis of unit failures to a modular level. Provide visual indication of converter status using cabinet mounted light emitting diodes.

][2.1.11 Magnetic Devices

Provide Class 180 power magnetic transformer and inductors in accordance with NEMA ST 20 and UL 506. The limits of Class 180 shall not be exceeded at the maximum specified ambient temperature and at 100 percent load.

]2.1.12 Acoustical Noise

****

NOTE: The following table serves as a guide for establishing the maximum allowable sound pressure level for each kVA rating. The designer should take into consideration that converters are inherently noisy when locating the unit. Do not modify these values unless required by the location of the frequency converter and new values have been confirmed by manufacturer as attainable. If values different than shown below are used, include acoustical noise test in Special Factory Tests.

Maximum Allowable	
Rating (kVA)	**Acoustical Noise (dBa)**
5 - 14	**65**
15 - 39	**65**
40 - 99	**68**
100 - 249	**72**
250 - up	**72**

****

Maximum continuous acoustical noise level shall be [_____] dBa (A weighted scale).

2.1.13 Assembly Construction

****
NOTE: Delete "louvers" when specifying NEMA Type 4X and 12K enclosures.
****

Provide enclosures suitable for [indoor][outdoor][corrosive][direct spray] [_____] environments in accordance with NEMA 250, Type [l][3][3R][4X][12K]. Arrange to provide required [louvers,] cooling air, entry and exit provisions for equipment within enclosures. Construct unit(s) so that components, with the exception of control and monitoring components, are totally enclosed within the enclosure. Electronic circuits including power circuits shall be modular construction readily accessible for maintenance, repair and module replacement from the exterior of the enclosure. [For units installed outdoors or in corrosive environments, electronic circuits shall be enclosed in a sealed electronics compartment that is not provided with direct cooling ventilation or forced air cooling.]Provide permanent identification tags for wiring. Uniquely identify each wire. Use the same identification system in the wiring diagrams in the Operation and Maintenance Manual. Provide each enclosure with a finish coat over a substrate which has been provided with a rust inhibiting treatment. [Provide two finish coats for outdoor enclosures.] Color shall be the manufacturer's standard color.

2.1.14 Nameplates

As specified in Section 26 20 00 INTERIOR DISTRIBUTION SYSTEM.

[2.2 AIRCRAFT POWER CABLE ASSEMBLY

****
NOTE: Coordinate cable assembly requirements with unit voltage requirements and aircraft requirements. Provide 300 ampere cable for converters 90 kVA and above. Provide 260 amperes cable for converters smaller than 90 kVA.
****

[For 400 Hz wiring at 200Y/115 volts, provide 7-conductor type cable configured as 6 phase conductors (2xA, 2xB, 2xC) tightly wound around the center located neutral, twisted and jacketed in accordance with SAE AS5756/6 rated for [300] [260] amperes.][For 400 Hz wiring at 575 volts, 3-phase delta, provide 7-conductor type cable configured as 6 phase conductors (2xA, 2xB, 2xC) tightly wound around the center located ground, twisted and jacketed in accordance with SAE AS5756/6.] Cable length must be[27 meters][_____][90 feet][_____]. Provide control cabling included within the jacket for interlock circuit and automatic line drop compensation. Terminate control wiring on accessible terminal blocks in unit. Provide cable assembly with integrally molded 400 Hertz male connector aircraft plug in accordance with MS 25486-17. Cable/connector assembly shall be suitable for severe duty. Contact terminations shall be crimped.

][2.3 REMOTE MONITORING AND CONTROL PANEL

****

NOTE: Delete this paragraph unless plans clearly indicate requirement for remote monitoring and control panel.

****

Provide remote monitoring and control panel and circuitry. Connect to clearly and permanently labeled terminal blocks located inside the converter's enclosure. Provide the circuitry such that indicator lamp/LED information and control function(s) can be extended from the terminals to a remote location in the future.

a. Pushbutton or switch for de-energizing the output terminals.

b. Indicator lamp/LED showing the unit status (energized or not energized).

c. Indicator lamp/LED showing the output circuit breaker position (open or closed).

d. System alarm.

]2.4 SOURCE QUALITY CONTROL

2.4.1 Converter Test Schedule

The Government reserves the right to witness tests. Provide frequency converter test schedule for tests to be performed at the manufacturer's test facility. Submit required test schedule and location, and notify the Contracting Officer 30 calendar days before scheduled test date. Notify Contracting Officer 15 calendar days in advance of changes to scheduled date.

Test Instrument Calibration.

a. The manufacturer shall have a calibration program which assures that all applicable test instruments are maintained within rated accuracy.

b. The accuracy shall be directly traceable to the National Institute of Standards and Technology.

c. Instrument calibration frequency schedule shall not exceed 12 months for both test floor instruments and leased specialty equipment.

d. Dated calibration labels shall be visible on all test equipment.

e. Calibrating standard shall be of higher accuracy than that of the instrument tested.

f. Keep up-to-date records that indicate dates and test results of instruments calibrated or tested. For instruments calibrated by the manufacturer on a routine basis, in lieu of third party calibration, include the following:

(1) Maintain up-to-date instrument calibration instructions and procedures for each test instrument.

(2) Identify the third party/laboratory calibrated instrument to verify that calibrating standard is met.

2.4.2 Routine Factory Tests

****
NOTE: Coordinate line drop compensation option with power cable assembly requirements.
****

Routine tests shall be performed by the manufacturer on each of the actual frequency converter(s) prepared for this project to ensure that the design performance is maintained in production. [As an exception, automatic line drop compensation shall be tested on only one unit on multiple unit orders.] Submit test reports, by serial number and receive approval before delivery of equipment to the project site.

For tests which require full load, use 1.0 power factor unless otherwise noted. All measurements shall be true RMS measurements. Measurements shall be obtained in accordance with IEEE 1159. Tests shall include the following:

a. Input current and power factor: Operate converter at low, nominal and high input voltage at full load. Measure and record input voltage, input power factor and input current in each phase [and neutral if the neutral conductor is connected to the converter input.]

b. Output voltage, output voltage THD, output current, output power factor, and voltage regulation: Operate converter at nominal input voltage for:

(1) 50 percent of rated capacity with 0.8 lagging power factor linear load.

(2) 100 percent of rated capacity with 0.5 lagging power factor, 0.8 lagging power factor, 1.0 power factor, and 0.8 leading power factor linear loads.

(3) 50 percent of rated capacity with the non-linear load as specified in the paragraph LOAD RANGE.

(4) 100 percent of rated capacity at low and high input voltage.

(5) 100 percent of rated capacity with the non-linear load as specified in the paragraph LOAD RANGE.

Operate for not less than 10 minutes at each test condition in (1), (2), (3) and (4) above and not less than 30 minutes at test condition in (5) above. Monitor and record output voltage, output voltage THD, output current, output current waveform, output power factor and frequency at the beginning and end of each test condition. Monitor and record output voltage single harmonic distortion for each test condition in (2) and (5) above at the beginning and end of each test condition. Verify output remains within specified regulation limits.

c. Efficiency: Operate at nominal input voltage at half load and full load at 1.0 power factor. Measure and record input voltage, input current, input power factor, output voltage, output current, and output power factor. Calculate the unit efficiency.

d. No load losses: Operate at no load and nominal input voltage. Measure and record input voltage, input current, input power, input power factor, and output voltage.

e. Burn-in Test: Before delivery, burn-in all units [under full load conditions for at least [24][_____] hours][by cycling units [6][_____] hours "ON" under full load conditions and [3][_____] hours "OFF" at no load conditions for at least [4][_____] complete "ON" cycles]. Burn-in test shall be performed with the converter enclosure doors closed and all ventilation in the final operating condition.

f. Include harmonic frequency spectrum analysis depicting Harmonic Order and Harmonic Magnitude at the unit's input and output terminals during full load THD test in test reports.

g. Automatic line drop compensation: Operate converter at nominal voltage at:

(1) No-load.

(2) 50 percent of rated capacity with a 0.8 lagging power factor linear load.

(3) 50 percent of rated capacity with the specified non-linear load.

(4) 100 percent of rated capacity with a 0.8 lagging power factor linear load.

(5) 100 percent of rated capacity with the specified non-linear load.

Loads shall be connected to the converter with the specified aircraft power cable assembly. No adjustments to the frequency converter shall be allowed between load tests. Monitor and record output voltage at the load end of the cable. Verify specified performance of the line drop compensation.

2.4.3 Special Factory Tests (Design Tests)

****

NOTE: Delete acoustical noise test unless frequency converter is installed in special locations such as

test laboratories or other confined spaces.
****

Submit special factory test (design test) reports (complete with test data, explanations, formulas, and results), in the same submittal package as the catalog data and drawings for [each of] the specified frequency converter(s). Tests shall be certified and signed by a registered professional engineer. Tests shall be on file based on a production model of converters of the same design, construction and kVA rating provided.

As an option, the manufacturer shall test [one][_____] unit[s] at the same time scheduled for routine tests, of each rating and size converter to assure compliance with the specification. For all tests which require full load, use 1.0 power factor unless otherwise noted. The tests shall include the following:

****
NOTE: Select Location Category C for outdoor locations only.
****

a. Surge protection: Apply input surges in accordance with IEEE C62.41.1 and C62.41.2, Location Category [B][C] and monitor output. Conduct a minimum of three consecutive successful tests on each unit listed. Confirm there is no interruption to 400 Hz output power and voltage stays within specified regulation tolerances. Surge protection tests shall be applicable on all frequency converter units utilizing same surge protection device by manufacturer and part number regardless of frequency converter kVA size.

b. Inrush current: After applying power to the converter, conduct a minimum of three inrush current tests at full load. Provide copies of waveform and THD analysis in test report.

c. Input current distortion: Operate at nominal input voltage at full load. Measure and record the input current THD for the current in each phase.

d. Overload: Operate at nominal input voltage and output voltage with loads listed below:

Percent of Full Load	Time
110 percent	60 minutes
125 percent	5 minutes
150 percent	2 minutes
200 percent	20 seconds

Monitor output to confirm there is no 400 Hz power interruption. After minimum operating time is achieved, unit shall interrupt output power.

e. Short-circuit: Apply a [bolted line-to-ground,] bolted line-to-line,

and bolted three phase fault directly to the output terminals of the unit. Conduct a minimum of three consecutive successful tests on each unit. Provide unit capable of carrying the fault current until the integral system protective devices interrupts the fault with no damage to the unit. Provide waveforms of short circuit current during short circuit tests.

f. Output voltage THD: Operate at nominal input voltage at full load with balanced and 15 percent unbalanced load. A 15 percent unbalanced load is defined as follows:

(1) Phase A at full rated single phase load.

(2) Phase B at 85 percent of Phase A

(3) Phase C at 85 percent of Phase A

Measure and record the output voltage THD for the line-to-neutral voltage of each phase.

g. Phase angle regulation: Operate at full load with balanced and 15 percent unbalanced loads. Measure and record displacement angle between adjacent output voltage phases. A 15 percent unbalanced load is defined as follows:

(1) Phase A at full rated single phase load.

(2) Phase B at 85 percent of Phase A.

(3) Phase C at 85 percent of Phase A.

h. Transient recovery: Operate at the following load steps: 0 to 100 percent, 0 to 50 percent, 100 to 0 percent and 50 to 0 percent. Measure and record recovery time and output voltage deviation limits. Provide recordings or display of output voltage during transient recovery test.

[i. Acoustical noise: Operate at no load, 50 percent and 100 percent of full load. Measure continuous steady sound pressure level 1525 mm 5 feet horizontally from the center of each side of the converter at a point 1525 mm 5 feet above the floor. Decibels (dB) are referenced to 20 micropascal.

][j. Electromagnetic interference (EMI) test: [EMI test shall meet the requirements of MIL-STD-461, Part 9, for Class C2 equipment.] [Certified test results on units of the same design shall be acceptable.]

][k. Paralleling: Operate at nominal input voltage at 50 percent and 100 percent of full load at 0.8 lagging power factor. Measure and record the output voltage, output current and power factor provided by each individual unit.

]PART 3 EXECUTION

3.1 INSTALLATION

Install products to operate at 400 Hz in the same manner as specified in other sections of this specification for products operating at [50] [60]

Hz, unless indicated or specified otherwise. Conform to the requirements of NFPA 70 and IEEE C2 and to manufacturer's instructions and recommendations.

3.1.1 Equipment

3.1.1.1 Floor Mounted

Provide proper floor mounting channels and install in accordance with the manufacturer's drawings and instructions and as indicated. Align, level, and bolt or weld units to channels to allow easy withdrawal or insertion of removable components and to permit proper operation and maintenance of equipment.

[3.1.1.2 Wall Mounted

****
NOTE: Wall mount units 5 kVA or less. All other units shall be floor mounted.
****

Bracket mount, but otherwise install as required for floor-mounted units.

]3.1.2 Grounding

****
NOTE: Insert appropriate Section number and title in the blanks below using format per UFC 1-300-02.
****

In accordance with NFPA 70 and as specified in [Section 26 20 00 INTERIOR DISTRIBUTION SYSTEM] [_____].

[3.1.3 Wiring and Conduit

****
NOTE: Conductors, circuit breakers, and devices operating at 400 Hz shall be derated as follows:

Circuit Breakers	
	Derating Factor
E Frame (100 A)	**0.87**
F Frame (225 A)	**0.85**
J Frame (600 A)	**0.82**
K Frame (1200 A)	**0.74**

Cable	
AWG	**Derating Factor**
#2	**0.9877**
#1	**0.9675**
#1/0	**0.9481**
#2/1	**0.9167**
#3/0	**0.8831**
#4/0	**0.8483**

****

3.1.3.1 Building Wiring

****
NOTE: Insert appropriate Section number and title in the blank below using format per UFC 1-300-02.
****

Provide Type XHHW or THHN with stranded copper conductors wiring for 400 Hz circuits. Provide wiring for 400 Hz circuits in non-magnetic conduit, aluminum or PVC. Provide wiring and conduit for 60 Hz circuits as specified in Section 26 20 00, INTERIOR DISTRIBUTION SYSTEM [_____].

3.1.3.2 Conduit

Use aluminum conduit for exposed feeders. Do not install aluminum conduit underground or encased in concrete. Use aluminum fittings and boxes with aluminum conduit. For underground or concrete encasement use PVC.

]3.1.4 Manufacturer's Representative

The manufacturer's representative shall place the system in operation and make necessary adjustments to ensure optimum operation of the equipment. The manufacturer's representative shall have at least 2 years of practical experience in the installation and testing of 400 Hz solid state frequency converters.

3.2 FIELD QUALITY CONTROL

3.2.1 Instruments

Provide test instruments capable of measuring and recording or displaying test data at a higher resolution and greater accuracy than specified for the converter's performance. The test instruments used in the field tests shall have current valid calibration stickers issued by an approved calibration laboratory. Verify calibration and adjustments of converter instruments provided prior to field tests. Instruments shall be calibrated for 400 Hz operation when measuring 400 Hz signals.

3.2.2 Performance of Acceptance Checks and Tests

Perform field tests and conduct inspections. Provide labor, equipment tests instruments, and incidentals required for the tests including load banks, except the Government will furnish electricity. For all electrical load tests, use 1.0 power factor.

Perform in accordance with the manufacturer's recommendations and include the following visual and mechanical inspections and electrical tests.

3.2.3 Initial Inspection and Tests

a. Compare equipment nameplate information with specifications and approved shop drawings.

b. Inspect physical and mechanical condition.

c. Inspect all bolted electrical connections for high resistance using low-resistance ohmmeter, verifying tightness of accessible bolted electrical connections by calibrated torque-wrench method, or performing thermographic survey.

d. Perform specific inspections and mechanical tests as recommended by manufacturer.

e. Verify correct equipment grounding.

f. Perform resistance measurements through all bolted connections with low-resistance ohmmeter, if applicable.

3.2.4 Performance Tests

Conduct converter performance tests under the supervision of the manufacturer's representative. Successfully complete the preliminary operation, control and protective devices check prior to performing load and transient tests. If the converter fails to operate within the specified limits during any of the performance tests the Contractor shall discontinue the test and shall make necessary repairs to correct the failure and restart testing of the converter.

3.2.4.1 Preliminary Operation

Inspect the converter and make adjustments necessary to assure proper operation in accordance with the manufacturer's instructions. Operate frequency converter at 0, 25, 50, 75, and 100 percent of rated full load. Measure and record the output voltage, current, frequency, and THD at each load. Calculate output voltage regulation. Verify converter is operating within specified limits at each load level.

3.2.4.2 Control and Protective Device Checks

Operate each control, switch, input/output device that is capable of being operated manually a minimum of three times, demonstrating satisfactory operation each time. Perform operation test on each protective device to ensure that devices functions properly. After each operation measure and record the converter output frequency, voltage and current. Verify converter is operating within specified limits.

3.2.4.3 Load Test

****
NOTE: Delete bracketed option only when the frequency converter will not be connected to aircraft cable assembly when in service.
****

Operate each unit continuously a minimum of 2 hours at 100 percent rated load. Measure and record the converter output frequency, voltage and current. Verify converter is operating within specified limits. Load test shall be performed with the converter doors closed[and the load connected to the converter with specified aircraft cable assembly].

3.2.4.4 Transient Tests

Transient recovery: Operate at the following load steps: 0 to 100 percent, 0 to 50 percent, 100 to 0 percent, and 50 to 0 percent. Provide recordings or displays of voltage and frequency during each transient test, and indicate on the recordings and displays the time intervals and acceptable limits for voltage and frequency. Repeat each transient test three times, record the results of each test. Verify converter is operating within specified limits.

3.2.4.5 Harmonic Distortion Tests

Perform output voltage harmonic distortion tests at the output of the converter terminals at 0 percent load and 100 percent load at unity power factor. The Contractor shall provide test equipment and instrumentation required for the tests. Tests shall be conducted with a distortion analyzer with test leads within 3 feet of the frequency converter's output terminals. Test data shall include total harmonic distortion amplitudes of all individual harmonics presented in a spectrum analysis format up to the 37th order.

3.2.4.6 Automatic Line Drop Compensation

Conduct automatic line drop compensation tests on each converter with the load connected to the converter with the specified aircraft power cable assembly. Operate each converter at no load, 50 percent and 100 percent of the rated capacity. No adjustments to the frequency converter shall be allowed between load tests. Monitor and record output voltage at the load end of the cable. Verify specified performance of the line drop compensation.

3.2.5 Grounding System

Inspect ground system for compliance with contract plans and specifications.

3.2.6 Follow-up Verification

Upon completion of acceptance checks and tests, the Contractor shall show by demonstration in service that circuits and devices are in good operating condition and properly performing the intended function. As an exception to requirements stated elsewhere in the contract, the Contracting Officer shall be given 5 working days advance notice of the dates and times of checking and testing.

3.3 DEMONSTRATION

3.3.1 Instructing Government Personnel

Provide field training to Government personnel on the operation and maintenance of the converter provided. Provide field training 2 weeks prior to the scheduled date for field acceptance tests. As a minimum the training shall include [2][_____] hours of instruction on the theory of operation and [4][_____] hours on the repair and maintenance of the converters. The instructor shall be approved by the manufacturer of the unit provided. Submit training syllabus including each topic of training and a brief outline of each topic to the Contracting Officer at least 4 weeks prior to training for approval. Training shall be approved by the Contracting Officer at least 2 weeks in advance. The Government may record, video and audio, the training sessions and use these recordings to train personnel on the operation and maintenance of the converter system. Provide two copies of video or audio tapes, if used in the training sessions, to the Contracting Officer.

-- End of Section --