



TECH NOTE #: CPS-1

SUMMARY OF APPLICABLE UL AND IEEE STANDARDS FOR SURGE PROTECTION DEVICES

This Tech Note provides an overview of the key standards associated with surge suppressors and AC powerline filters.

Standard (current revision date)	Purpose of Standard/Comments
UL 1449 (1987) - Transient Voltage Surge Suppressors	1. Safety Test (constructed of approved components in a safe manner). 2. Suppressed Voltage Rating (let-through voltage rating using the IEEE C62.41 C1 test wave). Other IEEE recommended wave forms such as the C3 and B3 Ringwave are not tested by UL. Note: UL 1449 does not require a maximum surge current test.
UL 1449 (2 nd Edition 1996)	1. Additional Safety Tests. Test for other standards used to improve safety of products. 2. Surge Test. Let through voltage tested at lower current than 1 st edition. 10 kA (IEEE Cat C3) used for the first time, however, it was used only to see if products fail safely.
UL 1283 (1996) - Electromagnetic Interference Filters	This safety standard covers EMI filters connected to 600 V or lower circuits. The UL 1283 is a safety standard and does include performance tests such as MIL-STD-220A Insertion Loss or Cat B3 Ringwave Let-Through Voltage tests.
UL 497, 497A, 497B	Safety standard for primary telephone line protectors, isolated signal loops and surge protection used on communication/data lines. No performance tests conducted for data/communication lines.
IEEE C62.41 (1991)	Recommended Practice on Surge Voltages in Low Voltage AC Power Circuits (ANSI). This document defines the test waves for SPDs.
IEEE C62.45 (1992)	Guide on Surge Testing for Low Voltage Equipment (ANSI). This document describes the test methodology for testing SPDs.
IEEE Emerald Book	Reference manual for the operation of electronic loads (includes grounding, power requirements, etc.)
NEMA LS-1	NEMA Technical Committee guide for the specification of surge protection devices including physical and operating parameters.
NEC	National Electrical Code articles 245, 680 and 800
NFPA 780	Lightning Protection Code recommendations for the use of surge protection devices at a facility service entrance.

Underwriter Laboratories – UL 1449 (Revision 7-2-87), "Transient Voltage Surge Suppressors (TVSS)"

UL 1449 is the standard for all equipment installed on the load side of the AC electrical service and throughout the facility for low voltage AC distribution systems. This includes both hardwire and plug-in products. To obtain a UL Listing, the suppressor must meet the required safety standards and pass a duty cycle test. In addition, UL conducts a Let-Through Voltage test on the suppressor and assigns a Suppressed Voltage Rating (SVR). UL1449 ratings represent a component rating and not the actual let-through voltage of the electrical distribution system (i.e., UL 1449 does not include the effects of installation lead length and over current protection).

A duty cycle test is based on a 26 shot withstand test. The test begins with a 6000 V, 3000 Amp Combination Wave, followed by 24 shots of a 6000 V, 750 Amp combination wave, and finishes with another 6000 V, 3000 Amp shot. The UL test uses waveforms similar to

those recommended in IEEE 62.41. To pass UL 1449, the TVSS unit must withstand the duty cycle test and not degrade by more than 10% from its initial Let-Through Voltage value.

All UL Listed TVSS equipment displays the SVR rating for each applicable protection mode. The suppression rating is the average let-through voltages of three 6000 V, 3000 A combination wave impulses (IEEE C62.41 Cat C1 test wave). If this rating is not affixed to the TVSS, then one must assume the device is not UL 1449 Listed.

The average rating is rounded to the next highest standard SVR class set by UL. For example, a 401 V rating is rounded up to 500 V. The standard SVR classes are: 330, 400, 500, 600, 800, 1000, 1200, 1500 or 2000 Volts.

Note:

1. UL 1449 does not test a suppressor to other important test waveforms such as the IEEE Cat C3

service entrance surge (20 kV, 10 kA) or the B3 Ringwave (6 kV, 100 kHz), the most common type of transient inside a facility.

2. UL does not verify that the TVSS device will achieve the manufacturer's published surge current ratings. Thus, a 200 kA/phase device is not tested to 200 kA, only to 3 kA.
3. Plug-in products are tested differently and cannot be compared to hardwired devices.

UL 1449 (1996 2nd Edition)

The core of the UL test remained the same into the 2nd edition. The procedures were rewritten to document the method used to actually test to 1st editions. As experience was gained in testing to 1st edition, the procedures changed. The upgrading of the procedures was one of the major changes. Additional testing in other UL standards was copied into UL 1449 instead of being referenced by UL 1449.

One of the two substance changes was in how surge testing is performed. Previous testing had the surge testing measured as the product shipped. That is a device with terminals was tested at the terminals, and a device with fly leads was tested at the end of the leads. 2nd edition testing now adds wire to terminals or cuts back the fly leads. Both units will be tested at 6" of lead measured out of the box. Also, the surge current for hard wired devices was changed from 3000 A to 500 A to match the surge current test for plug in devices.

The new Measure Limiting Voltage (MLV) test uses 6 inches (15cm) of wire measured from the outside of the enclosure. In the case of products supplied with wire leads, the leads are cut back to 6 inches. For products with terminal connections, wire is attached to the terminals and cut back so that 6 inches extends from the enclosure. This 6 inches of wire is used to simulate an installed product

The second substance change was the inclusion of the additional abnormal fault tests. The limited current test exposes the SPD to high voltage yet preventing the fusing from operating. The unit must not fail unsafely.

These changes are meant to enhance the safety aspects of UL and to place less importance to the performance aspect.

UL 1283 Electromagnetic Interference Filters

Surge suppressors must be Listed (or recognized) under UL 1449. Those devices employing an EMI Filter can also be complimentary listed under UL 1283 to ensure the filter components are properly designed to withstand the required duty cycle and stress requirements.

UL 1283 covers EMI filters installed on, or connected to, 600 V or lower circuits. These filters consist of capacitors and inductors used alone or in combination with each

other. Included under this requirement are facility filters, hardwired and plug-in devices.

UL 1283 reviews all internal components and enclosures, insulating material, flammability characteristics, wiring and spacing, leakage current, temperature ratings, dielectric withstand and overload characteristics.

Note: UL 1283 does not include performance tests such as the MIL-STD-220A insertion loss test to determine the dB rating of the filter at the desired frequency (i.e. 100 kHz for hardwired AC power systems) or the Let-Through Voltage test using the IEEE Cat. B3 Ringwave.

Data/Communication Line Protectors (UL497, 497A, 497B)

UL 497 is the safety standard for single or multi-pair Telco primary protectors. Every telephone line provided by a telephone operator must have an UL approved T1 protector (gas tube or carbon arrestor) in accordance with Article 800 of the NEC. A primary protector is required to protect equipment and personnel from the excessive potential or current in telephone lines caused by lightning, contact with power conductors and rises in ground potential.

UL 497A applies to secondary protectors for communication circuits. Secondary protectors are intended to be used on the protected side of telecommunication networks (it assumes primary protectors are in place) that have operating RMS voltage to ground less than 150 volts. These protectors are typically used at the facility incoming service or other areas where communication circuits require protection.

UL 497B applies to data communication and fire alarm circuit protectors (communication alarm initiating or alarm indicating loop circuits). This includes most dataline protectors in the electrical industry.

ANSI/IEEE C62.41 (1991) Recommended Practice on Surge Voltages in Low Voltage AC Power Circuits (ANSI)

This document describes a typical surge environment based on location within a facility, powerline impedance to the surge and total wire length. Other parameters include proximity, type of electrical loads, wiring quality and geographic location.

The document only describes typical surge environments and does not specify a performance test. The waveforms included in the document are meant as standardized wave forms that can be used to test protective equipment. Any statement where a manufacturer advertises that its "protector meets the requirement of, or is certified to IEEE C62.41", is inappropriate and misleading.

Two selected voltage/current waveforms (see Figure 1, on the back page) are identified as representative of typical electrical environments:

1. Combination Wave: A unipolar pulse that occurs most often outside a facility (eg. a lightning strike).
2. 100 kHz Ringwave: An oscillating waveform that occurs most often inside a facility.

The amplitude and available energy of the standard waveforms are dependent upon location within a facility. As shown in Figure 2, on the back page, locations are classified into three categories:

CATEGORY A: Outlets and long branch circuits

- All outlets at more than 10 m (30 ft) from Category B
- All outlets at more than 20 m (60 ft) from Category C

CATEGORY B: Feeders and short branch circuits

- Distribution panel devices
- Bus and feeder distribution
- Heavy appliance outlets with "short" connections to service entrance
- Lightning systems in large buildings

CATEGORY C: Outside and service entrances

- Service drops from pole to building
- Runs between meter and panel
- Overhead lines to detached building
- Underground lines to well pump

The Category C surges can enter the building at the service entrance. SPDs must be sized to withstand these types of surges when installed at switchgear or service entrance switchboard.

The second variable used to classify the environment of a power disturbance is Exposure. As shown in Figure 3, on the back page, IEEE has defined three exposure levels that characterize the rate of surge occurrence versus voltage level at an unprotected site. The three exposure categories include:

- Low Exposure: applications known for low lightning activity, little load switching
- Medium Exposure: systems and geographical areas known for medium to high lightning activity or, with significant switching transients or both.
- High Exposure: those rare installations that have greater surge exposure than those defined as low or medium.

Isokeraunic maps provide a good baseline for evaluating lightning occurrence within a region. Discussions with local utilities and other major power users combined with power quality surveys are useful for measuring the likely occurrences from load switching and power factor correction capacitors.

For each category and exposure level, IEEE has defined the test waveform that should be used by a specifier when determining performance requirements. For example, most SPDs installed at the main service panel

after the meter are in a Category C environment. Figure 4 details the C62.41 test waveforms for Categories A, B and C.

In the revised C62.41 (1991) document, special waveforms have been identified to address large banks of switching capacitors or the operation of fuses at the end of long cables. These situations warrant the consideration of additional waveforms whose energy is greater than those stipulated for Category A, B and C environments.

Many specifiers are confused about the recommendations contained in C62.41. Often the document is misapplied because category environments and test waveforms are used as performance standards (eg. "ability to meet C62.41").

The C62.41 recommendations should be used for selecting specifications appropriate to the needs of a given designer or end user.

IEEE C62.45 (1992) - Guide on Surge Testing for Equipment Conducted to Low Voltage AC Power Circuits

This document provides appropriate surge testing guidelines for equipment survivability, methods of test connection, surge coupling mode definitions, testing safety requirements and various theories of surge suppression techniques. The intent is to provide background information that can help determine if specific equipment or a circuit has adequate withstand capability.

An important objective of the document is to call attention to the safety aspects of surge testing. Signal and datalines are not addressed.

IEEE Std 1100 (1992) Emerald Book Recommended Practice for Powering and Grounding Sensitive Electronic Equipment

This publication presents recommended engineering principles and practices for powering and grounding sensitive electronic equipment. This standard is the recommended reference book for facility-wide power quality solutions. The scope of this publication is to: "recommend design, installation and maintenance practices for electrical power and grounding of sensitive electronic processing equipment used in commercial and industrial applications." The following sections apply to surge protection devices:

- Chapter 3 (particularly 3.4.2 and 3.4.3)
- Chapter 4 (particularly 4.4 and 4.5)
- Chapter 8 (particularly 8.2)
- Chapter 9 (particularly 9.11)

NEMA LS-1

This document is a specification guide for surge protection devices for Low Voltage AC Power

applications (less than 1000 V). The document identifies key parameters and evaluation procedures for specifications. NEMA employed established references such as IEEE and UL guidelines. The following parameters are included in the LS-1 document:

- Maximum continuous operating voltage (MCOV)
- Modes of protection
- Maximum surge current per mode
- Clamping Voltage (A3, B3 Ringwave, B3/C1 Impulse, C3 Impulse)
- EMI Noise Rejection (insertion loss)
- Safety UL approvals (including UL 1449, UL 1283)
- Application environment

NEMA LS-1 (and other organizations) do not recommend the use of Joule ratings or response time as a performance criteria for SPDs.

National Electric Code (United States): NEC - Article 280, 645 and 800 Surge Arrestors

NOTE: The adequacy section of the code clearly states that compliance with the code will not ensure the proper equipment performance. This fact is often overlooked by end users/customers considering electrical designs from a low bid perspective.

Article 280 covers the general requirements, installation requirements and connection requirements for surge arrestors installed on premises wiring systems.

Article 645 covers Electronic Computer/Data Processing Equipment and references NFPA 75.6.4 regarding the Protection of Electronic Computer/Data Processing Equipment.

Article 800 reviews Protection requirements (800-31), Secondary Protector requirements (800-32) and Cable and Protector Grounding (800-40) for communication circuits.

National Fire Protection Association (NFPA) - 780 Lightning Protection Code

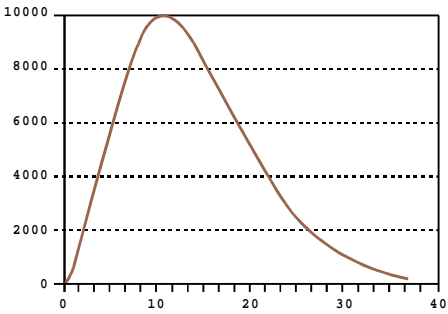
NFPA 780 is the code for lightning protection systems and addresses the protection requirements for ordinary structures, miscellaneous structures and special occupancies, industrial operating environments, etc. The following paragraphs are related to surge protection:

3-21 Surge Suppression. Devices suitable for protection of the structure shall* be installed on electric and telephone service entrances, and on radio and television antenna lead-ins (*shall indicates a mandatory requirement).

Note: Electrical systems and utilization equipment within the structure may require further surge suppression.

For more information on the safety and performance standards, please call our customer service staff or technical sales representatives.

Figure 1
Combination Wave



Ring Wave

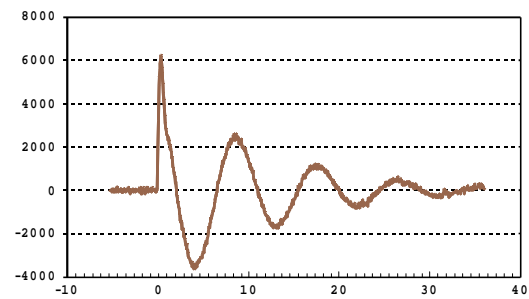


Figure 2: IEEE C62.41 Location Categories

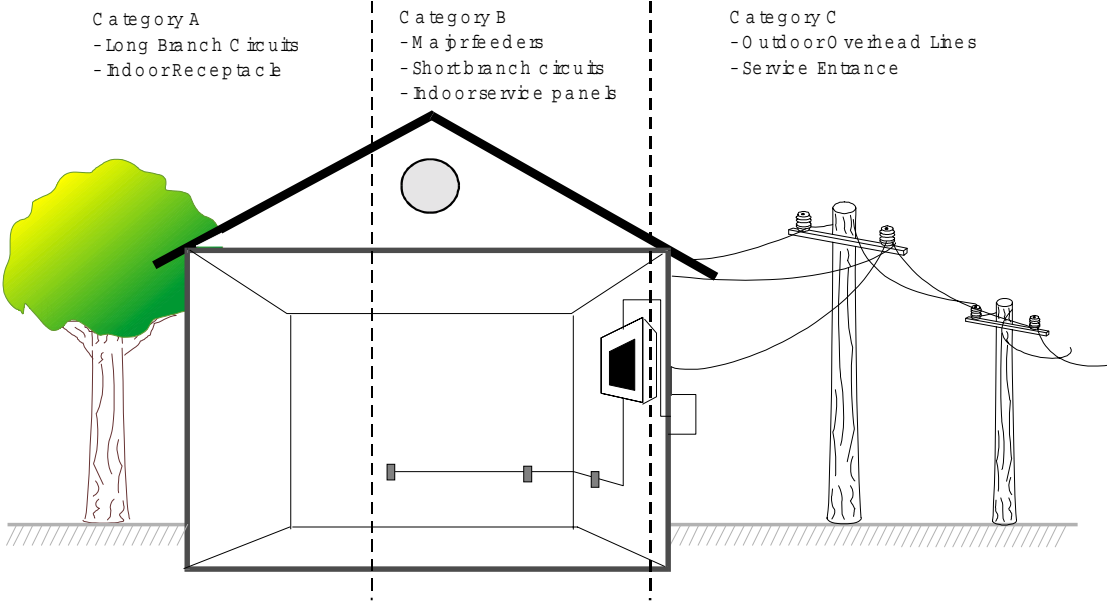


Figure 3: IEEE C62.41 Exposure Levels

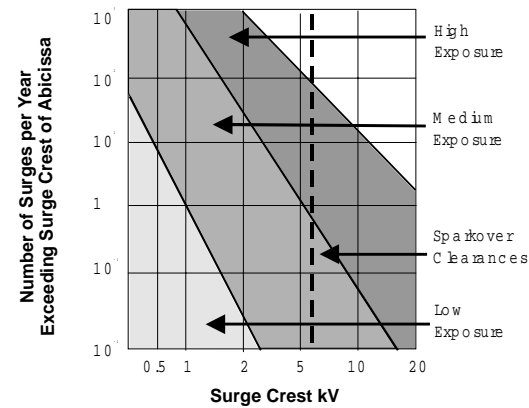


Figure 4: IEEE C62.41 Current/Voltage Waveforms for Various Exposure Locations

Category	Level	Voltage (kV)	0.5 μ S x 100kHz Ring Wave Current (A)	1.2 x 50 μ S (V) 8 x 20 μ S (A) Combination Wave Current (kA)
A1	Low	2	70	
A2	Medium	3	130	
A3	High	6	200	
B1	Low	2	170	1
B2	Medium	4	330	2
B3	High	6	500	3
C1	Low	6		3
C2	Medium	10		5
C3	High	20		10