

VariSTAR[®] AZE Station Surge Arresters

COOPER Power Systems



Metal Oxide Varistor Technology for Systems through 345kV

**Aluminum Alloy
Line Terminal**

Accommodates up to 3/4 inch copper/aluminum conductor and NEMA standard connectors.

**Metal Oxide Varistor
Valve Disks**

Specially formulated metal oxide compound provides exceptional non-linear electrical characteristics and ideal energy-absorbing protective levels.

Ground Terminal

Accommodates up to 3/4 inch copper/aluminum conductor and NEMA standard connectors.

**Aluminum Alloy
Castings**

Assure true vertical mounting: three mounting slots accommodate hardened 1/2 inch bolts.

**Directed Over-Pressure
Relief System**

A controlled and directed pressure-actuated relief system assures safety and reliability. Covers prevent the entry of foreign material and indicate operation. Directional venting of arc by-products allows incandescent gasses to be diverted away from nearby equipment.

Spring

Provides a permanent 300 pounds compressive force on internal components.

Silicone Rubber

Securely positions and cushions MOV disks.

**Wet Process
Porcelain Housing**

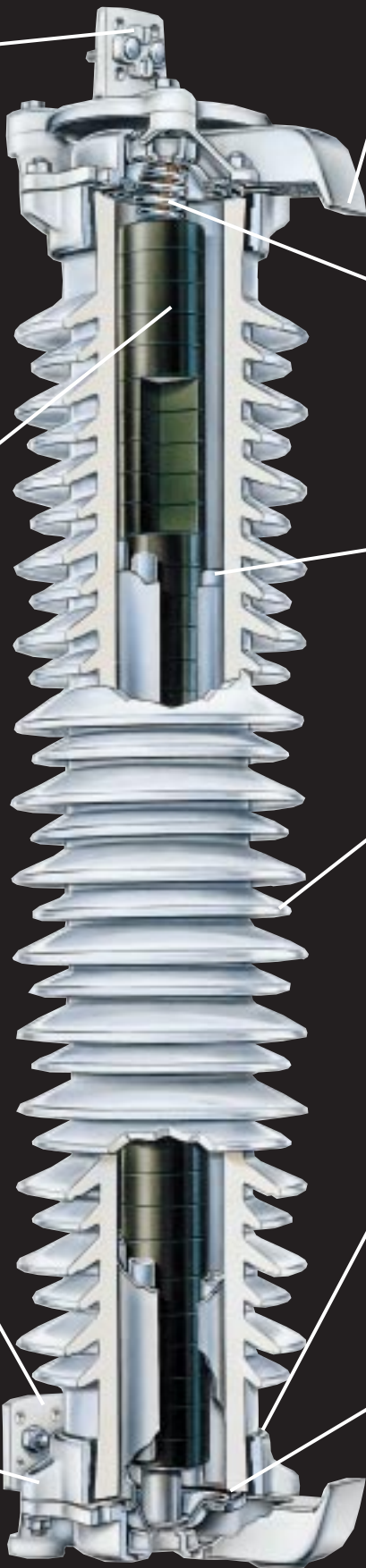
Withstands thermal and electrical shock; excellent self-washing characteristics. Sheds designed to provide high creepage distance and maximum pollution performance.

Nameplate

Complete ANSI/IEEE arrester identification; catalog number, voltage rating, MCOV, serial number, altitude and pressure relief ratings.

**Seal (Line and
Ground Ends)**

Obtained with compressed and confined synthetic rubber gasket, helium-mass spectrometer tested to assure a leakproof seal.



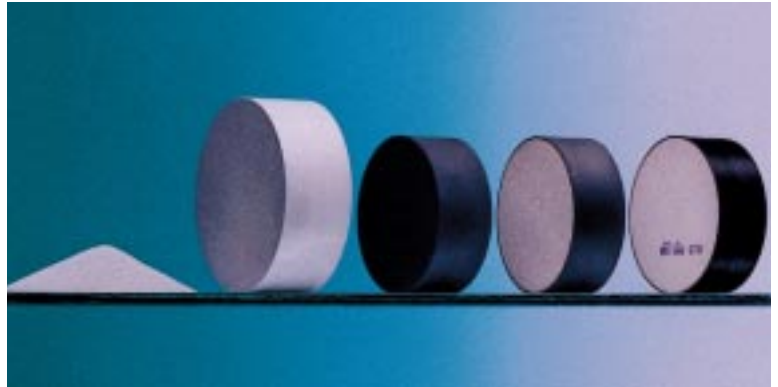
VariSTAR AZE STATION CLASS SURGE ARRESTERS

METAL OXIDE VARISTOR TECHNOLOGY FOR SYSTEMS THROUGH 345kV.

The manufacture of reliable zinc-oxide surge arresters at Cooper Power Systems begins with a superior metal oxide ceramic formulation, the most modern manufacturing facility and methods, and the process control procedures necessary to produce and test metal oxide varistors (MOVs) to the highest quality standards. Our entire varistor manufacturing process is carried out in a separate MOV facility, under strict quality methods dedicated to producing

and testing varistors to the highest commercial standards.

VariSTAR AZES, H, and X station class surge arresters incorporate these metal oxide varistors in gapless arrester designs tested exclusively to the requirements of ANSI/IEEE Standard C62.11-1993 and are offered for the reliable overvoltage protection of low, medium and high-voltage utility systems to 345kV.



AVAILABLE TYPES AND RATINGS:

VariSTAR Arrester Type	AZES	AZEH	AZEX
Applicable Design Standard	ANSI/IEEE C62.11-1993		
Application Guide	ANSI/IEEE C62.22-1991		
System Application Voltages	3-345kV	3-230kV	3-138kV
Rated Arrester Voltages	3-360kV	3-240kV	3-108kV
System Frequency	50/60Hz	50/60Hz	50/60Hz
Impulse Classifying Current	10kA	10kA	10kA
High Current Withstand	100kA	100kA	100kA
Pressure Relief Class, kA rms. sym.			
Metal-top design	65	65	65
Nominal Discharge Energy – kJ/kV of MCOV			
Ratings: 3-108kV	3.4	5.6	8.9
120-240kV	5.6	8.9	
258-360kV	8.9		

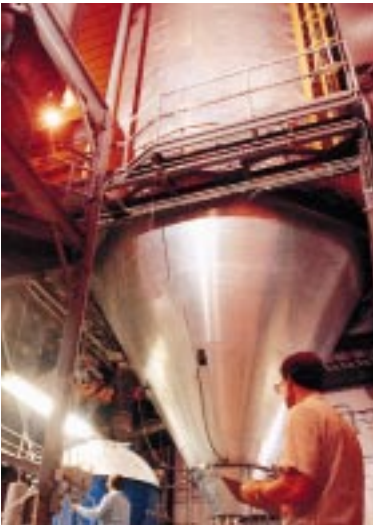
VARISTOR PROCESSING – PRECISION IN MANUFACTURING



◀ The exact proportion of ingredients is computer controlled for precision varistor manufacturing.



◀ Milling and drying of the zinc oxide mixture using the most modern methods.



◀ Spray drying the zinc oxide mixture into a powder having exact particle size.



▲ Zinc oxide powder being pressed into varistor bodies.



◀ Varistors exiting kiln after high temperature sintering.



◀ Surfaces of the varistor are precisely ground for parallelism.



◀ Electrodes are plasma sprayed to the varistor creating a bonded equipotential surface.



◀ The application of insulation to the disk periphery prevents flash-over.



▲ Each finished varistor is automatically tested for its steady-state, protective, and energy dissipation characteristics.

▶ Sample varistors under accelerated aging stress are routinely tested to assure long arrester life.



Cooper Power Systems manufactures all of the metal oxide varistors used in its family of surge arrester products, from the smallest of distribution arresters to arresters utilized in the protection of the most critical high-voltage station equipment. They all start with the same proprietary formula and are manufactured under the same strict process controls.

From the precise milling and mixing of elemental zinc-oxide with rare metals, to the pressing of high density disks, to the high temperature sintering needed to create a large scale, semi-conducting ceramic, through the finishing and quality testing processes utilized

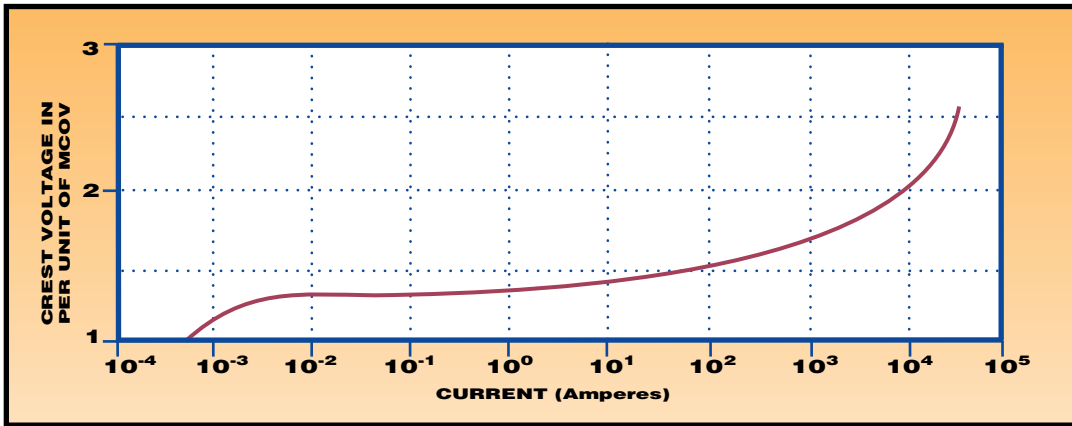
to transform this ceramic into a high voltage arrester varistor; all of these key processes are under the quality control of Cooper Power Systems' ceramists and engineers. These varistors have been formulated and designed for exclusive use in high-voltage surge arresters. Our arrester manufacturing center in Olean, NY includes a dedicated, high-volume disk production facility that ranks among the world's largest for the manufacture of MOV disks. Volume leadership assures our customers receive the economic benefits and the consistent quality associated with Cooper Power Systems' large-scale manufacturing capability.

PRINCIPLES OF VARISTOR OPERATION

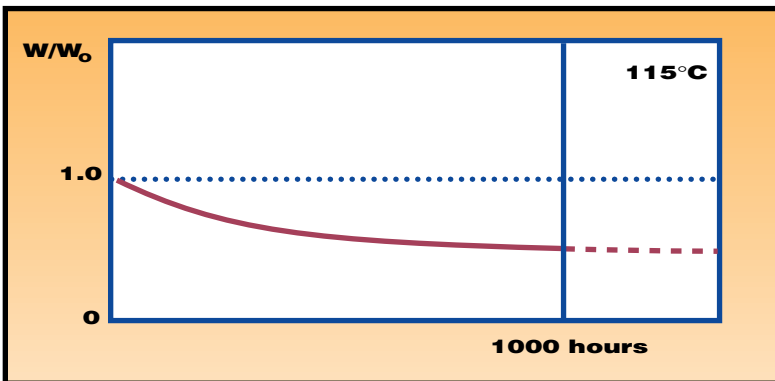
The benefits of Cooper Power Systems' varistors for surge protection are derived from their unique conduction properties and ability to remain stable under continuous energization even after repeated surge duties. Metal oxide varistors display a non-linear conduction mode that is highly desirable for overvoltage protection. The resistive intergranular molecular boundaries between the conductive zinc-oxide grains and the rare metal additives become conductive under sufficient electrical field stress. Very simply, after a certain threshold voltage is reached, small increases in electrical stress cause a dramatic increase in conduction current. This "non-linear" resistive behavior supports the application of system voltage with very low leakage current, yet maintains a remarkably constant voltage during high current surges.

VARISTOR QUALITY CONTROL TESTS

- Each varistor disk is classified by its discharge voltage at 10kA (8/20 μ s) and the tested value is recorded on its face.
- Individual varistor disks are tested for reference voltage at 1mA(d.c.)/sq. cm.
- Accelerated life tests are performed on varistor manufacturing lots to ensure that the design criterion of a continuing reduction in watts loss after 1000 hours at an elevated temperature of 115 degrees C, when energized at 1.05 times MCOV, is achieved.
- Every varistor disk is tested with a transmission line discharge current wave that exceed the arrester's stated energy level. This verifies that each disk in every arrester has demonstrated its guaranteed energy dissipation capability.



Protective characteristic of varistors as utilized in VariSTAR AZEX surge arresters.



Typical design test data verifying that the watts loss of Cooper Power Systems' varistors continue to decrease when energized at elevated voltages and temperatures for over 1000 hours. This accelerated test demonstrates an unlimited arrester design lifetime under ANSI/IEEE postulated service conditions.

VariSTAR AZE STATION CLASS SURGE ARRESTERS – DESIGNED AND BUILT FOR OPTIMUM PROTECTION

Metal oxide varistors, by their nature, are the ideal voltage limiter. By design, VariSTAR AZE arresters from Cooper Power Systems offer the best in system overvoltage protection.

Consistent, high-quality, metal oxide varistors are critical to the reliability of a heavy-duty station class surge arrester. Equal in importance is the overall AZE arrester design; a design that complements advanced varistor technology with an external package that enhances protective performance.

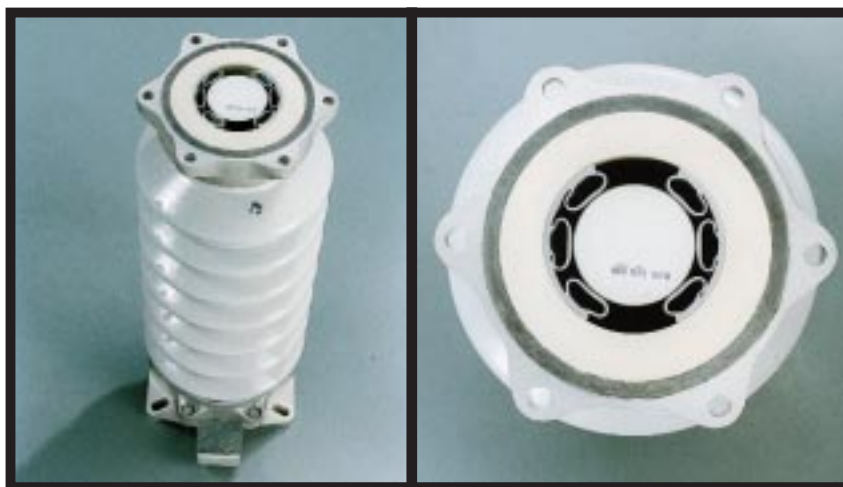
VariSTAR AZE arresters incorporate high quality porcelain housings manufactured in Cooper Power Systems' porcelain facility in Macomb, IL. Having complete control of porcelain manufacture gives Cooper the ability to respond rapidly to customers' needs with assured quality.

The arrester is constructed of a series assembly of metal oxide varistors, each is placed within the porcelain housing, securely and firmly cushioned by silicone rubber sleeves that shield the active elements against shipping shocks and vibration damage. This rugged internal construction is completed by placing the disk column under a permanent compressive spring force of 300 pounds. Special corrosion resistant aluminum alloy end rings and castings, containing the pressure relief

diaphragms, are cemented and secured to the porcelains. The entire assembly is filled with dry gas to prevent internal condensation and is leak tested by use of a helium mass spectrometer to positively assure that moisture will not enter the arrester during its lifetime.

VariSTAR AZE arrester porcelains are designed with insulation withstand and pollution performance in mind. Alternating diameter sheds give excellent resistance to the effects of housing contamination. VariSTAR arresters are tested to demonstrate pollution performance in excess of the requirements of existing standards.

As all arrester housings contain their own inherent overvoltage protection, ANSI/IEEE Standard C62.11 recognizes that the external housing insulation system should be coordinated with the maximum overvoltage the arrester will allow. As AZE arrester porcelains greatly exceed these voltage withstand requirements, the specification of correct housing insulation can now be made by merely considering and selecting the same creepage distance as required for other station insulation that experience shows to provide adequate local pollution performance. Sufficient porcelain insulation withstand levels will be automatically met, with ample margins of performance.



Internal arrester construction showing varistors secured and protected by silicone rubber.

AZE SURGE ARRESTER SELECTION

CONTINUOUS VOLTAGE

Gapless surge arresters should be selected with sufficient steady-state impedance to withstand the application of line-to-ground power frequency voltages under all system conditions of operation. This is achieved by making an initial selection based on an arrester having a “Maximum Continuous Operating Voltage”, or MCOV, that equals or exceeds the normal system *maximum* line-to-ground voltage.

POWER-FREQUENCY OVERVOLTAGES

The second criterion to be met is a condition established by the effectiveness of system grounding. During a single line-to-ground fault, under maximum system voltage conditions, the arrester selected should have a “Rating” that will not be exceeded by the voltages on the unfaulted phases at the point of application. One must pay particular attention to systems having low coefficients of grounding, ungrounded systems and systems that may become ungrounded under certain conditions of operation. This second voltage consideration may be modified for certain system conditions as long as the application does not violate the selected VariSTAR AZE arrester’s “Temporary Overvoltage (TOV)” capability.

System conditions resulting in *sinusoidal power-frequency voltages* that exceed arrester “Maximum Continuous Operating Voltage, (MCOV)” or even “Arrester Rating”, can be allowed by considering the permissible magnitude and duration of these overvoltages (including the full time of system back-up protection), with appropriate allowances made for any recent discharge energies, as shown at right.

ENERGY CONSIDERATIONS

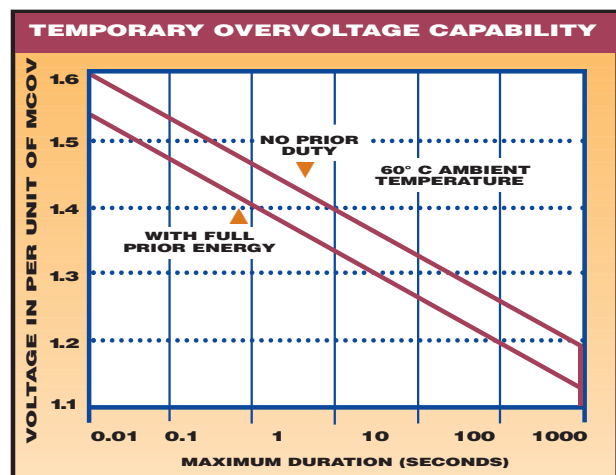
The third selection criterion determines the particular type of AZE arrester (type S, H, or X) based upon the switching surge energy that the arrester will be expected to discharge in a specific application. Lightning is rarely, if ever, an energy consideration in shielded substation environments.

The energy an arrester is expected to discharge is generated by switching overvoltages and stored in the

power system. The discharged “switching surge energy” is a function of the non-linear interaction between the arrester’s volt-ampere characteristic and the system parameters. The effects of capacitor banks, multiple or long transmission lines and breaker switching operations may be predicted through the transient network analyzer (TNA) or by digital programs (such as EMTP) that accurately model system and arrester dynamics. Cooper Power Systems’ engineers are available to make such studies.

Computer modeling will predict arrester discharge energies and discharge current magnitudes that can be compared to the arrester’s capabilities. Frequently energy selections are based simply upon the transmission line parameters of surge impedance, line length, and an assumed number of switching operations within a given period. The standard series of AZE arresters (AZES) have energy absorption capabilities in accordance with ANSI/IEEE standard C62.11. These energy absorption capabilities have been standardized to exceed the duties imposed in most applications. Where the expected switching surge duties dictate the application of arresters having increased capabilities, the AZEH and AZEX models are offered (see table on page 3).

ANSI/IEEE Application Guide C62.22, Section 3.3.3 discusses a method for arrester selection based upon estimating system switching surge energy. Experience in known circuit configurations may be the best guide in selection where a study is not warranted. Arresters used for lightning protection alone may be selected without regard to energy capability; noting that if increased insulation protection is desired it may be obtained with an AZE arrester having the same rating, but a higher energy capability.



SUMMARY

Using this method of selection will result in the minimum arrester rating necessary to survive system power frequency voltage conditions. Increasing rating above this minimum will result in a greater arrester tolerance for system voltage excursions; but, if rating is increased unnecessarily, compromised insulation protection will result. Rating selection is an engineering balance of arrester survivability against the insulation protection afforded to the equipment. An arrester having just sufficient power-frequency voltage withstand is preferred – it is the best economic choice and will provide optimum insulation protection.

SIMPLE AND DIRECT INSULATION COORDINATION

AZE arresters provide excellent insulation protection due to the inherent non-linear electrical characteristics of metal oxide varistors. The insulation protection afforded by gapless metal oxide arresters is a function of the volt-ampere characteristic of the series connected varistor disks and is also dependent on the time-to-crest of the current discharge. Because AZE metal oxide arresters have a well defined current and voltage relationship obtained by direct

measurement, insulation coordination of AZE surge arresters is both simple and direct.

An insulation coordination analysis of the protection afforded by an arrester (after making an initial arrester choice based on system voltages as outlined in the preceding section) is normally made by comparing selected arrester discharge voltages to the three known voltage withstand points of the protected equipment's insulation: the chopped wave, full wave, and switching surge insulation test values.

To make an insulation coordination study, obtain the appropriate AZE surge arrester discharge voltages from Cooper Power Systems AZE product literature. For a specific application, the calculation of the recommended protective margins at the three equipment test points will reveal the superior protection afforded by AZE surge arresters, especially to oil-filled equipment. One finds that the protective ratios (protective margins) at each insulation coordination point are approximately equal; that is, the shape of the voltage-time protective characteristic of the arrester closely matches the shape of the equipment's tested insulation withstand. AZE surge arresters protect equipment across the entire lightning and switching surge overvoltage spectrum with "balanced margins of protection".

INSULATION COORDINATION		
EQUIPMENT INSULATION WITHSTAND VOLTAGE	ARRESTER DISCHARGE VOLTAGE	RECOMMENDED PROTECTIVE RATIO* (MINIMUM MARGIN)
Chopped Wave		
<ul style="list-style-type: none"> • 1.15 x BIL for paper/oil insulation • 1.0 x BIL for solid or SF₆ insulation 	Front-of-Wave Impulse Protective Level at Lightning Impulse Classifying Current	1.2 (20%)
Full Wave BIL		
<ul style="list-style-type: none"> • 1.0 x BIL 	Lightning Impulse Discharge Voltage at Lightning Impulse Classifying Current	1.2 (20%)
Switching Surge		
<ul style="list-style-type: none"> • 0.83 x BIL 	Switching Surge Discharge Voltage at: <ul style="list-style-type: none"> • 500 A for Maximum System Voltages 3-150kV • 1000 A for Maximum System Voltages 151-325kV • 2000 A for Maximum System Voltages Above 325kV 	1.15 (15%)
* Protective Ratio = I/A, or alternatively – Percent Margin = 100 x [I - A]/A Where, I = the equipment insulation withstand. A = the arrester discharge voltage (protective level). The "Recommended Protective Ratios" shown are after allowances for any circuit configurations (usually separation distance) or other installation specific conditions that may compromise the arrester's ability to provide over-voltage protection.		

SUPERIOR VENTING ACTION WITH DIRECTED PRESSURE RELIEF



A controlled and directed pressure relief system is a key feature in the design of Cooper Power Systems' AZE arrester. In the unlikely event of arrester failure, any arc by-products and incandescent gasses are expelled and then directed by the venting system away from nearby equipment. This directed venting action minimizes the possibility for creating an evolving and potentially catastrophic failure of other substation equipment.

When tested by independent laboratories up to its maximum capability, this superior venting system prevented the breakage of any portion of the external housing. By design, the uncontrolled axial rupture of synthetically housed arresters may allow a cloud of expelled ionized gasses to engulf adjacent equipment, increasing the risk of a major and forced substation outage.

You can be assured that substation equipment protection will never be compromised when VariSTAR AZE arresters are selected.

ROUTINE TESTS ON ALL ARRESTERS

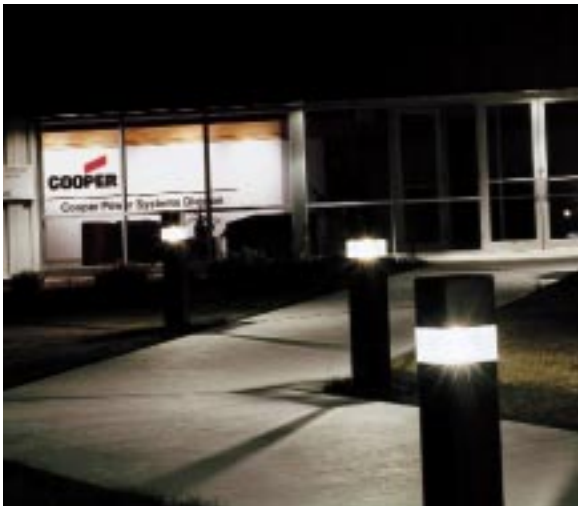
(ALL PROCEDURES ARE IN ACCORDANCE WITH ANSI/IEEE C62.11, SECTION 13)

- Power Frequency Test at a minimum of 1.2 times MCOV.
- Discharge Voltage (8/20 μ s).
- Ionization Voltage Test at 1.05 times MCOV.
- Sealing Effectiveness Test by helium mass spectrometer at full vacuum.

Customer conformance tests in the presence of an inspector are available upon the purchaser's request; they will be performed in accordance with Section 9 of ANSI/IEEE C62.11 at additional cost.







THOMAS A. EDISON TECHNICAL CENTER

The Thomas A. Edison Technical Center located in Franksville, WI is a complete electrical testing and laboratory facility offering a wide range of testing and analytical services to electrical equipment manufacturers and the utility industry.

Cooper Power Systems assures the design integrity of AZE surge arresters through a rigorous testing program at this and other independent testing laboratories. This means that all continuing product advances are professionally validated to the highest commercial and technical standards.



SURGE ARRESTER FACILITIES

ARRESTER MANUFACTURE

Olean, NY



ADMINISTRATION

Pewaukee, WI



PORCELAIN MANUFACTURE

Macomb, IL

 **COOPER** Power Systems

**Cooper Industries
Cooper Power Systems
Division**

1045 Hickory Street
Pewaukee, WI 53072-3792
Fax: 414 691-9330
www.cooperpower.com