

When photocontrols as we know them were introduced in the early 1960's, air gap arrestors provided sufficient surge protection in the application of photocontrols. In the 1970's, the invention of metal oxide varistors (MOV) became the electronic industry's standard for surge protection: MOVs were placed in all electronic appliances and utility equipment.

1. ALL ABOUT MOV'S

1.1 What is a MOV?

MOV stands for metal oxide varistor. It is made by forming zinc oxide powder into a pill and firing it into a hard ceramic. This ceramic is an insulator except when high voltage causes it to conduct.

1.2 Are MOVs new?

In the 1960's, metal oxide varistors (MOV) became the industry's standard for surge protection in electronic equipment. Since then, MOVs have been placed in all electronic appliances and utility equipment.

1.3 How are MOVs rated?

MOVs are rated in Joules, Maximum AC Voltage, and Maximum Surge Current.

Joules. A joule equals a watt-second. This is the amount of energy that a MOV can absorb without changing its characteristics. Since a MOV works by converting surge energy into heat energy, physically larger MOVs generally have a higher joule rating. DTL offers several levels of surge protection including 160 joules as standard, 320 joules for high lighting areas, and 1280 joules for long life applications.

Maximum Continuous AC Voltage. MOVs are rated for the highest AC voltage they can withstand without conducting any current. In photocontrols, this is usually about 1.2 to 2 times the AC peak voltage or 1.5 to 3 times the AC RMS voltage. If a 160 joule or 320 joule MOV rated for 320 VAC was subjected to a 3000 volt/6000 amp surge, the MOV would clamp to about 850 volts. The control and fixture would be protected and keep on working.

Maximum Surge Current. This is the peak value of surge current that the MOV will pass without destruction. The most common rating for a 20 mm MOV is 6500 amps. This is what DTL has provided as standard since 1990. We have tested our finished controls at a surge lab with repeated 6500 amp surges. The MOVs may get warm, but the controls keep working.

1.4 What is the life span of a MOV?

MOVs do not wear out with age. Except when they are conducting surge currents, a MOV is a passive component within the photocontrol; the ceramic "heart" insulator is not affected by extremes of heat, cold, humidity, impact, or insects.

1.5 How do repeated surges affect MOVs?

When MOVs are properly sized, MOV life is years or decades. However, if a MOV is subjected to repeated surges beyond its limit (joules), it will eventually fail. The most commonly used MOV in photocontrols is rated at 160 joules, 6500 amp peak surge current, and can be considered a non-perishable or non-wear out device.

DTL has examined 5+ year old working controls from Florida utilities; we have seen no degradation of the MOV. When we do see surge-related MOV failure, the MOV has done its job and acted as a sacrificial surge protector.

1.6 Do MOVs have follow current?

A MOV doesn't have follow current; it converts surge energy into heat energy which is dissipated throughout its ceramic insulator and into the photocontrol legs. See additional comments/definitions below.

1.7 Can a MOV explode?

Not if a properly rated MOV has been sensibly placed on the circuit board. Of course, it is possible to devise a test that will explode a MOV but not an air gap arrestor. Reasonable test limits (including ANSI) will not do this.

1.8 Other than photocontrols, where are MOVs used?

In this electronic age, MOV surge protection is a crucial element in all electronic applications. Every computer, TV, telephone, microwave, and anything electronic that is plugged into line power has a MOV across the input line. There

are automotive MOVs and telephone line MOVs. MOVs are the primary surge protection in the ubiquitous "surge strip" that feeds office computers.

In areas of maximum lightning exposure, customers depend upon reliable surge suppression as a means of safety and efficiency. For example, the City of Leesburg, Florida offers its customers whole house, meter-based surge protection. In selecting the protection device, "...reliability came first. It was critical that the device handle large currents. The Meter TreaterTM with twin over-sized 40 mm distribution grade metal oxide varistors (MOVs) met [the] technical requirements." 1

1.9 What sort of MOV protection do my photocontrols require?

For most applications, a MOV rated 160 joules, 6500 amps is sufficient. In areas of severe surge, a MOV rated 320 joules, 13000 amps is ideal. DTL would be happy to recommend the proper MOV rating for your specific applications.

2. WHAT ABOUT AIR GAP ARRESTORS?

2.1 What is an air gap arrestor and how does it operate?

An air gap arrestor consists of two metal plates (separated by an organic plastic such as a film of phenolic impregnated paper) connected to a current limiting wire (often a spring). The surge of 2500 volts or more causes the arrestor to "fire." Current is drawn from line to neutral limited by the wire. The arc of high current continues until the arc is blown out or voltage drop (at the next zero crossing) extinguishes the current. Note that lower voltage surges below 2500 volts may damage the control without being clamped by the gap arrestor.

2.2 Is an air gap arrestor the same as an expulsion arrestor?

Air gap arrestors are also called spark gap arrestors, open type expulsion arrestors, and modified expulsion arrestors. The loosely applied term "expulsion" is a misnomer. "Expulsion" implies that the "fire" caused from the transient surge is extinguished immediately upon built-up air pressure. The fact is "expulsion" arrestors shall have follow current albeit less than standard gap arrestors. The surge suppression process is identical in all types. The only differentiating factor is an added component in the modified expulsion arrestor in which a canister covering the spark gap prevents carbon deposits (decomposed Delrin) from covering the photocontrol's internal components after surges.

2.3 How do repeated surges affect air gap arrestors?

Whenever a surge is large enough to produce an arc, the air gap is alternated. The arc causes pitting on the walls of the arrestor, which alters the firing voltage of the arrestor. In addition, the carbon produced by the arc is deposited on the plastic insulator; the carbon trail alters the firing point with each surge. The result is an arrestor with lower and lower firing points after each surge.

2.4 Does follow current occur in air gap arrestors?

Yes, air gap arrestors experience follow current. Follow current is the AC current that flows after the surge has passed but before a spark gap arrestor has a chance to de-ionize or extinguish the arc. Once a gap arrestor has "fired," the voltage drop across the gap is very low; it is a short circuit across the AC line until the 60 hertz AC line current goes through the next zero crossing. This may be as long as 16 milliseconds. During this time, large amounts of current flow through the control, the internal wiring and the gap arrestor. Over time, such current flow causes the deterioration of the photocontrol.

3. WHAT SURGE PROTECTION STANDARDS APPLY?

3.1 What ANSI Standards apply to MOVs and air gap arrestors?

ANSI has established minimum standards for control performance. ANSI C136.10-1996 doesn't recommend a particular form of surge arrestor; it defines a text book surge (3000 amps at 6000 volts or a high level surge of 6500 amps at 10, 000 volts) and says that controls must meet this standard. Through such liberal standards, nearly all controls could pass the standard surge.

3.2 What UL Standards apply to MOVs and air gap arrestors?

UL Standard 1414 covers MOVs installed across the line. This specification sets forth standards for flammability and other safety issues. All MOVs used by DTL are UL Recognized components.

UL does not have a standard for air gap or "expulsion" arrestors simply because they are no longer the choice of surge protection.

3.3 What do most utility standards specify?

The most common utility specification for MOVs is 160 joules, 6500 amps surge current. Florida and Gulf Coast utilities are increasingly specifying 320 joules, 13,000 amps surge current rated MOVs.

4. HOW TO CHOOSE?

4.1 Which form of surge protection works best in real life?

Very simply, MOVs work in real life: on real poles in North America and all over the world. They also work in test labs and pass the ANSI high level surge test. When a 320 joule MOV is specified, MOVs pass multiple hits of 10,000 amps at 20,000 volts. DTL Engineering with over 65 years combined experience at 3 different photocontrol manufacturers--consistently finds that MOVs lead to fewer control failures. Since 1990, DTL has shipped 4 million electronic photocontrols to utilities in North America, Central America, Australia and Asia. Total surge failures are less than 0.2%.

4.2 What's the cost difference?

MOVs typically have a higher initial cost but better field performance. Electronic photocontrols with MOVs prove their superiority over time. Superior MOV performance decreases the potential of photocontrol failure.

4.3 What makes MOVs the choice of surge protection?

There are three fundamental differences which prove MOV protection to be advantageous: 1) reaction time, 2) clamping voltage, and 3) energy absorption.

- 1.) MOV surge reaction time is three orders of magnitude faster than that of a spark gap arrestor. MOVs react in nanoseconds, indicated as 10^{-9} seconds. Spark gap arrestors react in microseconds, indicated as 10^{-6} seconds. Particularly in higher volt surges, the quicker response time of a MOV greatly reduces the threat of damage to the photocontrol and the fixture.
- 2.) MOVs react and clamp at much lower voltages than gap arrestors. Typically, spark gap arrestors begin to "fire" at a minimum of 2,500 volts. DTL's standard 160 joule, 320 volt RMS clamps at 850 volts. The mass of the MOV provides direct absorption for the surge, allowing faster response time. Using a spark gap arrestor, particularly during higher surges, will potentially weaken the photocontrol's structure. For example, if a 1600 volt surge strikes and the gap arrestor doesn't fire until 2,500 volts, the internal structure of the photocontrol and fixture must absorb the initial voltage. Our standard 160 joule MOV will arrest the same surge at 850 volts, eliminating potential internal damage to the control.
- 3.) MOVs are self-contained, allowing 100% energy absorption. Consequently, they can withstand repeated surges without harming other components within the unit. At Florida Power and Lights Surge Laboratory, 160 joule MOVs were subjected to repeated 6500 amp surges: the MOVs become warm, the controls continued working. As spark gap arrestors fire approximately 1,000 amperes of line follow current occurs across the gap and through the resistance wire. The follow on current vaporizes the arrestor parts, causing build-up of carbon and molten metal within the photocontrol. In open type air gap arrestors, a black film coats the window, changing operating light levels dramatically. In modified "expulsion" arrestors, a canister contains most of the carbon and metal particles within its enclosure. However, the residue causes pitting and arcing on the metal plates within the canister, thus altering the firing levels.

The table on the next page, based on the 1998 Harris Catalog, Transient Voltage Suppression application note # 9768, provides a detailed comparison of the zinc oxide varistors and air gap arrestor.

Comparison of Zinc Oxide Varistors and Air Gap Arrestor:

Leakage	Low. Leakage of current occurs when voltage is applied. Current is drawn during normal, non-surge application, creating the potential for low leakage of current. The impedance of the MOV is greater than 1000M ohms, resulting in low current leakage.	Zero. The spark gap is an open circuit.
Follow-On Current	No. Follow on current is the current that flows after the surge protection is fired. The MOV has no follow on current because it converts the surge energy into heat energy. The heat energy is dissipated throughout the ceramic MOV and into the photocontrol legs.	Yes. Follow on current is created at the spark gap's ignition voltage; an "arc" draws current between until the next zero crossing. If there is enough energy in the surge, the current will not stop at the first zero crossing.
Clamping Voltage	Moderate to Low. Clamping voltage refers to the voltage in which the MOV will arrest the surge. In MOV's, clamping voltage depends upon several factors, including joule rating and MOV thickness. The 160 joule or 320 joule MOV's used by DTL clamp around 850V.	High Ignition Voltage, Low Clamp. The initial voltage, or ignition voltage, needed to ignite the spark gap is high, about 2500 volts. At this voltage the air becomes ionized, creating an arc through which the current will flow. The voltage clamp is the amount of current times the in-line resistance: $0.01S \times 10KA = 100V$. The in-line resistance is usually quite low, within the milliohms range.
Energy Capability	High.	High.
Capacitance	Moderate to High. The MOV is a parallel plate capacitor. A MOV yields a moderate to high (depending on size) capacitance because ceramic has a much higher dielectric constant than air.	Low. The air gap arrester is a parallel plate capacitor. The spark gap has air as its dielectric material; air has a much lower dielectric constant and therefore a lower capacitance.
Response Time	Fast. MOV response time is measured in nanoseconds. The combination of fast response and low clamping voltage is what makes the MOV a superior surge suppressor.	Slow. The spark gap response time is slow, measured in microseconds. The slow response time and high ignition voltage make the spark gap a poor choice for the protection of electronic equipment.

1 Tardugno, Joseph. Transmission and Distribution. A City Battles Lightning. (September 1996)