PART 1 GENERAL
1.1 References

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

FEDERAL SPECIFICATION (FS)
FS W-C-375 (Rev. B; Notice 1) Circuit Breakers, Molded Case, Branch Circuit and Service

INSTITUTE OF ELECTRICAL AND ELECTRONIC ENGINEERS

NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION (NEMA)
NEMA AB 1 (1986; Rev. 1989) Molded Case Circuit Breakers and Molded Case Switches
NEMA 250 (1985; Rev. 1988) Enclosures for Electrical Equipment (1000 Volts Maximum)

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

UNDERWRITERS LABORATORIES (UL)
1.2 FACTORY TESTS

1.2.1 Routine Factory Tests

The manufacturer shall test every converter to ensure compliance with the specifications. For tests which require full load, use 0.8 power factor unless otherwise noted. Tests shall include the following:

a. Input Current: Operate the converter at low and high voltage at no load and full load. Measure and record phase current.

b. Input Power Factor: Operate at low, nominal, and high input voltage at no load, half load, and full load. Measure and record input voltage, input phase currents and input power factor.

c. Output Voltage, Power, Power Factor, and Voltage Regulation: Operate at Low, Nominal, and High input voltage at 25%, 50%, and 100% loads. Measure and record output voltage, output current (peak and RMS), output current wave form, power factor and frequency. Verify output voltage and frequency remain within specified regulation limits.

d. Efficiency: Operate at nominal input voltage and full load. Measure and record input voltage, input current, input power factor. Calculate the unit efficiency. Efficiency shall be 91% or greater.

e. 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.

f. Burn-In: Before delivery, burn-in all units under full load conditions for at least 8 hours.

1.2.2 Special Factory Tests

The manufacturer shall test one converter to ensure compliance with the specification. Conduct tests on production model of converters of the same design, construction and KVA rating provided. For all tests which require full load, use 0.8 power factor unless otherwise noted. The tests shall include the following:

a. Surge Protection: Surge Suppression, MOV’s shall be installed across the input phases of the converter and MOV’s shall be installed across the output phases of the converter. Per FCC Class A.

b. Inrush Current: After applying power to the converter, conduct a minimum of three inrush current tests. Measure and record maximum inrush current after the first half cycle (8 to 10 millisec).
c. Input Current Distortion: Operate at nominal input voltage at no load, half load, and full load. Measure and record the total harmonic distortion (THD) for the current in each phase.

d. Overload/Overcurrent: Operate at nominal input voltage with the loads listed below:

<table>
<thead>
<tr>
<th>Percent of Full Load</th>
<th>Minimum Operating Time</th>
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<tr>
<td>110 percent</td>
<td>60 min</td>
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<tr>
<td>125 percent</td>
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<td>150 percent</td>
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Monitor output to confirm there is no 60 Hz power interruption.

e. Short-Circuit: Apply a 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 recording or display of short circuit current during short circuit tests.

f. Output Total Harmonic Distortion (THD): Operate at nominal input voltage at no load and full load with balanced and 15% unbalanced load. A 15% 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 THD for the line-to-line voltage of each phase current.

g. Amplitude Modulation: Operate at no load and full load. Measure and record percentage of amplitude modulation.

h. Phase Angle Regulation: Operate at no load and full load with balanced and 15% unbalanced loads. Measure and record displacement angle between voltage phases. A 15% 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.
i. Transient Recovery: Operate at steady state conditions at 75% rated load. Apply a 15 percent load change, as an added load then as a dropped load. Measure and record recovery time and output voltage deviation limits. Provide recordings or display of output voltage during the transient recovery test.

j. Acoustical Noise: Operate at no load, 50% and 100% of full load. Measure continuous steady sound pressure level 5 feet horizontally from the center of each side of the converter at a point 5 feet above the floor: Noise level shall be less than <69dBA.

1.3 SUBMITTALS

The following submittals shall be required.

1.3.1 Manufacturer’s Catalog Data

1.3.2 Frequency Converter Drawings
   a. Dimensional - Mechanical
   b. Electrical power one-lines

1.3.3.1 Routine Factory Test Procedures

Provide detailed description of test procedures, including test equipment and setups, to be used to ensure the converter meets the performance specification. As a minimum, the test procedures shall include the tests required under the paragraph entitled "Routine Factory Tests".

1.3.3.2 Special Factory Test Procedures

Provide detailed description of test procedures, including test equipment used to ensure the converter meets the performance specification. As a minimum, the test procedures shall include the tests required under the paragraph entitled "Special Factory Tests".

1.3.3.3 Qualifications of Manufacturer

Submit a certification that the manufacturer has a minimum of five (5) years experience in the design, manufacturing and testing of 60 Hz solid state frequency converters.

1.3.3.4 Field Test Procedures

Provide detailed description of test procedures, including test equipment used to ensure the converter meets the performance specification. As a minimum, the test procedures shall include the tests required under the paragraph entitled "Field Tests and Inspections".
1.3.4 Factory Test Reports

Routine Factory Test Reports. Special Factory Test Reports. Burn-In Tests.

1.3.4.1 Routine Factory Test Reports

Submit within 21 calendar days after completion of tests. Certify tests were conducted on each converter in accordance with the requirements set forth in paragraph entitled "Routine Factory Tests" and certify converter satisfactorily operated within specified limits. Report shall include copies of the test procedures and test data and results.

1.3.5 Field Test Reports

50/60 Hz Frequency Converter

Submit within 21 calendar days after completion of tests. Provide in accordance with the requirements set forth in paragraph entitled "Field Tests and Inspections". Certify tests were conducted on each converter in accordance with the paragraph entitled "Field Tests and Inspections" and certify converter satisfactorily operated within the specified limits. Report shall include copies of the test procedures, test data and results.

1.3.6 Certificates

Routine Factory Test Certification. Special Factory Test Certification. Burn-In Test.

1.3.6.1 Routine Factory Tests Certification

Submit certification that routine factory tests were conducted on each converter and converter operated within the specified limits.

1.3.6.2 Special Factory Tests Certification

Submit certification that special factory tests were conducted on a converter of the same design, construction, and KVA rating to be provided and converter operated within specified limits.

1.3.6.3 Burn-In

Submit certification that burn-in tests were conducted in conformance with the paragraph entitled "Routine Factory Tests".

1.4 SPARE PARTS

Furnish recommended manufacturer's spare parts list and schedule of prices for a converter and other equipment specified in this section. They 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

PART 2 PRODUCTS

2.1 FREQUENCY CONVERTERS

Provide frequency converters consisting of modular construction solid-state components for 50 to 60 Hz conversion and ancillary control devices. The frequency converters shall be a standard product of the manufacturer and shall be the manufacturer's latest design that complies with the specification requirements. The 50/60 Hz frequency converters provided (KVA ratings) shall be products of the same manufacturer. The units shall have a calculated mean time between failure (MBTF) exceeding 24,000 hours as calculated when the converter is provided with yearly servicing and maintenance.

2.1.1 Electrical Characteristics

2.1.1.1 Input Voltage

380/220 volts, 3 phase, 4 wire, grounded, 50 Hz. Converter shall provide rated output voltage when input voltage is varied plus or minus 10 percent. Neutral currents shall not exceed 2 percent of any individual phase current at no load and at full load.

2.1.1.2 Input Power Factor

Between 0.8 and unity of steady state line and load variations from half load to full load as specified herein.

2.1.1.3 Surge Protection

Provide units capable of sustaining an input surge described in and tested in accordance with FCC Class A and continue to operate within the specified tolerance.
2.1.1.4 Inrush Current

When the converter is turned on and after the first half cycle, the inrush current shall not exceed 100 percent of the rated full load current. A “soft start” power walk-in circuit shall be used so the rectifier ramps up to full load.

2.1.1.5 Input Current Distortion

For units 40KVA and greater:
Maximum 15% THD at nominal input voltage while providing full rated output power.

For Units 30KVA and below:
Maximum 33% THD at nominal input voltage while providing full rated output power.

2.1.1.6 Output Voltage

480/277 volt, 3 phase, 4wire, grounded, 60 Hz. (OR) 208/120 volt, 3 phase, 4wire, grounded, 60 Hz. Output voltage shall be specified per KVA requirement. Adjustable to plus or minus 10 percent of any rated voltage. The limits overvoltage and undervoltage shall be plus or minus 5 percent. The phase rotation of the output voltage shall be clockwise sequence of A-B-C.

2.1.1.7 Power Output

KVA Output Power rating shall be 0.8 power factor lagging.

2.1.1.8 Load Range

Operate into a non-linear load with a minimum crest factor for each phase current of 2.0. The crest factor is the ratio of the peak value to the RMS value under steady state conditions. The applied peak load current shall not exceed the maximum peak rated current of the Frequency Converter. The maximum peak rated current is defined as the full load RMS current times 1.414.

2.1.1.9 Efficiency

The units shall have a minimum efficiency of 91 percent at 100 percent load.

2.1.1.10 No Load Input Losses

The frequency converter shall have no-load input losses no greater than 10 percent of the output KVA rating.
2.1.1.11 Overload/Overcurrent

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

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2.1.1.12 Short Circuit

When 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 or electronic device interrupts the fault.

2.1.1.13 Output THD

a. Balanced linear load:
   (1) THD: Not to exceed 3 percent line-to-line.
   (2) Maximum single harmonic distortion: Not to exceed 2 percent of the fundamental at the nominal voltage.

2.1.1.14 Amplitude Modulation

Shall not exceed 2 percent no load to full load, measured line to neutral.

2.1.1.15 Frequency Stability

60 Hz within plus or minus 2 percent for all operating conditions, including maximum and minimum specified input voltages, ambient temperature and relative humidity. The frequency regulation shall be independent of 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 percent with three phase 15% unbalanced load. A 15% 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
2.1.2 Environmental rating

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

a. Ambient temperatures ranging from 0 degrees C to 50 degrees C.

b. Relative humidity from 0-95% non-condensing.

c. Ambient pressures from sea level to 1,500 meters.

2.1.3 Monitoring and Control Panel

Provide converters with a Control Panel, LCD Display and LED Indicators so that it is equipped with the following controls, indicators, instruments and alarms.

2.1.3.1 Controls

a. Start/Stop pushbuttons

b. Alarm silence – a switch or button that shall disable the audible alarm.

c. Emergency stop – disconnects the output of the frequency converter by activation from a remote location.

d. Output voltage adjust - locate output voltage control inside converter enclosure, available for adjustment by maintenance personnel only when the door is open.

2.1.3.2 Indicators – Status Indicators

a. Rectifier AC Fail - Lamp/LED to indicate that the supply voltage is not available.

b. Converter Output On – converter is running normally.

c. Short Circuit – converter output is in shorted circuit state.

d. Fuse / Overtemp SD – converter has shut down due to either fuse is open or high temperature.

e. Overload – converter shutdown due to overload for a period greater than converter can accept.

f. Fault – the converter is off due to the following abnormal conditions:
   1. overload
   2. short circuit
   3. high dc voltage to inverter
   4. fuse failure
   5. over temperature
2.1.3.3  Audible Alarm

The unit shall be capable of detecting and sounding an audible alarm for the following conditions:

a.  Overload
b.  Converter is short circuited
c.  Fuse Open
d.  Over temperature
e.  Emergency Stop is activated

2.1.4  Input Device

Fully rated, three-pole devices for control of 50 Hz input.

2.1.4.1  Circuit Breaker

Conform to requirements of FS W-C-375, NEMA AB 1, and UL 489.

2.1.4.2  Input Circuit Breaker

Provide converter with an UL listed input circuit breaker of appropriate rating as an integral part of the converter.

2.1.5  Protective Controls

Provide circuitry for the following protective controls.

a.  Input undervoltage
b.  Input overvoltage
c.  Phase rotation error
d.  Loss of input power
e.  Door Locks - Cabinet doors are to be provided with keyed locks.

f.  Output overvoltage - Protect by shutting the converter output off if overvoltage trip point setting is reached.

g.  Output undervoltage - Protect by shutting the converter output off if the undervoltage trip point setting is reached.

h.  Output overload
2.1.8 Auto Restart

After a total input power outage less than 10sec, the unit shall be capable of automatically restarting and re-energizing loads upon restoration of normal power. If the input power outage last more than 10sec then the converter must be manually restarted.

2.1.9 Built-In Test Equipment

The 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.

2.1.10 Acoustical Noise

A maximum continuous airborne sound level of 69 dBA (A weighted scale) at full load.

2.1.11 Assembly Construction

Provide enclosures in accordance with NEMA 250, Type 1. Arrange to provide required louvers, cooling air, entry and exit provisions for equipment within enclosures. Electronic circuits including power circuits shall be modular construction readily accessible for maintenance, repair and module replacement. Provide each enclosure with a finish coat over a substrate which has been provided with a rust inhibiting treatment. All electronic circuit boards are to have protective Conformal coating. The solid state power electronic modules shall be removable from the front of the unit.

2.2 CONDUIT AND FITTINGS

On frequency converter modules rated 160KVA and smaller, cable access shall consist of knockout plates or a fitting area on the bottom of enclosure located near the front.

On frequency converter modules rated above 160KVA, cable access shall consist of knockout plates or a fitting area via the top rear, utilizing a rear extension which extends the depth by 6 -7 inches to accommodate for larger power conductors required for the input and output.

PART 3 EXECUTION

3.1 INSTALLATION

Conform to the requirements of NFPA 70 and IEEE C2 and to manufacturer's instructions and recommendations.

3.1.1 Floor Mounted

Provide proper floor mounting to allow for installation on the concrete floor slab in accordance with the manufacturer's drawings and instructions and as indicated. System shall have holes in the mounting corners so the unit can be anchored to the floor after it is aligned and leveled.
3.1.2   Grounding
Grounding shall be in accordance with NFPA 70.

3.1.3   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 practical experience in the installation and testing of 50/60Hz solid state frequency converters.

3.2   FIELD TESTS AND INSPECTION
Perform field tests and conduct inspections. Provide labor, test instruments and incidentals required
for the tests including load banks. The Contracting Officer will furnish electricity. Provide the
Contracting Officer 14 days notice in writing of the dates and times scheduled for performance test.
After testing, submit written copies of test results within 21 days of completion.

3.2.1   Instruments
The test plan shall list make and model and provide functional description of the test instruments and
accessories. 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 and valid calibration stickers issued by an
approved calibration laboratory. Verify calibration and adjustments of converter instruments provided
prior to field tests.

3.2.2   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 make necessary repairs to correct the failure and to
continue the testing from the point of failure.

3.2.2.1   Preliminary Operation
Inspect the converter and make adjustments necessary to ensure proper operation in accordance with
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 and frequency at each load. Verify converter is
operating within the specified limits at each load level.
3.2.2.2 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 where applicable to field testing to ensure that devices function properly.

3.2.2.3 Load Test

Run each unit continuously a minimum of 2 hours at 100 percent rated load at 1.0 power factor using a resistive load bank. Measure and record the converter output frequency, voltage and current in 15 minute intervals throughout the load test. Verify converter is operating within the specified limits.

3.2.2.4 Transient Tests

Conduct transient tests on each converter by instantaneously adding 50% load then removing 50% of rated load and by instantaneously adding 100% load then removing 100% of rated load. Provide recordings or display of voltage and frequency during each transient test, and indicate on the recording and display the time intervals and acceptable limits for voltage and frequency. Verify converter is operating, within the specified limits.

3.3 TRAINING

Provide field training to personnel on the operation and maintenance of the converter provided. As a minimum, the training shall include 1 hour of instruction on the theory of operation and 2 hours on the repair and maintenance of the converters. The instructor shall be approved by the manufacturer of the units provided. The Contracting Officer has the option to video record the training session and use recordings to train additional personnel on the operation and maintenance of the converter system. The Contracting Officer shall be responsible for furnishing and operating the video camera.

-- End of Section --