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STANDARDS PUBLICATION NO. LS 1

LOW VOLTAGE SURGE PROTECTIVE DEVICES

NEMA

NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION ■ 2101 L STREET, N.W., WASHINGTON, D.C. 20037

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NEMA STANDARDS PUBLICATION NO. LS 1-1992

LOW VOLTAGE SURGE PROTECTIVE DEVICES

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Foreword

A properly derived and professionally presented product specification enhances the credibility and reputation of a manufacturer because the actual performance or independently verified characteristics and capabilities of its product are accurately described by its own published product specifications.

This document represents the collective view of the Technical Committee of NEMA's Low Voltage Surge Protective Device Section. It is intended to serve primarily as a guide to manufacturers and others affiliated with the Low Voltage SPD marketplace in the hope that uniformity of specifications, in terms of valid, understandable physical parameters, will improve the understanding of SPD literature.

Generally, this product has been known as a Transient Voltage Surge Suppressor (TVSS). In an effort to harmonize with developing technical literature and international nomenclature, the term "Low Voltage Surge Protective Device (SPD)" has been adopted to refer to the same product.

These standards are reviewed periodically by NEMA for any revisions necessary to keep them up-to-date with advancing technology. Proposed or recommended revisions should be submitted to:

Vice President, Engineering
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2101 L Street, N.W., Suite 300
Washington, DC 20037-1526

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Scope

This document addresses a uniform specification of Low Voltage Surge Protective Devices (also called Transient Voltage Surge Suppression (TVSS) devices) specifically manufactured for use in the Low Voltage (Line Service Voltages of less than 1000 VRMS) Transient Surge Environment.

This document consists of two sections:

1. *Specification Introduction and Definitions*—where specification parameters and their definitions are given.

2. *Test and Evaluation Procedures*—where the guides, standards, and methodology of determining specification parameter values are introduced.

In presenting a specification format, it is not the intent of this document or that of NEMA (Low Voltage SPD Section) to introduce new standards, derive test and evaluation methodology, or define extensive vocabulary. Rather, those parameters considered essential, and above all measurable, using current, off-the-shelf test equipment and referencing established standards and measurement guidelines, are introduced as constituting the body of a proper specification format. The methods associated with their measure or derivation will be referenced, though most are not extensively addressed, since adequate procedural definition and discussion is readily available in ANSI, IEEE, and other technical publications.

Above all, this document is intended to be general in nature. As such, some terms and procedures may not apply to certain devices. Others may require additional technical information in order to adequately define unique application capability or special characteristics. Therefore, specification format and reference to existing standards are emphasized.

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Section 1
REFERENCED STANDARDS

1.1 REFERENCED STANDARDS

The following standards are referenced in this publication and are available from the following sources:

Institute of Electrical and Electronics Engineers
P.O. Box 1331
Piscataway, NJ 08855-1331

IEEE C62.41-1991*	*IEEE Recommended Practice on Surge Voltage in Low-Voltage AC Power Circuits*
ANSI/IEEE C62.45-1987*	*IEEE Guide on Surge Testing for Equipment Connected to Low-Voltage AC Power Circuits*

Underwriters Laboratories, Inc.
333 Pfingsten Road
Northbrook, IL 60062

UL1449-1985 (including revisions through July 1987)	*Standard for Transient Voltage Surge Suppressors*

*Copies also may be obtained from the American National Standards Institute, 11 West 42nd Street, New York, NY 10036.

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Section 2
SPECIFICATION PARAMETER INTRODUCTION AND DEFINITIONS

2.1 INTRODUCTION

The following parameters and definitions make up the body of a proper SPD specification format in the Appendix. Suggested parameters units are identified in parentheses, ( ).

Please note that not all parameters are required for complete specification of all SPD devices; less complex SPDs may be addressed with fewer parameters. More complex or special products may require additional specification terminology. Ultimately it is the manufacturer's responsibility to accurately specify his product. Manufacturers should, therefore, make every effort to include all applicable performance parameters.

NEMA Standard 5-18-1992

2.2 DEFINITIONS

2.2.1 SPD Device Name and Model Number

2.2.2 SPD Category and Type

Three categories: Service Entrance, Distribution Panel, and Receptacle. Two types: Permanently wired and plug-in or cord connected.

NEMA Standard 5-18-1992

2.2.3 SPD Functional Description

A description of the SPD circuit in terms of components and configuration. Not intended to reveal proprietary information, but to inform the potential user of the design approach and performance capability.

NEMA Standard 5-18-1992

2.2.4 Nominal Line Voltage

The nominal power frequency voltage for which the SPD is designed. Usually specified as a label item by safety approval agencies.

NEMA Standard 5-18-1992

2.2.5 Maximum Continuous Line Current (Amperes)

The maximum load current a series-connected SPD is able to conduct to a load at rated Maximum Continuous Operating Voltage (MCOV) within its rated temperature range. Usually specified as a label item by safety approval agencies.

NEMA Standard 5-18-1992

2.2.6 Maximum Continuous Operating Voltage (MCOV)

The maximum steady state voltage at which the SPD device can operate and meet its specification within its rated temperature.

NEMA Standard 5-18-1992

2.2.7 Protection Modes (L-N, L-L, L-G, N-G)

This parameter identifies the modes for which the SPD has directly connected protection elements, i.e. line-to-neutral (L-N), line-to-line (L-L), line-to-ground (L-G), neutral-to-ground (N-G).

NEMA Standard 5-18-1992

2.2.8 Connection Means

The means of connection to the SPD to the electrical distribution system. May be specified in terms of standard NEMA receptacle/plug designations or physical connection means such as a lug terminals, screw-down devices, and such.

NEMA Standard 5-18-1992

2.2.9 Maximum Surge Current (Single Pulse Rated, 8/20μs, by Mode, Amperes)

The maximum 8/20μs surge current pulse the SPD device is capable of surviving on a single-impulse basis without suffering either performance degradation or more than 10 percent deviation of clamping voltage at a specified surge current. Listed by mode, since number and type of components in any SPD may vary by mode.

NEMA Standard 5-18-1992

2.2.10 Clamping Voltage Data ANSI/IEEE C62.41 (Taken at 90 Degrees Phase Angle, by Mode, Positive Polarity Only)

Includes the following waveforms:

Category A3 Ringwave (6 kV open circuit voltage, 200 A, short circuit current, 100 kHz)

Category B3 Ringwave (6 kV open circuit voltage, 500 A, short circuit current, 100 kHz)

Category B3 Combination Wave (6 kV 1.2/50μs open circuit voltage, 3kA 8/20μ short circuit current

Category C3 Combination Wave (20 kV 1.2/50μs open circuit voltage, 10kA 8/20μs short circuit current

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The above listed waveforms from ANSI/IEEE C 62.41 are now adopted by ANSI for transient voltage performance analysis. These waveforms constitute the most complete and widely adopted means of characterizing SPD performance. Testing is performed by mode and, by convention, is conducted at the 90-degree phase angle position of the applied power frequency voltage. Positive polarity clamping voltages measured from zero voltage reference for waveforms applicable to the SPD are a required specification minimum. Clamping voltage data is sometimes supplemented by actual scope traces or photographs of the clamping voltage waveforms.

NEMA Standard 5-18-1992

2.2.11 EMI-RFI Noise Rejection

This section applies only to SPD devices for which EMI-RFI suppression or filtering is claimed. EMI-RFI filters in SPD serve to reduce or remove unwanted disturbances superimposed on the power system which tend to cause undesirable effects on connected load equipment. Due to the nature of filters, it is necessary to provide a continuous plot of noise rejection, also called attenuation, over the rated frequency range.

NEMA Standard 5-18-1992

2.2.12 Safety Agency Approvals

Approvals and ratings are obtained by manufacturers from nationally recognized testing laboratories. Such a listing or approval denotes that the SPD has passed the requirements of the safety approval agency.

NEMA Standard 5-18-1992

2.2.13 Safety Agency Approval Ratings (By Mode, VPeak)

Approval ratings pertain to tests performed by safety agencies during safety approvals, such as suppression voltage according to UL Standard 1449.

NEMA Standard 5-18-1992

Safety agency, standard identification, rating and rating unit of measure (VPeak, Amperes, and such) should be clearly specified.

Authorized Engineering Information 5-18-1992

2.2.14 Application Environment

A description of the physical and electrical environment for which the SPD device is designed.

NEMA Standard 5-18-1992

Description may include discussion of specific requirements of the SPD, such as device housing, and construction.

Authorized Engineering Information 5-18-1992

2.2.15 Physical and General Data

This parameter set may include physical dimensions and weights, operating temperatures, humidity or other environmental constraints, mounting requirements, wire sizes, and specific locations.

Authorized Engineering Information 5-18-1992

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Section 3
TEST AND EVALUATION PROCEDURES

3.1 GENERAL

Determination of the specification parameters defined in the previous section may be accomplished using a combination of off-the-shelf laboratory equipment, component manufacturer's specifications, engineering formulations, and standardized procedures. Few represent endeavors beyond the capability of the standard electronics laboratory and those exceptions that may exist should not present extreme difficulty to the SPD manufacturer.

In this section each of the specification parameters is reviewed and the specific test procedure is identified in terms of test type or standard. For those areas of evaluation where standards that exactly specify test procedures already exist, like those associated with ANSI/IEEE clamping performance, applicable standards, or published guidelines are simply identified. Other parameter areas may require more detail, or little or no explanation.

Authorized Engineering Information

3.2 SPD DEVICE NAME AND MODEL NUMBER

Complete description of device and model.

3.3 SPD CIRCUIT DESCRIPTION

Brief description of component type and arrangement is usually sufficient. "Gas Tube/MOV hybrid, both Normal and Common Mode" is a typical example.

Authorized Engineering Information

3.4 NOMINAL LINE VOLTAGE

See safety agency label requirements.

NEMA Standard 5-18-1992

3.5 MAXIMUM CONTINUOUS LOAD CURRENT

See safety agency label requirements and UL 1449.

NEMA Standard 5-18-1992

3.6 MAXIMUM CONTINUOUS OPERATING VOLTAGE

Should not be higher than the lowest maximum continuous operating voltage of any component used in the SPD.

Authorized Engineering Information 5-18-1992

3.7 PROTECTION MODES

Identify all across-the-line component modes in the SPD device. See safety agency requirements or UL 1449 or both.

NEMA Standard 5-18-1992

3.8 CONNECTION MEANS

Specify per the connection means employed.

NEMA Standard 5-18-1992

3.9 MAXIMUM SURGE CURRENT

This parameter should be tested with a transient generator capable of generating a specified 8/20μs current waveform.

Suppression Voltage measured from zero voltage reference at the Maximum Transient Current may be included with specification of Maximum Transient Current as determined from actual measurements.

Authorized Engineering Information 5-18-1992

3.10 CLAMPING VOLTAGE

More than any other parameter set, clamping voltage provides the basis of comparison between similar products. The clamping voltage is the voltage measured at the output terminals of the SPDs. For this reason it is imperative that proper procedures are followed and calibration of equipment is maintained.

Since actual test procedures associated with this portion of the specification format are well established and defined in the literature, further detailed discussion has been omitted. A number of commercially available genreators produce the waveforms described in ANSI/IEEE C62.41. With this equipment, performance evaluation of SPD devices to these waveforms is readily accomplished once the generator and the measuring system are properly calibrated. Clamping voltage is measured from zero voltage reference. ANSI/IEEE C62.45 describes how the on-line testing should be conducted. UL1449 also addresses this topic. (Note: Equipment limitation may necessitate the use of a 10kA, 8/20μs current impulse through the SPD from a surge generator having at least 6kV open circuit voltage. This may result in a slightly higher measured peak suppression voltage. The waveform used should be noted on the data sheet.)

Authorized Engineering Information 5-18-1992

3.11 EMI-RFI NOISE REJECTION

This section is applicable only to those SPD devices that contain filter components or claim noise filtration, or both. Testing procedures for 50 ohms system.

NEMA Standard 5-18-1992

Noise rejection criteria are well established and used extensively throughout the electronics industry and, therefore, are not addressed here.

The SPD should be connected to a 50 ohm sweep generator, a spectrum analyzer and a 50 ohm load resistor and

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should be swept for the specified frequency range. The test should be performed for all modes for which EMI-RFI suppression is claimed.

The test results should be presented in a plot or photograph showing the attenuation over the whole frequency spectrum with proper identification of vertical and horizontal values of the display. Care should be taken to provide adequate resolution of the waveforms and equipment settings. A description of the test equipment should be provided upon request.

NEMA Standard 5-18-1992

3.12 SAFETY APPROVALS AND APPROVAL RATINGS

Approvals and ratings should be listed according to the guidelines and requirements of the safety approval agency(s).

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3.13 APPLICATION ENVIRONMENT AND OTHER PHYSICAL OR GENERAL DATA

This data may be general or very specific in nature and may be included to provide additional information for the proper selection and installation of the product. It is not a "catch-all" category for irrelevant terminology with which some manufacturers intentionally "load" their specifications.

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Appendix

SPECIFICATION FORMAT

SPD Model: _____

SPD Circuit Description: _____

Nominal Line Voltage: _____

Maximum Continuous Line Current: _____

Maximum Continuous Operating Voltage: _____

Connection Means: _____

SPD Protection Modes: _____

Maximum Surge Current: _____
(Single Pulse, 8/20 μs, Mode, Data obtained from actual tests)

Clamping Voltage during Maximum Surge Current (VPeak measured): _____

Clamping Voltage: _____
(Data taken at 90 degrees phase angle of
power frequency voltage, positive polarity only,
applicable surge current)

EMI-RFI Noise Rejection
Safety Approvals (Agency, Standard, File): _____
Safety Ratings (UL1449, VPeak): _____
Application Environment: _____

Physical Data
Dimensions: _____
Weight: _____
Materials: _____
Wire size and length: _____
Accessories: _____

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NEMA STANDARDIZATION BACKGROUND

The purpose of NEMA Standards, their classification, and status are set forth in certain clauses of the NEMA *Standardization Policies and Procedures* manual and are referenced below:

Purpose of Standards

National Electrical Manufacturers Association Standards are adopted in the public interest and are designed to eliminate misunderstandings between the manufacturer and the purchaser and to assist the purchaser in selecting and obtaining the proper product for their particular needs. Existence of a National Electrical Manufacturers Association Standard does not in any respect preclude any member or nonmember from manufacturing or selling products not conforming to the standard.

(Standardization Policies and Procedures, p. 1)

Definition of a Standard

A Standard of the National Electrical Manufacturers Association defines a product, process or procedure with reference to one or more of the following: nomenclature, composition, dimensions, tolerances, safety, operating characteristics, performance, rating, testing, and the service for which they are designed.

(Standardization Policies and Procedures, p. 2)

Dimensions

Where dimensions are given for interchangeability purposes, alternate dimensions satisfying the other provisions of the Standards Publication may be capable of otherwise equivalent performance.

(Standardization Policies and Procedures, p. 8)

Categories of Standards

National Electrical Manufacturers Association Standards are of three classes, which have received the affirmative vote of at least two-thirds of the Subdivision votes cast in the affirmative or negative:

1. NEMA Standard, which relates to a product, process, or procedure commercially standardized and subject to repetitive manufacture.
2. Suggested Standard for Future Design, which may not have been regularly applied to a commercial product, but which suggests a sound engineering approach to future development.
3. Adoptive Standard, which is adopted in whole or in part from the standards of another organization, either domestic, regional, or international.

(Standardization Policies and Procedures, pp. 7 & 16)

Authorized Engineering Information

Authorized Engineering Information consists of explanatory data and other engineering information of an informative character not falling within the classification of NEMA Standard or Suggested Standard for Future Design, which standard has received the affirmative vote of at least two-thirds of the Subdivision votes cast in the affirmative or negative.

(Standardization Policies and Procedures, pp. 7 & 16)

Identification of Status

Standards in NEMA Standards Publications are identified as "NEMA Standard," "Suggested Standard for Future Design," or "Adoptive Standard." These indicate the status of the standard. A statement incorporating the auxiliary verb "shall" indicates that compliance with a requirement is mandatory for compliance with the standard. These classes of standards are identified in the foreword or throughout the text.

The material identified as "Authorized Engineering Information" is designated similarly. Statements incorporating other auxiliary verbs such as "should," "may," etc. refer to authorized engineering information and not to procedures required for compliance with the standard.

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Transtector Systems, Inc.
Hayden Lake, ID 83835-0300

Winders & Geist, Inc.
Lincoln, NE 68501

The Wiremold Company
West Hartford, CT 06133-0639

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