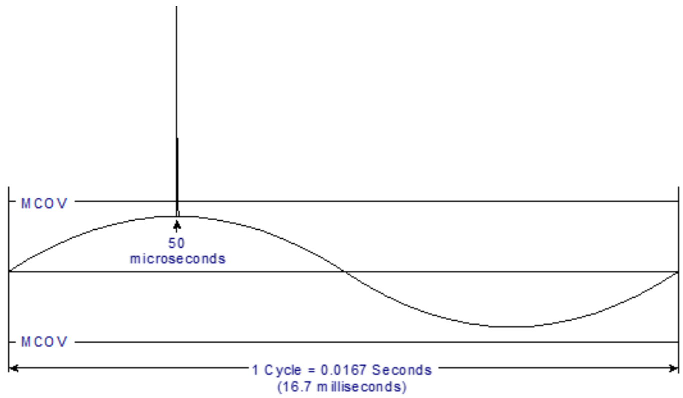
The IEEE C62.41.1-2002 document identifies that, “Surge voltages and surge currents occurring in low-voltage ac power circuits originate from two major sources, lightning and switching.”

a) ***Lightning surges.*** Lightning surges are the result of a direct flash to the power system, to the structure of interest and nearby structures, or to the soil. Distant lightning flashes can also induce voltage surges in the circuits of an installation.
b) ***Switching surges.*** Switching surges are the result of intentional actions on the power system, such as load or capacitor switching. They can also be the result of unintentional events, such as power system faults and the subsequent corrective actions.

Surge Protective Devices (SPDs) are installed in an electrical distribution system as a shunt path and provide protection against these surge impulses (spikes).

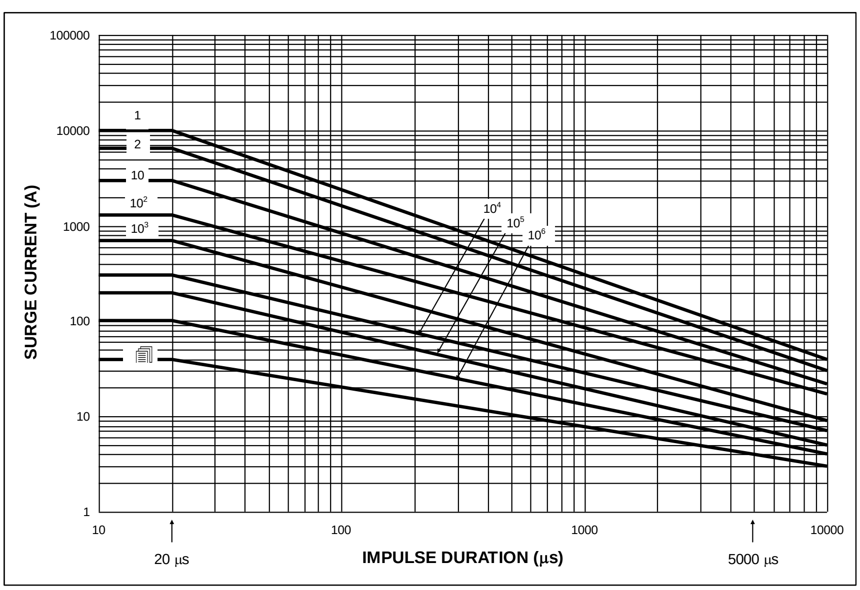
An SPD is designed to turn on at about 15-25% over the nominal line voltage. This turn on point is called the Maximum Continuous Operating Voltage (MCOV). When a spike exceeds the MCOV, the SPD begins clamping down the voltage to a level that is benign to the equipment in the facility.

The total duration of a surge event is approximately 50 μs. In relation to power flow, a surge is extremely short. (See the illustration at the right.)



In the US, electricity flows from the utility at the rate of 60 cycles per second. The duration of a single cycle, therefore, is approximately 0.0167 seconds, or 16.7 milliseconds (ms).

Metal Oxide Varistors (MOVs) are the components most SPD manufacturers use as the protection against these spikes. The MOVs are arrayed in a configuration that allows multiple small components to share high surge currents. Based on the number of MOVs included an an SPD, a given level of surge current (given in kA) protection can be obtained; a higher kA rating of the unit allows protection for a higher amplitude spike, as well as a higher number of smaller spikes.



Due to their ability to share surge currents equally for higher surge current levels and higher reliability, MOVs are ideally suited for the typical surge events with their characteristic, extremely short duration.

To define that reliability, for each size of MOV, manufacturers produce a Pulse Rating Curve (a typical example is shown at the left) which identifies the MOV’s performance characteristics.

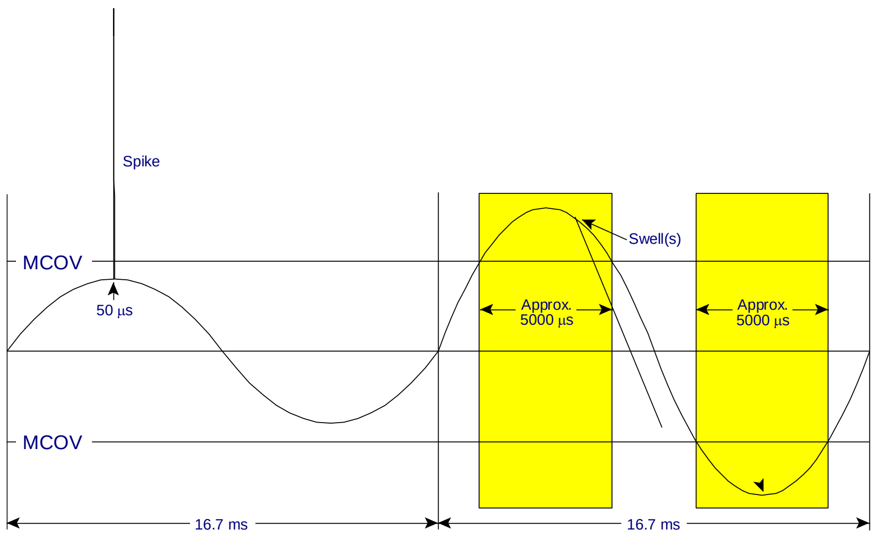
The chart shows the number of impulses an MOV can sustain (the diagonal lines) at the given surge current (y-axis) for a given impulse duration (x-axis).

For Example, at an impulse duration of 20 µs, this MOV can sustain one impulse of 10,000 A; at 100 A, this same MOV can sustain 1,000,000 impulses. As the impulse duration increases, though, the amount of current that this MOV can sustain before failure decreases exponentially. And this exposes the weakness of SPD systems which only incorporate MOVs.

Growing evidence identifies that momentary overvoltage swells (which typically occur upon recovery of the power system from momentary undervoltages, i.e. “sags”) cause a large number of SPD failures – perhaps the majority – rather than ‘large’ spikes.

The differences between a spike and a voltage swell can be seen in the graphic below.

While the effect of a spike lasts approximately 20-50 µs and occurs as a singular event, voltage swells of 200% are possible, lasting up to several cycles or a few seconds. During a 200% voltage swell, the voltage exceeds the MCOV for the SPD every half cycle for greater than 5000 µs. This occurs <u>every</u> half cycle. While this is still only 1/200th of a second, it is an eternity for an MOV.



A glance back to the Pulse Rating Curve chart reveals how destructive these swells are to MOVs. At a 200% voltage swell, with the MCOV exceeded for approximately 5000 µs, it takes only 75 A one time (one half cycle) to fail the MOV; it takes only 30 A one hundred times (less than one second) to fail the MOV.

During these swells, the MOVs conducts line current, and there are few, if any, facilities where 75 A is not available. The result of all of this is that it is possible that an MOV-only SPD could fail before it is ever exposed to a spike.

The Current Technology SL3 SPD is a hybrid system, combining MOVs with selenium cells (and high frequency capacitors) providing enhanced protection from transient voltage spikes <u>and voltage swells</u>. This hybrid system is designed so that the MCOV for the selenium cells is just below that of the MOVs. During voltage swells, the selenium cells turn on first and conduct current away from the MOVs. The result is that the selenium enhanced suppression system will not fail during voltage swells.

An additional benefit of selenium enhanced systems is that since the selenium cells turn on first, low level transients are conducted by the selenium alone. The MOVs, therefore, are not exposed at all to these low level transients, providing longer life and higher reliability. Remember that the main purpose of an SPD is to provide protection to the loads in the facility. Selenium, therefore, enhances the protection to the loads by enhancing the reliability of the SPD to ensure it is on line and protecting the loads from whatever happens on the power line.