ENGINEERING
BULLETIN

Design Features for SPD/TVSS Safety

Following is generalized information about design choices influencing SPD safety. As an overview, SPD failures are caused by system level sustained overvoltages. SPDs rarely fail from surges. When MOV(s) conduct a sustained overvoltage, they can overheat. If heat is generated very, very quickly, the MOV(s) can rupture or explode. At the opposite end of the spectrum, if heat can be transferred away, MOV(s) might warm up to tolerable levels. If MOV(s) generate more heat than can be dissipated, thermal runaway results in overheating and a fire hazard.

Overcurrent Protection (OCP) – OCP should be selected such that higher current MOV(s) faults are cleared prior to MOV(s) rupture. This is easier said than done because OCP needs to pass large *surge* currents, while clear modest *fault* currents. Because most SPDs have multiple internal current paths, it is important that OCP stays cleared after operation and does not inadvertently reclose.

Thermal Disconnector – Any current drawn by MOV(s) *below* OCP's operating threshold is not considered *over*-current and passes through the MOV(s). Thus OCP is blind to smaller fault currents. During sustained MOV current draws, heat is generated via I^2R losses. Thermal disconnectors operate on *heat*, not current. When MOV(s) overheat, the thermal disconnectors will clear them from the circuit as a safety precaution.

Coordinated OCP and Thermal Disconnectors - This ensures that the thermal protection of the thermal disconnector(s) overlaps OCP's blind spot such that MOV(s) are satisfactorily protected.

MOV size – Larger MOVs tend to be more robust. In addition to obvious durability advantages, the additional mass acts as a heat sink. This can yield an extra few moments needed for OCP to operate, whereas smaller MOV(s) might rupture sooner.

Encapsulants – Encapsulants can provide bi-directional containment, plus offer limited heat transfer capabilities. These assist by containing internal ruptures and preventing outside contaminants from reaching key components. Common encapsulants are epoxy based or sand. (Unencapsulated SPDs are usually associated with lower-end products.) Epoxy based encapsulants are good insulators and offer better mechanical and vibration isolation than sand. If overheated above about 450°F, epoxies tend to liquefy. Some epoxies can be brittle. APT developed and patented Ceramgard® as an elastomeric compound that solves this issue. Sand is inorganic and a good insulator, with manufacturing challenges because of its leaky and non-hardening nature. Encapsulants can transfer limited heat to their enclosures.

Exceeding UL requirements – Better SPD manufacturers test to blind spots in UL's testing. Such testing is one reason why new UL procedures are upgraded periodically. For example, UL does not test entire SPDs for accidental misapplication. Suppose someone installs a 208Y/120V SPD on a 480Y/277V or 600Y/347V system. This will cause instant SPD failure.

Another aspect is off-gas control. Better SPDs try to control off-gassing too. Disintegrating MOV(s) can expel conductive, ionized particulate and soot. In turn, this can contaminate nearby electrical equipment, causing additional damage associated with arc-flash style hazards. APT holds a design patent addressing this.

Barriers – Better SPDs include electrical isolation inside the SPD. This may be modular construction where each phase is visually isolated. Internal barriers within the SPD can prevent arc-flash situations too. APT takes these extra steps.

Metallic enclosures – Conventional theory suggests that metallic boxes would be better because they are stronger. That is partly true. It turns out that MOV failures inside an SPD tend to be arcing, sparking events similar to a severe arc-flash scenario. A metallic enclosure creates an arc path to ground, thus perpetuating or accelerating an undesirable situation. Whereas plastic-type enclosures are non-conductive. This is one reason why so many SPDs use non-metallic enclosures.

Diagnostic Indicators – Better SPDs use low voltage visual indicators, rather than line voltage lights that could introduce a touch hazard if something goes wrong.

Dry Contacts – Dry Contacts are supposed to change state if the SPD fails. Failure presumes something has gone wrong inside the SPD; sometimes very wrong. There are advantages to using low voltage at SPD Dry Contacts. This could avoid an unintentional and potentially hazardous backfeed through damaged SPD circuitry.

N-G MOV configuration – Occasionally, L-N and L-G MOVs are configured so they share common OCP. If both L-N and L-G MOVs failed short and cleared their OCP, then an inadvertent N-G connection may exist. This accidental N-G bond can cause clearing problems for other circuits and can be very difficult to find.

Failure Mode & Effects Analysis (FMEA) – This concept is used to examine potential failures and their impact. Originally developed by the military, better SPD manufacturers evaluate SPD various failure modes. This is voluntary testing above and beyond UL. These can be Design FMEA's or Manufacturing FMEA's. As examples, what happens when a thermal disconnector is purposely bypassed, or is out of normal production specifications? APT spends the extra effort to chase down answers to these situations.

Summary – UL 1449 provides good safety guidelines. APT prefers an additional level of safety and expends substantial resources and energy to that goal. Failure testing is an inexact science based on trial and error at the manufacturer level. We are proud of our products and would more than happy to discuss construction and advantages.

Stay in touch with APT Engineering Sales at 800-237-4567, visit our website, www.aptspd.com, or email us at info@apttvss.com.

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