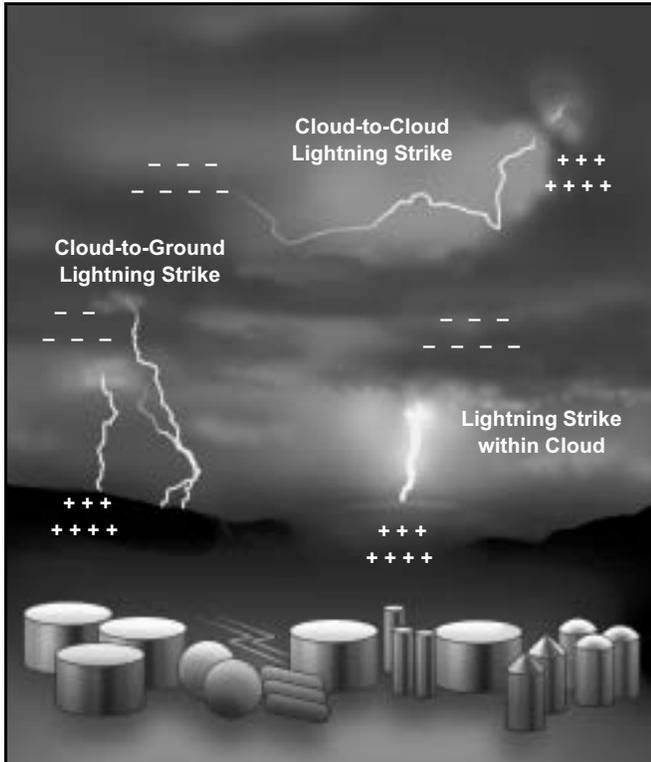


Lightning and Static Effects on Industrial Electronics



Lightning is a force as old as our planet. It enralls and disturbs us, and it occurs more frequently than we might expect. Approximately 100 lightning flashes strike the earth every second. At any given time, approximately 2000 thunderstorms are in progress throughout the world. Lightning caused by these storms can produce currents as high as 500 kiloamperes (kA) and voltage potentials up to 30,000 kilovolts (kV). Such voltages can disable or destroy unprotected electronic equipment.

Electrostatic charges, on the other hand, are neither as visible nor as powerful, but have just as much potential to damage electrical equipment—especially microelectronic components. Simply walking across the carpet in a room with low humidity can generate up to 35,000 volts of static charge.

This data sheet examines the damage caused by transients from lightning and static and offers advice on minimizing the harmful effects of these two phenomena.

WHAT IS LIGHTNING?

Lightning is the attraction of a charged cloud to an oppositely charged earth, another cloud, or another area within the same cloud.

Clouds produce lightning with the help of strong updraft air currents. These air currents cause rapid freezing of water droplets, which inherit a charge as they crystallize.

Among the many types of lightning, cloud-to-ground strikes are the most researched. They also pose the greatest threat to industrial electronic equipment.

LIGHTNING AND TRANSIENTS

Damaging power surges or “transients” occur when lightning strikes transmitters; metallic plant equipment, such as pipelines or vessels; power plants; or signal or power cabling. Damage to a transmitter varies depending on the access route of the lightning strike. A direct hit generally destroys a transmitter. Even nearby strikes can induce damaging currents in piping or wiring.

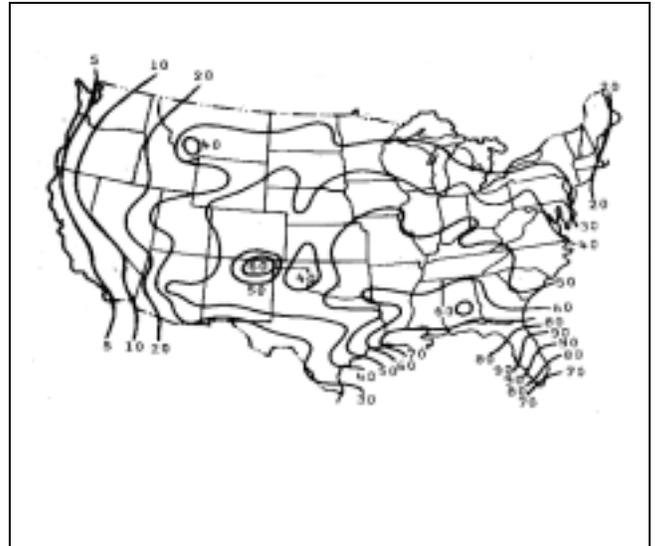
A lightning strike on process piping will usually damage the sensor module and may damage the electronics of a transmitter. A strike on signal or power leads will cause damage to the sensor module and electronic components on printed circuit boards. The result is a transient that is usually powerful enough to damage electronically based equipment. The cost of this damage is process downtime, reduced throughput, increased maintenance, strained inventories, and headaches—all of which can be avoided.

DETERMINING POTENTIAL FOR LIGHTNING DAMAGE

Four factors are important in assessing the threat of lightning damage to a plant or facility:

- Frequency and severity of lightning storms
- Vulnerability of existing and proposed instrumentation
- Exposure of systems wiring to possible lightning strikes
- Potential harmful impact of instrument failure on the process

FIGURE 1. Annual Thunderstorm Days in the U.S.

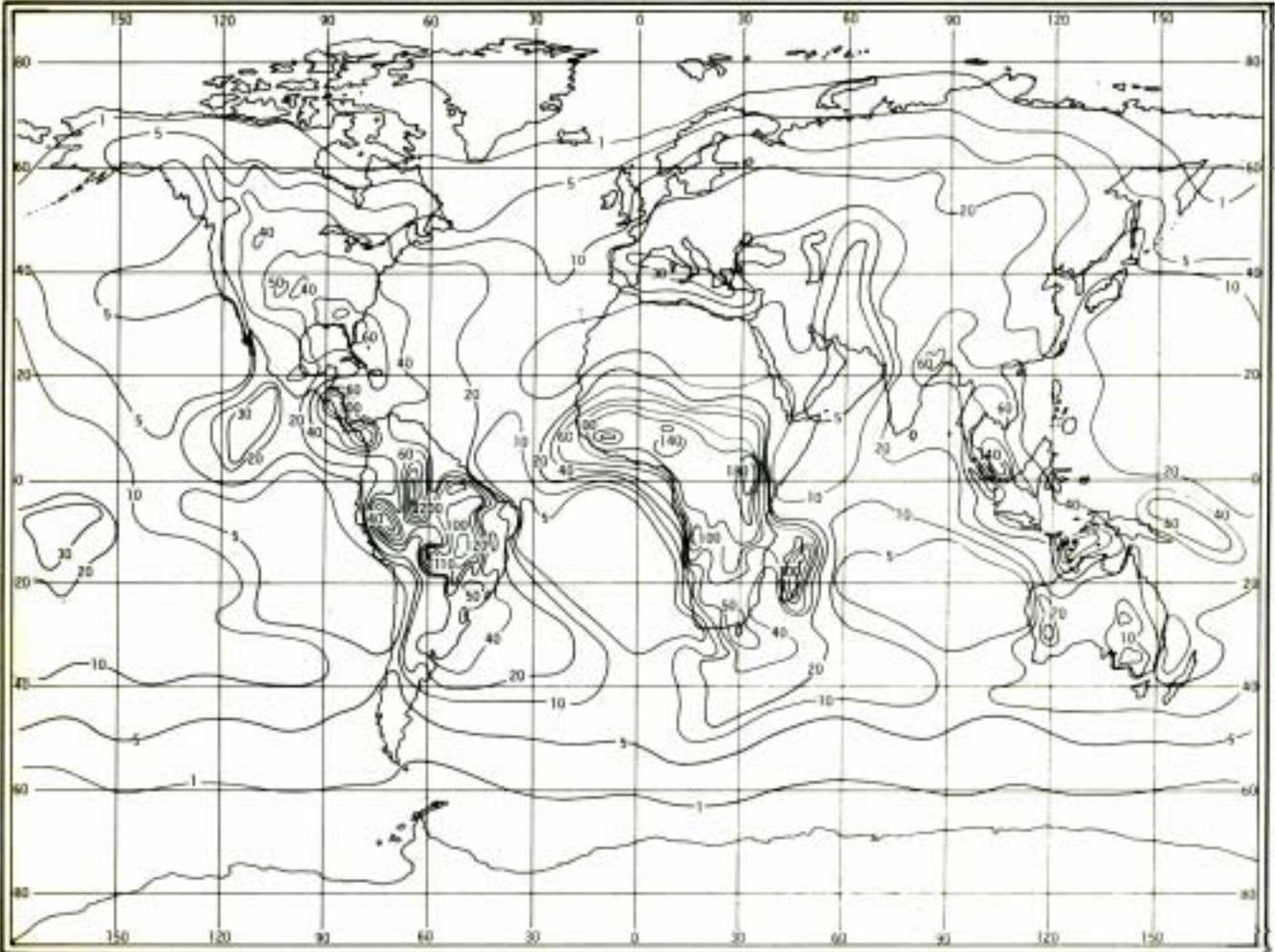


Comparing the above factors to the costs of not protecting electronic equipment will help you decide if protection is beneficial. For workers who oversee installation and maintenance of equipment in diverse locations, the isokeraunic charts in Figure 1 and Figure 2 depict the frequency of thunderstorm activity in the U.S. and around the world.

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FIGURE 2. Average Annual World-Wide Thunderstorm Days



MINIMIZING TRANSIENTS EFFECTS

Three strategies are effective in minimizing lightning-induced transients on industrial electronics:

- **Diversion:** Grounded metallic structures form a “cone of protection” to protect equipment and cabling.
- **Attenuation:** Judicious wiring practices, such as metallic raceways, cable shields, twisted pairs, and extensive grounding and earthing reduce the magnitude of transients.
- **Suppression:** Add-on devices limit the magnitude of the transient appearing at the instrument.

Information on minimizing transients through diversion and attenuation is available through the National Fire Protection Association’s National Electrical Codes (NEC), the Institute of Electrical and Electronic Engineers (IEEE), and in technical articles. This paper examines the “suppression” strategy.

TRANSIENT PROTECTORS

The purpose of a transient protector in transmitter applications is to limit the magnitude of a transient appearing at the transmitter. This add-on device must meet fundamental requirements:

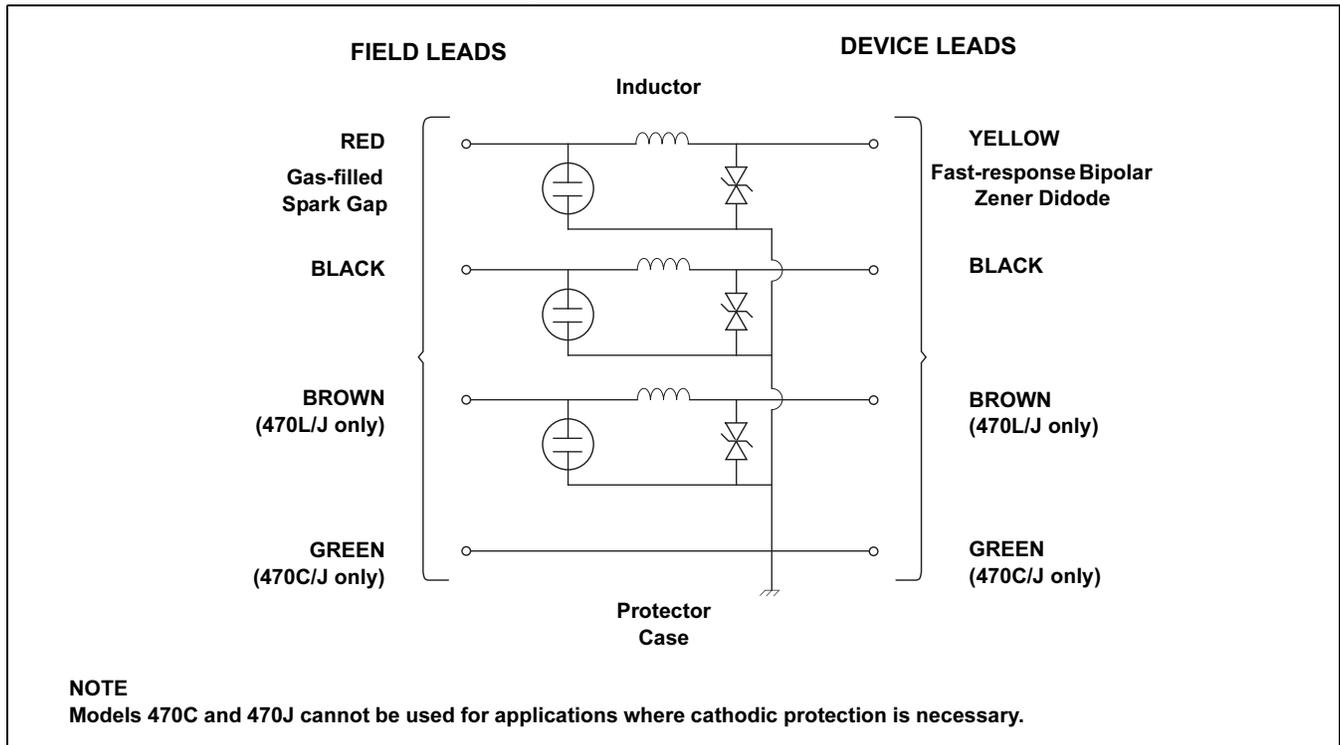
- At normal voltages, it must be essentially non-conducting. Leakage current must be so low that it does not affect the accuracy of the current loop.
- At an overvoltage or “breakdown voltage” that is moderately greater than normal, it must become a conductor.
- The response time for conductivity must be in nanoseconds (10^{-9} seconds).

Because transient voltage is highly variable in wave, shape magnitude, and duration, a transient protector must be designed to meet that varied criteria. The following devices meet this criteria:

- Gas Discharge Tubes (GDT)
- Metal Oxide Varistors (MOV)
- Transient Zener Diodes (TZD)

Testing has shown that a combination of the GDT and MOV or TZD effectively limits the magnitude of a transient on a transmitter. The GDT can carry high current, but is slow to react. The MOV and TZD have lower current capabilities, but respond faster to transients.

FIGURE 3. Schematic Diagram of Transient Protector Models 470D, C, L, and J.



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Model 470 Transient Protector

The Rosemount® Model 470 Transient Protector combines the high-current carrying capability of a GDT and the fast response time of a TZD to provide maximum protection against all types of transients. It consists of separate circuits—one for each lead wire (excluding the green ground wire)—epoxy-sealed inside a 1/2–14 NPT stainless steel pipe nipple for direct mounting to a transmitter. Each signal lead uses an identical protector circuit consisting of a GDT, an inductor, and a bipolar zener diode (TZD).

A high-voltage transient appearing on any field signal wire is conducted to case through the gas-filled spark gap. This device conducts large currents, but has a slow reaction time. The fast-rising portion of the transient is conducted to case through the zener diode. The inductor limits the diode current during the time required for the spark gap to conduct.

The bypass wire connected between the protector case and instrument case ensures that both remain at the same potential, thus preventing dielectric breakdown inside the protected device.

Once the spark gap has begun to conduct, it will continue to do so unless the instrument power supply short circuit limits current to 0.5 A or less. A 47-ohm quenching resistor can be added to ensure the GDT ceases to conduct.

It is important to note that this transient protector conducts transients to case only. It is intended to protect only the instrument being bypassed, and will not prevent damage or injury to other equipment or to personnel in the event of a nearby lightning strike. An adequate grounding system must be established to conduct the transient from the transmitter case to the earth. It is the responsibility of the plant to design the grounding network for this path.

STATIC ELECTRICITY⁽¹⁾

Like lightning, static electricity is a growing area of concern for industrial workers. Damage caused by electrostatic voltages on microelectronic components is well documented. It manifests in physical damage to components and increased labor costs for repair. Static damage was noticed in the 1960s with the advent of microelectronic equipment. Since then, the miniaturization of components and their increased sensitivity has made them even more susceptible to static damage. See Table 1.

Manufacturers have become more aware of the problem, and have acted to control it. Field service organizations, however, have not been so quick to act. Actually, static damage costs are highest in the field, and the potential for savings is greatest in this area.

Educating the electronics industry and field service organizations has been difficult for two reasons. First, the amount of static charge needed to cause damage is far below the level of human perception. Most people are unable to feel a static discharge below 3,000 volts. Yet, less powerful voltages can destroy some semiconductor devices. Therefore, it is difficult to convince workers that they may cause damage when they cannot perceive such damage. See Table 2.

TABLE 1. Typical Electrostatic Voltages.

Means of Electrostatic Voltage Generation	10 to 20% Relative Humidity	65 to 90% Relative Humidity
Walking on carpet	35,000	1,500
Walking on vinyl floor	12,000	250
Worker at bench	6,000	100
Vinyl work instruction envelopes	7,000	600
Common poly bag picked up from bench	20,000	1,200
Polyurethane foam padded chair	18,000	1,500

(1) Information from "10 Myths of Static Damage" by Dixon Gleeson & Bill Russeth, *Computer/Electronics Service News*, June 1985, pp. 46-50, was used in preparing this data sheet. Tables 1 and 2 are reproduced courtesy of *Computer/Electronics Service News*.

TABLE 2. Static Susceptibility of Semiconductor Devices.

Device Type	Range of ESD Threshold Susceptibility (Volts)
VMOS	30 to 1,800
MOSFET	100 to 200
GaAsFET	100 to 300
EPROM	100
JFET	140 to 7,000
SAW	150 to 500
OP-AMP	190 to 2,500
CMOS (input protected)	250 to 3000
Schottky Diodes	300 to 2,500
Thick/Thin Film Resistors	300 to 3,000
Bipolar Transistors	380 to 7,000
DCL (PC board level)	500
SCR	680 to 1,000
Schottky TTL	1,000 to 2,500

Second, it is physically difficult to locate and identify static-damaged areas on electronic components. Such verification requires sophisticated and expensive equipment.

MINIMIZING STATIC DAMAGE

A number of guidelines can be followed, however, to minimize static damage:

- **Grounding:** Technicians should wear grounded wrist straps. Simply touching an equipment frame drains existing charges, but it does not drain regenerative charges. Subsequent movement by a technician quickly regenerates static charge.
- **Education:** Persons who handle electronic equipment should be educated about the damage cause by static charges.
- **Static Shielding:** Use true static shielding bags with a highly conducting layer to prevent static build-up inside the bag and provide a shield to the external static voltage field.
- **Humidity:** High humidity reduces static levels but does not completely eliminate static.
- **Antistatic sprays:** Topical antistatic sprays also reduce static levels, but they are subject to environmental changes and, since they are surface-applied, may wear out.

The best solution to static damage is an ongoing program of education and prevention. Minimizing static requires little effort but can produce immediate and tangible savings in operating and repair expenses.

CONCLUSION

This data sheet has examined the potential for lightning and static damage to industrial electronics. It also has provided advice on protecting equipment and offered possible solutions to lightning and static problems. Considering the information presented should help you determine how best to protect equipment and reduce costs.

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