

**WAVEFORM CORRECTOR (WAVEFORM CORRECTORS)
REPLACES SURGE PROTECTION DEVICES (SPD)
PREVIOUSLY KNOWN AS (TVSS)**

1 PART 1: GENERAL

This section describes materials and installation requirements for low voltage Waveform Correctors for the protection of all AC electrical circuits. Devices to be installed at designated service entrance equipment, distribution panels, electronic equipment, and receptacle devices.

1.1 SUBMITTALS

- A. Submit product data on each Waveform Corrector indicating the following:
1. Type of construction and components
 2. Model number and conductor sizes
 3. Dimensional drawings for each model showing mounting and connection arrangements
 4. Clamping voltage for each model number
 5. Attenuation roll off curve and noise attenuation in dB per decade
 6. Operating temperature and frequency
 7. Listing, safety standards and compliances
- B. Submit manufacturer's NRTL certified test data and nameplate data for each model of Waveform Corrector.
- C. Submit electrical single-line diagram showing location and model of each Waveform Corrector.

1.2 TESTING, WARRANTY AND DURABILITY

Manufacturer must provide independent testing on repetitive capability and maximum surge current rating of all Waveform Corrector units. This shall be performed at a nationally recognized lab not affiliated with the manufacturer.

1.2.1 Testing

- A. Single pulse surge current capacity: single pulse surge current tested in a mode at rated surge currents.
- B. Single pulse surge current capacity test: an initial UL 1449 defined 1.2 x 50us, 6000V open circuit voltage waveform and an 8 x 20us, 500A and 3kA short circuit current waveform is applied to benchmark the unit's voltage protection rating (VPR).
- C. IEEE C62.41 category A1 .5uS*100 kHz, 2kV, 70 amp ring wave should be tested on Waveform Corrector. Testing should be performed with the initial pulse in the positive direction. Testing should be performed at 90,180 and 270 electrical degrees to help establish Waveform Corrector performance at the positive peak, the zero crossing and the negative peak of the waveform.
- D. IEEE C62.41 category B3 .5uS*100 kHz, 6kV, 500 amp ring wave should be tested on Waveform Corrector. Testing should be performed with the initial pulse in the positive direction. Testing should be performed at 90,180 and 270 electrical degrees to help establish Waveform Corrector performance at the positive peak, the zero crossing and the negative peak of the waveform
- E. IEEE C62.41, Category B1 1.5/50uS & 8/20uS, 2kV, 1kA amp combination wave (pulse in positive direction) should be tested on Waveform Corrector. Testing should be performed with the pulse in the positive direction.
- F. IEEE C62.41, Category B3 1.5/50uS & 8/20uS, 6kV, 3kA amp combination wave

(pulse in positive direction) should be tested on Waveform Corrector. Testing should be performed with the pulse in the positive direction

- G. Random noise testing should be tested on Waveform Corrector. Random noise should be from 1 kHz to 100 kHz, analogous to noise generated by Variable Frequency Drives. Waveform Corrector should suppress the noise levels to at least 20dB from 1 kHz to 100 kHz.

1.2.2 Durability

- A. IEEE C62.41, Category B3 1.5/50uS & 8/20uS, 6kV, 3kA amp combination wave should be imposed on the Waveform Corrector. Waveform Corrector attenuation levels should be monitored and recorded to at least 1900 repetitive consecutive surges.
- B. Performance (energy absorption) of the Waveform Corrector after 10000 surges should not deviate more than 5% from the Waveform Corrector's response of the initial surge test.

1.2.3 Warranty

- A. Five years on non-modular units.
- B. Ten years on Modular units.

1.3 QUALITY ASSURANCE

- A. Regulatory Labeling:
 - 1. Provide units that are listed and labeled by NRTL.
- B. The specified unit shall be designed, manufactured, tested and installed in compliance with the above references. The unit shall be "Listed by Underwriters Laboratories" to UL 1449 3rd Edition.
- C. ANSI Compliance: Use Waveform Corrector devices in compliance with the recommendations of IEEE C62.41.1, IEEE C62.41.2, and IEEE C62.45.
- D. All the units should comply with NEMA LS-1, Low voltage surge protective Devices.
- E. Each product should be tested individually for quality control
- F. Each product should have unique serial number so that it can be easily traceable.

2 PART 2: PRODUCTS

2.1 GENERAL

- A. All Waveform Correctors for power circuits, provided under this section, shall be the product of a single manufacturer.
- B. All Waveform Correctors for power circuits, provided under this section shall be designed to meet the following housing and mounting criteria:
 - 1. For Waveform Corrector devices used in Outside Plant applications where the device is internal to a cabinet or common equipment vault (CEV) the Waveform Corrector shall be capable of wall mounting with its housing rated to at least NEMA 4.
 - 2. For Waveform Corrector devices used in MSO, CO, or other occupied premises the Waveform Corrector shall be capable of wall mounting and have a housing rated to at least NEMA 4.
- C. Waveform Correctors can be either modular or non-modular in design.
- D. Waveform corrector devices shall be capable of performance at ambient temperatures between -40°C to 65°C at relative humidity ranging from 0 percent to 95 percent, and at altitudes ranging from sea level to 12,000 feet.
- E. Waveform Corrector devices shall be fused such that they disconnect the Waveform

Corrector from the electrical source should the Waveform Corrector fail. The product's fusing shall be certified to survive the full rated surge handling capacity of the unit and to afford safety protection from thermal overloads and short circuits. Waveform Corrector shall meet UL 1449 3rd Edition

- F. Waveform Corrector devices shall have been tested and certified (Listed) by an NRTL to have a short circuit current rating (SCCR) equal to or greater than the available fault current in accordance with NEC Section 285. Series ratings expressly prohibited.
- G. Waveform Corrector devices shall be labeled such that they show the short circuit current rating (SCCR) in compliance with the requirements of the most current revision of UL 1449 in force upon the date of installation.
- H. Waveform Corrector devices that absorb, dissipate, correct the waveform, and do not utilize the ground conductor as a path for power surge energy, supersede SPD devices that meet UL 1449 minimum requirements in force upon the date of installation.
- I. Design Waveform Corrector devices for the specific type and voltage of the electrical service. Single-phase, split phase, and three-phase wye-configured systems shall have L-N. Grounded delta-configured systems shall have L-L. As recommended by the IEEE Emerald Book, Waveform Correctors shall not shunt energy to ground or contribute frequency energy leakage to the ground conductor.
- J. Waveform corrector's active waveform tracking components shall have a maximum continuous operating voltage (MCOV) of no less than 110% of the nominal phase-to-neutral operating voltage for 120V power systems. It can have no less than 110% of the nominal phase-to-neutral voltage for 230V and higher power systems, and not less than 110% of the nominal phase-to-phase voltage for delta systems.
- K. All Waveform Corrector devices will provide filtering across an extended range from 2.5kHz to 2.5MHz, with greater than -30 db filtering across the total frequency spectrum.
- L. SPD filter options that meet minimum standards only at peak resonance shall not meet specification and are expressly prohibited regardless of UL minimum compliance.
- M. Waveform Corrector performance shall be tested by a 3rd party to IEEE C62.41 standards for the following categories:
 - 1. A1 (low system exposure, 2kV, 70 amp ring wave)
 - 2. B1 (low system exposure, 2kV, 1kA combination wave)
 - 3. B3 (high system exposure, 6kV, 500 amp ring wave) and B3 (high system exposure, 6kV, 3kA combination wave).
 - 4. Third party data shall be submitted for review.
- N. Waveform Correctors' performance for the frequency noise between 1kHz to 90kHz should be third party tested and data should be submitted for review.

2.2 MANUFACTURER

Manufacturer list is in alphabetical order and not in order of preference.

- A. Environmental Potentials
- B. (Other Qualified Manufacturer inserted here)

2.3 SERVICE ENTRANCE AC Waveform Corrector

- A. Provide Waveform Corrector meeting IEEE C62.41.1 and IEEE C62.41.2 Location in accordance with Category C. Must also be UL96A compliant.
- B. Type of construction shall be of RLC based circuit. Construction must have absorption, dissipation and filtering circuits. SPD devices incorporating MOV, SAD, gas tube, and/or Selenium technology solely are expressly prohibited as to maintain safety ground integrity

- C. Surge current capacity shall be not less than the following:
 1. L-N Capacity: **320 kA/mode**
 2. L-L Capacity: **320kA/mode**
- D. Due to sensitivity of electronic based devices and negative effects of high frequency noise on an electrical system, Waveform Corrector must be installed and it must filter noise from 2.5 kHz to 2.5 MHz with greater than -30 dB filtering across the total frequency spectrum. Filters/SPD that only meet requirements at peak resonance or simply shunt to ground shall be expressly prohibited.
- E. Waveform Corrector should not only provide low impedance between phase and neutral, but physically convert the electrical noise (energy) and voltage surges to heat, preventing the noise/surge from staying inside the facility, and preventing noise/surge from being shunted to ground. Third party test and certifications data shall be submitted for review.
- F. Waveform Corrector housing shall be in an enclosure that has the same NEMA rating, or higher, as the equipment it protects.
- G. Waveform Corrector shall be installed EXTERNAL to Switchgear or in an explosion and vapor proof separate enclosure inside the gear. Waveform Corrector enclosure does not count as an explosion and vapor proof enclosure.
- H. UL 1449 maximum suppression voltage shall not be more than:
 1. 1500 Volt for 277/480 Volt, 3phase, 4wire
 2. 2000 Volt for 480Volt, 3phase, 3wire
 3. 1500 Volt for 120/208Volt, 3phase, 4wire
 4. 1500 Volt for 208Volt, 3phase, 3wire
 5. 1500 Volt for 120/240Volt, 3phase, 4wire
 6. 1800Volt for 240v 3phase, 3wire

2.4 SWITCHGEAR, MOTOR CONTROL CENTERS, SWITCHBOARDS AND DISTRIBUTION PANELBOARDS AC FILTER-PROTECTOR

- A. Provide Waveform Corrector that meets IEEE C62.41.1 and IEEE C62.41.2 Location in accordance with Category B or C.
- B. Type of construction shall be of RLC based circuit. Construction must have absorption, dissipation and filtering circuits. SPD devices incorporating MOV, SAD, gas tube, and/or Selenium technology solely are expressly prohibited as to maintain safety ground integrity.
- C. Due to sensitivity of electronic based devices and negative effects of high frequency noise on an electrical system, Waveform Corrector must be installed and it must filter noise from 2.5 kHz to 2.5 MHz with greater than -30 dB filtering across the total frequency spectrum. Filters/SPD that only meet requirements at peak resonance or simply shunt to ground shall be expressly prohibited
- D. Waveform Corrector should not only provide low impedance between phase and neutral, but physically convert the electrical energy (noise) and voltage surges to heat, preventing the noise/surge from staying inside the facility, and preventing noise/surge from being shunted to ground. Third party test and certifications data shall be submitted for review.
- E. Waveform Corrector housing shall be in an enclosure that has the same NEMA rating or higher as the equipment it protects.
- F. Waveform Correctors shall be installed EXTERNAL to Switchgear or in an explosion and vapor proof separate enclosure inside the gear. Waveform Corrector enclosure does not count as an explosion and vapor proof enclosure.
- G. UL 1449 maximum suppression voltage shall not be more than:

1. 1500 Volt for 277/480 Volt, 3phase, 4wire
2. 2000 Volt for 480Volt, 3phase, 3wire
3. 1500 Volt for 120/208Volt, 3phase, 4wire
4. 1500 Volt for 208Volt, 3phase, 3wire
5. 1500 Volt for 120/240Volt, 3phase, 4wire
6. 1800 Volt for 240Volt, 3phase, 3wire.

For safety, the Waveform Correctors shall be installed EXTERNAL to any MCC, switchboards, and/or panel boards, unless installed in an explosion and vapor proof enclosure inside the gear. Waveform Corrector enclosure does not count as an explosion and vapor proof enclosure.

- I. Surge current capacity shall be not less than the following:
 1. L-L Capacity: **160 kA/mode**
 2. L-N Capacity: **160 kA/mode**
- J. Waveform Corrector housing shall be in an enclosure that has the same NEMA rating or higher, as the equipment it protects.

2.5 PANELBOARD AC FILTER-PROTECTOR GREATER THAN 300 AMPERES

- A. Provide Waveform Corrector meeting IEEE C62.41.1 and IEEE C62.41.2 Location Category A/B.
- B. Type of construction shall be of RLC based circuit. Construction must have absorption, dissipation and filtering circuits. SPD devices incorporating MOV, SAD, gas tube, and/or Selenium technology solely are expressly prohibited as to maintain safety ground integrity
- C. Waveform Corrector should not only provide low impedance between phase and neutral, but physically convert the electrical noise (energy) and voltage surges to heat, preventing the noise/surge from staying inside the facility, and preventing noise/surge from being shunted to ground. Third party test and certifications data shall be submitted for review.
- D. Due to sensitivity of electronic based devices and negative effects of high frequency noise on an electrical system, Waveform Corrector must be installed and it must filter noise from 2.5 kHz to 2.5 MHz with greater than -30 dB filtering across the total frequency spectrum. Filters/SPD that only meet requirements at peak resonance or simply shunt to ground shall be expressly prohibited.
- E. Surge current capacity shall be not less than the following:
 1. L-L Capacity: **80 kA/mode**
 2. L-N Capacity: **80 kA/mode**
- F. Waveform Corrector shall be in an enclosure that meets the NEMA rating of the panel board, or higher.
- G. For safety, the Waveform Corrector shall be installed EXTERNAL to panel boards, unless installed in an explosion and vapor proof enclosure inside the panel board. Waveform Corrector enclosure does not count as an explosion and vapor proof enclosure.
- H. UL 1449 maximum clamp voltage shall not be more than:
 1. 1500 Volt for 277/480 Volt, 3phase, 4wire
 2. 1800 Volt for 480Volt, 3phase, 3wire
 3. 700 Volt for 120/208Volt, 3phase, 4wire
 4. 1500 Volt for 208Volt, 3phase, 3wire
 5. 700 Volt for 120/240Volt, 3phase, 4wir
 6. 1500 Volt for 240Volt, 3phase, 3wire

2.6 PANELBOARD AC FILTER-PROTECTOR LESS THAN 300 AMPERES

- A. Provide Waveform Corrector meeting IEEE C62.41.1 and IEEE C62.41.2 Location Category A.
- B. Type of construction shall be of RLC based circuit. Construction must have absorption, dissipation and filtering circuits. SPD devices incorporating MOV, SAD, gas tube, and/or Selenium technology solely are expressly prohibited as to maintain safety ground integrity
- C. Waveform Corrector should not only provide low impedance between phase and neutral, but physically convert the electrical noise (energy) and voltage surges to heat, preventing the noise/surge from staying inside the facility, and preventing noise/surge from being shunted to ground. Third party test and certifications data shall be submitted for review.
- D. Due to sensitivity of electronic based devices and negative effects of high frequency noise on an electrical system, Waveform Corrector must be installed and it must filter noise from 2.5 kHz to 2.5 MHz with greater than -30 dB filtering across the total frequency spectrum. Filters/SPD that only meet requirements at peak resonance or simply shunt to ground shall be expressly prohibited.
- E. Surge current capacity shall be not less than the following:
 - 1. L-L Capacity: **12.5 kA/mode**
 - 2. L-N Capacity: **12.5 kA/mode**
- F. Waveform Corrector shall be in an enclosure that meets the NEMA rating of the panel board, or higher.
- G. For safety, the Waveform Corrector shall be installed EXTERNAL to panel boards, unless installed in an explosion and vapor proof enclosure inside the panel board. Waveform Corrector enclosure does not count as an explosion and vapor proof enclosure.
- H. UL 1449 maximum clamp voltage shall not be more than:
 - 1. 1000 Volt for 277/480 Volt, 3phase, 4wire
 - 2. 1800 Volt for 480Volt, 3phase, 3wire
 - 3. 400 Volt for 120/208Volt, 3phase, 4wire
 - 4. 800 Volt for 208Volt, 3phase, 3wire
 - 5. 400 Volt for 120/240Volt, 3phase, 4wir
 - 6. 800 Volt for 240Volt, 3phase, 3wire

ANNUNCIATION AC CIRCUITS

- A. Provide unit or separately mounted LED-type indication lights to show the normal and failed status of each module.
- B. [Optional] Provide one set normally open and one set normally closed remote alarm contacts, which operate when the unit fails.

2.7 SURGE COUNTER AC CIRCUITS

- A. [Optional] Provide each Waveform Corrector rated above 80 kA with dual surge counters displaying the number of voltage transients that have occurred on the unit input. The counter shall retain the count through system power outages. One counter shall be resettable while the other registers aggregate lifecycle surge counts.

3 PART 3: EXECUTION**3.1 INSPECTION:**

- A. Inspect the facility for voltage configurations and panel boards

3.2 APPLICATION REQUIREMENTS

- A. Install Waveform Correctors as indicated on manufacturer installation instructions and drawings
- B. For Electronic Equipment Paired Cable Conductors: Install Waveform Correctors at the input and output interface for each cabinet, CEV, or Shelter.
 - 1. Use secondary Waveform Correctors on lines that do not exit the structure.
 - 2. Use primary Waveform Correctors on lines that exit and enter the structure.

3.3 GENERAL INSTALLATION REQUIREMENTS

- A. Install Waveform Correctors according to manufacturer's recommendations.
- B. Install Waveform Correctors directly to the cabinet which houses the circuit to be protected so that the Waveform Corrector leads are straight and short, with all conductors laced, running directly to the point of connection within the panel, without loops or bends. If bends are unavoidable, no bend may exceed 90 degrees and bending radius may not be less than 6 inches.
- C. Connecting wires shall be as short as possible. Connecting wires shall not exceed 24 inches on main service equipment and no longer than 12 inches in length at any other point.
- D. For field installed leadless filter-protectors, AC conductors shall be the same as specified for building wire, not smaller than No. 8 AWG and not larger than No.1 AWG. Device leads shall not be longer than the length recommended by the manufacturer, unless specifically reviewed and approved by the manufacturer.
- E. Provide dedicated disconnecting means for AC Waveform Corrector devices installed at panel boards. Provide dedicated 15-30 ampere circuit breakers (size dependent upon cable size used) with number of poles as required, as disconnecting means for Waveform Corrector devices installed for panel boards, and outside plant applications. The interrupting capacity of the circuit breakers shall be that specified for the other breakers at that location.
- F. Main service entrance, switchgear, MCC and distribution panel rated 800A do not require dedicated circuit breaker.

END OF SECTION