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An American National Standard

Standard Specification for Surge Suppressors for Shipboard Use[1]

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1. Scope

1.1 This specification establishes performance requirements of surge suppressors for use on shipboard ac power circuits.

1.2 Surge suppressor shall be a protective device for limiting voltage transients on equipment by discharging, dissipating internally, bypassing surge current, or a combination thereof and which prevents continued flow of follow current to ground and is capable of repeating these functions.

1.3 Surge suppressors covered by this specification may consist of a single circuit element or may be a hybrid device using several suppression devices.

1.4 *This international standard was developed in accordance with internationally recognized principles on standardization established in the Decision on Principles for the Development of International Standards, Guides and Recommendations issued by the World Trade Organization Technical Barriers to Trade (TBT) Committee.*

2. Referenced Documents

2.1 The following documents of the issue in effect on the date of material purchase form a part of this specification to the extent referenced herein.

2.2 *American National Standards:*[2]

ANSI/IEEE Std 4 IEEE Standard Techniques for High Voltage Testing

ANSI/IEEE C62.41 Recommended Practice on Surge Voltage in Low-Voltage AC Power Circuits

ANSI/IEEE C62.45 Guide on Surge Testing for Equipment Connected to Low-Voltage AC Power Circuits

ANSI/IEEE C84.1 Electrical Power Systems and Equipment—Voltage Ratings

2.3 *Military Standard:*[3]

MIL-STD-1399 Section 300; Military Standard Interface Standard for Shipboard Systems, Section 300, Electric Power, Alternating Current

2.4 *Underwriters Laboratories Standard:*[4]

UL 1449 Transient Voltage Surge Suppressors, 2nd Edition

3. Terminology

3.1 *Definitions:*

NOTE 1—These definitions other than specific to the standard are taken from UL 1449, ANSI/IEEE C62.41, and MIL-STD 1399 to provide for harmonization of terms.

3.1.1 *combination wave, n*—a surge delivered by an instrument that has the inherent capability of applying a 1.2/50-µs voltage wave across an open circuit and delivering an 8/20-µs current wave into a short circuit. The exact wave that is delivered is determined by the instantaneous impedance to which the combination wave is applied. (Also called combination voltage/current surge or combination V/I surge.)

3.1.2 *crest (peak) value (of a wave, surge or impulse), n*—the maximum value that a wave, surge, or impulse attains.

3.1.3 *electric power source, n*—the electric power that is supplied for testing.

3.1.4 *electric power system ground, n*—ground is a plane or surface used by the electric power system as a common reference to establish zero potential. Usually, this surface is the metallic hull of the ship. On a nonmetallic hull ship, a special ground system is installed for this purpose.

3.1.5 *follow (power) current, n*—the current from the connected power source that flows through a surge protective device following the passage of discharge current.

3.1.6 *frequency tolerance, n*—frequency tolerance is the maximum permitted departure from nominal frequency during normal operation, excluding transient and cyclic frequency variations. This includes variations such as those caused by load changes, switchboard frequency meter error, and drift. Unless specified otherwise, frequency tolerance shall be considered to be ±10 % of nominal frequency.

[1] This specification is under the jurisdiction of ASTM Committee F25 on Ships and Marine Technology and is the direct responsibility of Subcommittee F25.10 on Electrical.

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[2] Available from American National Standards Institute (ANSI), 25 W. 43rd St., 4th Floor, New York, NY 10036, http://www.ansi.org.

[3] Available from DLA Document Services, Building 4/D, 700 Robbins Ave., Philadelphia, PA 19111-5094, http://quicksearch.dla.mil.

[4] Available from Underwriters Laboratories (UL), 2600 N.W. Lake Rd., Camas, WA 98607-8542, http://www.ul.com.

3.1.7 *inrush current, n*—the inrush current is a sudden change in line current that occurs during startup or as a result of a change to the operating mode. Inrush current is dependent on the type of load connected to the surge suppressor, and typically will rise to a maximum value in a few milliseconds and decay to rated value in several milliseconds to several seconds.

3.1.8 *leakage current, n*—line current drawn, either line-to-line or line-to-ground, by the suppressor when operated at the maximum continuous operating voltage.

3.1.9 *maximum continuous operating voltage, n*—maximum sinusoidal rms voltage which may be continuously applied without degradation or deleterious effects.

3.1.10 *measured limiting voltage, n*—the crest (peak) value of the voltage measured at the leads, terminals, receptacle contacts and the like, intended for connection to the load(s) to be protected, and resulting from application of a specified surge.

3.1.11 *nominal frequency, n*—the nominal frequency is the designated frequency in Hz.

3.1.12 *nominal system voltage, n*—a nominal value assigned to designate a system of a given voltage class in accordance with ANSI/IEEE C84.1. For the purpose of this standard, nominal system voltages are 120, 208, 240, and 480 vac. All voltages in this standard are root-mean-square (rms) unless stated otherwise. All tolerances are expressed in percent of the nominal system voltage.

3.1.13 *one-port transient voltage surge suppressor, n*—a TVSS having one set of electrical connections (terminals, leads and the like) intended only for shunt-connection to the ac power circuit, such that load current in the ac power circuit bypasses the TVSS.

3.1.14 *peak overshoot voltage, n*—maximum voltage above the voltage protection level (peak voltage minus suppression voltage rating) across the suppressor output terminals during initial response to a voltage spike.

3.1.15 *power interface, n*—the electrical points where the surge suppression device is electrically connected to the ac power system.

3.1.16 *rated rms voltage (varistor), n*—maximum continuous sinusoidal rms voltage which may be applied to a varistor.

3.1.17 *response time (varistor), n*—the time between the point at which the wave exceeds the voltage protection level (suppression voltage rating) and the peak of the voltage overshoot. For the purpose of this definition, voltage protection level is defined with an 8/20 µs current waveform of the peak current amplitude as the waveform used for this response time.

3.1.18 *secondary surge arrestor, n*—a surge protector device acceptable ahead of the service entrance equipment on circuits not exceeding 1000-V rms (location category C as described in ANSI/IEEE C62.41).

3.1.19 *surge, n*—a transient overvoltage superimposed on the ac power circuit. A voltage surge is generally one in which the superposition of the surge and normal power frequency voltage involves peak voltage levels of twice or more the normal voltage of the ac power system and generally lasting not more than one-half period of the nominal system voltage waveform.

3.1.20 *surge protective device (SPD), n*—a protective device composed of any combination of linear or non-linear circuit elements and intended for limiting surge voltages on equipment by diverting or limiting surge current; it prevents continued flow of follow (power) current and is capable of repeating these functions as specified.

3.1.21 *temporary overvoltage (TOV), n*—a voltage swell from a sudden change in voltage which goes outside the voltage tolerance limits but does not exceed 120 % of nominal system voltage and returns to and remains within these limits within 2 s after the initiation of the disturbance.

3.1.22 *transient voltage surge suppressor (TVSS), n*—a surge protective device intended for connection electrically on the load side of the main overcurrent protection in circuits not exceeding 600 V. (Location Categories A and B as described in ANSI/IEEE C62.41.)

3.1.23 *two-port transient voltage surge suppressor, n*—a TVSS having one set of electrical connections (terminals, leads and the like) intended for connection to the ac power circuit and one or more separate sets of electrical connections (terminals, leads, outlet receptacles, and so forth) intended for connecting the load(s) to be protected. This device is series-connected such that load current will flow through the transient voltage surge suppressor.

3.1.24 *voltage drop, n*—voltage differential measured from input terminals to output terminals under conditions of rated load current for two-port surge suppressors.

3.1.25 *voltage protection level, n*—a suppression rating (or ratings) in volts or kilovolts, selected by the manufacturer that is based on the measured limiting voltage determined during surge testing. Also referred to as the suppression voltage rating.

3.1.26 *voltage spike, n*—a voltage spike is a voltage change of very short duration (100 µs to ½ cycle). The standard 1.2/50-µs lightning impulse, as defined by ANSI/IEEE Std 4, is the characteristic voltage spike used for test purposes.

3.1.27 *voltage tolerance, n*—voltage tolerance is the maximum permitted departure from nominal system voltage during normal operation, excluding transient voltage variations. Voltage tolerance includes variations such as those caused by load changes, switchboard meter error, and drift. Unless otherwise specified, voltage tolerance shall be considered to be ±10 % of nominal system voltage.

4. Classification

4.1 Surge suppressors covered in this specification shall be classified by class and type.

4.2 The two classes of surge suppressors covered in this specification are based on and reflect ANSI/IEEE C62.41 locations.

4.2.1 *Class A*—Surge suppressor associated with long circuit branch that being greater than 30-ft cable distance from the distribution panel and usually installed as a series-connected TVSS at the distribution system receptacle (wall outlet).

4.2.2 *Class B*—Surge suppressor for short branch circuit, either installed at loads within 30-ft cable distance from the circuit breaker distribution panel or within the distribution panel.

4.3 Type designations for surge suppressors covered in this specification are as follows:

4.3.1 *Type I; Permanent Connected Type*—A suppressor designed for hard-wired or panel-mount applications. This type surge suppressor is the only one-port-type TVSS.

4.3.2 *Type II; Plug-In Type*—A suppressor provided with blades for direct connection at a receptacle and with integral output receptacle(s). By nature of its design, a plug-in suppressor is inserted into the circuit as a series connection.

4.3.3 *Type III; Cord-Connected Type*—A suppressor that is connected to a receptacle through a flexible cord that is permanently attached to the suppressor device. The cord shall be in accordance with requirements of UL 1449. Cord-connected devices shall not have means for permanent mounting.

4.3.4 *Type IV; Power Director (Power Center) Type*—A suppressor unit with two-pole main circuit breaker, a master switch for controlling all receptacle outlets, and individual switches for controlling all outlets.

5. Ordering Information

5.1 Orders for suppressors under this specification shall include the following:

5.1.1 This specification number;

5.1.2 Nominal system voltage—120, 208, 240, and 480 V;

5.1.3 Frequency—50, 60, and 400 Hz;

5.1.4 Service—single-phase, three-phase delta, three-phase wye;

5.1.5 Load current;

5.1.6 Surge suppressor—class and type;

5.1.7 Protection modes;

5.1.8 Voltage protection level (suppression rating), if known;

5.1.9 Quantity;

5.1.10 Testing requirements—include only if tests other than the production tests required by this specification are to be performed;

5.1.11 Certification requirements; and

5.1.12 Packaging and shipping requirements.

6. Materials and Manufacture

6.1 *Materials*—All materials used in the construction of these surge suppressors shall be of a quality suitable for the purpose intended and shall conform to the requirements of this specification.

6.1.1 All metallic enclosures shall be either painted or coated with corrosion resistant material.

6.2 *Manufacture*—Plastic, when used, shall be a suitable thermoplastic or thermosetting material so molded as to produce a dense solid structure, uniform in texture, finish, and mechanical properties.

7. Requirements

7.1 *Performance Requirements:*

Maximum continuous operating voltage	110 % of nominal voltage
Temporary overvoltage withstand	120 % of nominal voltage for 2 s
Voltage drop[A]	Less than 0.25 % of nominal voltage at rated current
System frequency tolerance	±10 % of nominal frequency
Voltage protection level:[B]	
• 120-V nominal suppressor	±350 V
• 208-V, 240-V nominal suppressor	±700 V
• 480-V nominal suppressor	±1200 V
Maximum peak overshoot voltage	Less than 250-V overvoltage protection level for voltage spike with 5 kV/μs or lower rate of rise
Response time	Less than 50 ns
Maximum leakage current	Less than 30-mA line-line or line-ground
Inrush current	10 times rated current for 10 cycles
Peak surge current	3000 A
Operating temperature	−10 to 60 °C
Storage temperature	−40 to 85 °C
Minimum insulation resistance to case	10 MΩ at 500 VDC
Humidity resistance	0 to 100 %
Minimum life	2000 operations

[A] For two-port (plug-in and series-connected) suppressors only.
[B] Measured line-to-line and line-to-neutral with an 8/20-μs, 3000-A peak waveform in accordance with ANSI/IEEE C62.41 applied.

7.2 *Operating Requirements:*

7.2.1 Protection modes for all two-port hybrid surge protective devices shall provide protection for common mode (line-to-ground and neutral-to-ground) and normal mode (line-to-line) transients.

7.2.2 Fails to an open (versus short) circuit unless otherwise specified and provides indication (visual) of failure.

7.2.3 Capable of installation into a dedicated container for mounting or as an assembly or component of a switchboard or power supply.

7.2.4 Maximum voltage drop for two-port devices at full current/voltage shall not exceed 0.25 % of nominal system voltage.

7.3 *Grounding Requirements:*

7.3.1 The surge suppressor shall be provided with a means for grounding all exposed dead-metal parts that might become energized. Grounding shall be accomplished in accordance with the requirements of UL 1449.

7.3.2 Type I (permanently connected) suppressors requiring grounding shall have a field-wiring terminal or an insulated ground lead that is intended solely for connection of a grounding conductor.

7.3.3 The flexible cord of Types III and IV suppressors which requires grounding shall have a grounding conductor connected to the suppressor enclosure. Type II, direct plug-in, suppressors requiring grounding shall be provided with a grounding pin as one of the attachment plug contacts.

7.3.4 Any leads emanating from a suppressor are to be of color coded insulated wire. The color green shall be used for the grounding conductor and shall not be used for any other purpose.

7.4 *Supplementary Protection:*

7.4.1 Surge protective devices that are series-connected (Types II, III, and IV) shall have supplementary overcurrent protection and overtemperature protection.

7.4.2 Supplementary overcurrent protection using fuses shall be readily replaceable while circuit breaker protected devices shall be resettable.

7.4.3 Supplementary overcurrent protection shall interrupt all phases of the source circuit plus the circuit neutral where applicable to assure suppressor isolation of the load.

7.4.4 Overtemperature protection shall sense suppressor enclosure or suppression device overtemperature condition and initiate opening of the voltage supply.

7.4.5 Suppressor supplementary protection shall provide a visual or audible indication or both of the opening of the protective device.

8. Enclosures

8.1 Unless specified differently by the purchaser, the suppressor shall be packaged in a safety grounded enclosure with foundation attachments that meets the requirements of UL 1449.

8.1.1 The enclosure shall be capable of confining any material that may be expelled during a catastrophic failure of any suppression device.

9. Receptacles

9.1 Receptacles provided as part of a suppressor shall have a current rating not more that the current rating of the suppressor and a voltage rating consistent with rating of the suppressor.

9.2 All receptacles shall be of the grounding type.

10. Design Tests

10.1 *Insulation Withstand Test*—The assembled insulating members of the surge suppressor shall withstand impulse and power-frequency voltages applied between each pair of line terminals and between each line terminal and the grounded case. Internal parts designed to conduct to discharge impulses shall be removed or rendered inoperative to permit these tests.

10.1.1 *Impulse Insulation Withstand*—A 1.2/50 µs impulse voltage wave, as defined by ANSI/IEEE Std 4, shall be applied between each set of line terminals and between each line terminal and ground. The magnitude of the impulse voltage shall be at least 1.2 times the sum of the voltage protection level (suppression rating) and the maximum peak overshoot voltage, but need not exceed 6 Kv.

10.1.2 *Power Frequency Insulation Withstand*—An ac potential of the nominal system frequency shall be applied for a period of 1 min between each set of line terminals and between each line terminal and ground. The magnitude of the test voltage shall be 1000 V plus twice nominal system voltage. The same test voltage magnitude shall be applied for line-to-line and line-to-ground tests.

10.2 *Power Frequency Withstand Test*—Power frequency withstand tests shall be performed to demonstrate the ability of the surge suppressor to withstand sustained periods of operation at the maximum continuous operating voltage and periods of transient power frequency overvoltage without degradation. The power supply voltage, measured at the input terminals of the suppressor, shall be maintained as close as practicable to, but not less than, the specified test voltage. Three suppressors shall be connected across a power supply within the tolerances of the nominal frequency. The power supply shall have a short circuit capacity, measured at the suppressor input terminals, of at least 500 amps. For multi-phase suppressors, tests shall be performed for the assembled suppressor and power frequency voltage shall be applied to all phases.

10.2.1 *Maximum Continuous Operating Voltage*—The three test samples shall be placed in a controlled-temperature chamber with an ambient temperature of 85 °C ± 5 °C and the rated maximum continuous operating voltage shall be applied for a period of 1000 h. The suppressor leakage currents shall be measured at the beginning of the test (after the suppressor temperature has stabilized), and again after 1000 h. The leakage currents at the conclusion of the test shall be less than 30 mA and shall be less than 110 % of the initial leakage current for each sample.

10.2.2 *Maximum Line-to-Ground Voltage*—Rated maximum continuous operating voltage shall be applied to the three test suppressors between each line terminal and ground for a period of 1 h. A single-phase voltage source may be applied between all line terminals (in parallel) and ground for this test. Leakage current to ground shall not increase by more than 10 % at the conclusion of this test.

10.2.3 *Temporary Overvoltage*—The three test samples shall be exposed to ten cycles of temporary overvoltage. Each overvoltage cycle shall consist of 120 % of rated nominal voltage for a period of 2 s followed by the maximum continuous operating voltage for a period of 1 min. The leakage currents shall not exceed 30 Ma and the leakage current immediately following the 1-min period of the last cycle shall not exceed 110 % of the value obtained at the conclusion of the maximum continuous operating voltage test.

10.3 *Impulse Voltage-Time Tests*—The impulse voltage-time tests demonstrate the suppressor's ability to limit overvoltage in response to varying voltage spike rates of rise. Voltage impulses with fast (5–kV/µs) and slow (150–V/µs) rates of rise and of both polarities shall be applied between each set of input line terminals and between each line terminal and ground. Normal operating voltage need not be applied for these tests. The tests shall be performed on three samples, and the highest crest voltage recorded at the output terminals shall be less than the maximum peak voltage (voltage protection level plus peak overshoot). The response time shall also be less than 50 ns. For one-port type suppressors, input and output terminals are the same terminals. Where three-phase suppressors consist of three identical circuits, these tests need only be performed on one of the three circuits in each sample. If the suppressor discharge current exceeds 3000 amps, a resistance of up to 2Ω may be added in series with the surge generator to limit the current after suppressor operation to 3000 amps.

10.3.1 *Fast-Front Impulse Suppression Tests*—A 1.2/50-µs voltage impulse wave having a prospective crest voltage of 6-kV (5-kV/µs rate of rise) shall be used for the fast-front test. Five impulses of each polarity shall be applied to each set of terminals and the maximum peak voltage and response time obtained line to line and line to ground shall be recorded.

10.3.2 *Slow-Front Impulse Suppression Tests*—Slowfront tests shall be performed using a voltage impulse with a prospective crest of 4.5 kV and a wavefront (time from zero to crest) of 30 µs to 60 µs (approximately 150-V/µs rate of rise). The time to half-crest value on the tail of the prospective waveform should be at least twice the wavefront time. Five impulses of each polarity shall be applied to each set of terminals and the maximum voltage and response time obtained line-to-line and line-to-ground shall be recorded.

10.4 *Voltage Protection Level Tests*—The purpose of this test is to determine the voltage protection provided by the suppressor when passing a surge current. The voltage protection level shall be measured at the output terminals of the suppressor using 8/20-µs current impulse waveforms of both polarities applied to the input terminals. Three new specimens (not previously surged) shall be subjected to five 1500-amp impulses of each polarity, followed by one 3000-amp surge of both polarities, applied between each set of input terminals and between each input terminal and ground. The time interval between current impulses shall not exceed 120 s. In the event that the input voltage developed by the current impulse generator exceeds 6 kV after the initial suppressor overshoot, the current impulse magnitude may be limited to a value which produces a 6-kV input voltage. The maximum value of line-to-line and line-to-ground voltage protection level at each current level shall be recorded and shall be less than the rated maximum suppression voltage rating. The range of voltage protection level values obtained with the series of 1500-amp impulses across the same set of terminals on any one unit shall not vary by more than 10 %.

10.5 *Duty Cycle Tests*—The duty cycle test establishes the ability of the suppressor to interrupt follow current successfully and repeatedly. Duty cycle tests shall be performed using one of the three suppressors previously used in the power frequency withstand tests. The suppressor shall be connected across a power supply within the tolerances of the nominal frequency. The power supply voltage, measured at the input terminals of the suppressor, shall be maintained as close as practicable to, but not less than, the rated maximum continuous operating voltage. The power supply shall have a short circuit capacity, measured at the suppressor input terminals, of at least 500 amps.

10.5.1 A series of ten 8/20 µs current impulse waves with a crest value of 1500 A and constant polarity shall be applied line-to-line with a time interval between surges of 50 s to 60 s. The first surge shall be timed to occur 30° after voltage, zero in the power-frequency half-cycle of the same polarity as the impulse. The second impulse will be timed to occur at 60°, and the timing will be increased an additional 30° for each subsequent surge. A second series of ten current impulses shall be applied line to ground, with the first surge of this series occurring within 2 min of the tenth line-to-line surge. The leakage current before the first impulse and immediately following the last impulse of each series of impulses and the suppression voltage rating during each surge shall be measured. The measured leakage currents shall be less than 30 mA. The leakage current following the last (tenth) impulse shall not have increased by more than 10 % of the value obtained before testing. The measured suppression voltage rating shall be less than the rated voltage protection level. The range of voltage suppression values obtained shall not vary by more than 10 %. If the voltage produced at the suppressor input terminals exceeds 6 kV, the current impulse magnitude can be limited to the value which results in a 6-kV input voltage. Where a three-phase unit consists of three identical circuits, or the peak overvoltages and clamping overvoltages determined by the previous tests are within 10 % for all three phases, only one line-to-line and one line-to-ground test need be performed.

10.6 *Life Cycle Tests*—Life cycle tests establish the ability of the suppressor to retain its voltage limiting function following exposure to a large number of impulses equivalent to the suppressor's life expectancy.

10.6.1 *Voltage Impulses*—Upon successful completion of the duty cycle tests, the suppressor selected for duty cycle testing shall have a series of 1000 voltage impulses with a 1.2/50-µs waveshape and 6-kV magnitude applied between one phase and ground (or between the same two phases if no ground connection is used). Power frequency voltage need not be applied during these tests. If the suppressor discharge current for these tests exceeds 750 A, a resistance of up to 8Ω may be added in series with the surge generator to limit the current after suppressor operation to 750 A. Surges shall be applied at 5 s intervals. Measurements of the maximum peak voltage (voltage protection level plus peak overshoot) shall be taken for the first ten surges and for the last ten surges. The average of the maximum peak voltage for the first ten surges and for the last ten surges shall not vary by more than 10 %.

10.6.2 *Current Impulses*—Following the 1000 voltage impulses, 1000 current impulses with an 8/20 µs waveshape and 750-A magnitude shall be applied to the same set of terminals as were used for the 1000 voltage surges. If the voltage developed at the input terminals exceeds 6 kV, the current impulse magnitude may be limited to a value which produces an input voltage of 6 kV. Nominal frequency voltage shall be applied to the suppressor immediately before and for at least 10 s following application of the current impulse. Current surges shall be applied at 5 s intervals. The value of voltage protection level and the leakage current through the suppressor 10 s following the impulse shall be measured for the first ten surges and the last ten surges. The average of these two parameters for the first ten and last ten measurements shall not vary by more than 10 %.

10.7 *Load Current and Voltage Drop Tests*—For two-port surge suppressors, tests of the ampacity and voltage drop shall be conducted on one sample. A reduced voltage source may be used for the performance of these tests. For multi-phase suppressors, tests shall be performed using the assembled suppressor and the specified magnitude of test current shall be conducted through all phases simultaneously.

10.7.1 *Rated Current and Voltage Drop*—A current not less than the rated current of the suppressor shall be passed through the device (from "input" to "output" terminals) for a period of 1 h. The maximum voltage between corresponding input and output terminals shall be measured with rated current flowing through the suppressor at the end of the 1 h test period and shall not exceed 0.25 % of the nominal system voltage. The temperature rise of the suppressor case and any internal current-carrying components shall not exceed 20 °C.

10.7.2 *Inrush Current*—A current equal to ten times rated current shall be passed through the suppressor (from input to output terminals) for ten cycles without loss of continuity (including interruption of fuses or other protective devices), causing the suppressor to shunt or limit current, or elevating