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THE CONNECTOR CORRECTOR

Surge Arrester Currents

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Discharge current is the surge current that flows through a surge arrester during discharge of an overvoltage surge (and discharge voltage is the voltage that appears across the terminals of an arrester during that time). There are four additional currents that are of significance in the design, application, and performance of a surge arrester. Those currents can be defined as follows:

- Grading current: Current that flows through the arrester internal grading circuit.
- Leakage current: Current that flows over the outer surface of the arrester housing that is primarily a function of the application environment.
- Fault current: Current from the connected power system that flows in a short circuit.
- Power follow current: Current that continues to flow following discharge of the surge by the arrester.

The difference in fault and power follow current is timing. The low arrester impedance during discharge is, for all practical purposes, a short circuit but the arrester must interrupt and reseal against power follow current.

Fault current is dictated by the power system and the available current at the arrester location. Power follow current is dictated by the power system and the surge arrester design. The others depend upon the arrester age, class, rating, and design [gapped silicon-carbide (SiC), gapped or gapless metal oxide (MOV)].

Surge arresters manufactured before about 1977 are gapped SiC and there are many distribution, riser pole, intermediate, and station class arresters in service today that are of that design. The majority of these arresters were manufactured from 1950 through 1977. They represented state of the art at the time they were installed and for the most part their service history has been satisfactory.

The design of the earliest SiC arresters consisted of a simple multigap structure in series with non-linear SiC valve blocks. In those arresters, all system voltage was applied to the gap structure. The gap structure sparked over in response to an overvoltage surge to prevent damage to line or equipment insulation and the resulting power follow current flowed through the series gap-valve block combination. The non-linear blocks limited the follow current to a level that the gap structure could typically interrupt on the next voltage zero crossing (although restrikes were not uncommon). Following successful reseal the arrester returned to normal operation.

A major improvement in that design, primarily for station and intermediate class arresters, occurred with the introduction of the current-limiting gap in 1957. The current-limiting gap helped limit system follow current by generating a back EMF which, in combination with the non-linear SiC blocks, allowed current interruption without reliance on a voltage zero crossing.

Most gapped SiC arresters also utilized resistive (R), capacitive (C) or resistive-capacitive (RC) grading circuits to grade the system voltage and obtain uniform voltage distribution across the gap structure. These grading circuits were electrically connected external to the gaps and blocks so that grading current flowed only through the grading circuit. Typical grading circuits resulted in a few milliamps of line to ground current.

A concern with gapped SiC arresters was operation in severely contaminated environments. Severe external contamination and the resulting leakage currents could couple and upset weaker internal grading circuits and alter the voltage distribution over the gap structure.

One method of monitoring grading and leakage currents as well as the number of line to ground discharges primarily through station arresters is a discharge counter with a leakage/grading current meter, Counters are used with gapped SiC and gapped and ungapped MOV arresters to assist in monitoring their duty and condition. Installation of discharge counters requires grounding the arrester through the discharge counter. This is typically done by mounting the arrester on an insulating sub base, as shown in Figure 1. (Many years ago, one manufacturer offered a discharge counter that also contained a mirrored replica gap in the discharge path. By examination of the replica gap and the copper mirror electrodes one could theoretically judge the condition of the arrester internal gaps and determine the duty to which they had been exposed).

The introduction of metal-oxide [primarily zinc-oxide (ZnO)] semiconductors for use in MOV surge arresters in 1977 was the second major advancement in surge arrester design and performance. The metal-oxide varistor is characterized by an extremely non-linear current-voltage relationship resulting in a much higher voltage exponent over the nonlinear portion of the volt-amp curve than SiC. This characteristic is what allows the design of gapless surge arresters. It also requires the introduction of another current called the reference current (Iref), which is an AC current specified by the surge arrester manufacturer in conjunction with a reference AC voltage (Vref) that essentially defines the point at which the arrester elements go into conduction. Below that point (and when energized at normal line to ground operating voltage) MOV elements can be characterized as lossy capacitors with current leading voltage by almost 90^o. As voltage is increased above Vref the MOV elements become more resistive and at full conduction almost purely resistive with current and voltage in phase.

The significant improvement in operating characteristics and protective levels afforded by gapless MOV surge arresters also renders them virtually immune to the effects of contamination and external leakage currents.

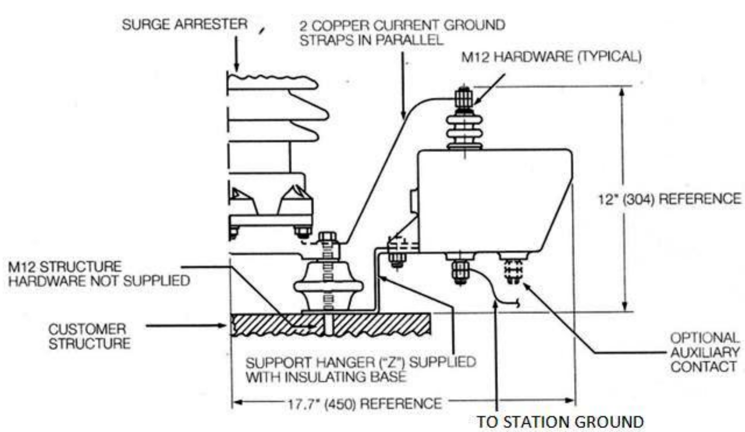

Figure 1 Typical Installation (Cooper)

The IEEE C62 family of standards covers surge arresters and their application. For example, C62.11 is titled, "IEEE Standard for Metal-Oxide Surge Arresters for AC Power Circuits (>1kV)".