Recent Improvements in Distribution Surge Arrester Reliability

Ground Lead Disconnectors Greatly Improved

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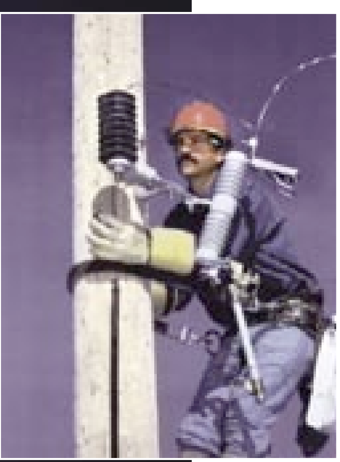
Electric utilities continue to look for ways to provide more reliable service to end users. This can be a challenge in areas with moderate to high lightning activity. It has been common practice to install surge arresters to protect apparatus from failure. Additionally, it is becoming more common to improve power quality by using surge arresters to protect line insulation from flashover. A long standing concern with power companies is that when surge arresters experience an internal failure, they must reliably clear themselves from the line. This article will review the function of distribution arrester disconnectors, and explain enhancements that will improve system performance.

Background



Installing a surge arrester.

Several years ago the industry converted from porcelain housed Silicone Carbide (SiC) distribution type arresters, to polymer housed Metal Oxide Varistor (MOV) arresters. The MOV surge arrester has improved performance due to the fact they are made entirely without gaps. SiC arrester operation depend on the arrester gaps withstanding the normal power frequency voltages and not sparking over. When excessive contamination occurs, it is possible that the normal operating voltage may spark over the gaps, and if the contamination is severe enough, it will cause arrester failure. MOV arresters are typically gapless and therefore immune to this type of failure.

A major problem with porcelain house arresters, is the danger to the lineworkers and the public from fragmented porcelain in the event of an explosive failure. Polymer housed MOV arresters have avoided this problem; however, they must be disconnected rapidly in the event they experience an internal short. The ground lead disconnector is the key element of the arrester that performs this function. The disconnector utilizes an unprimed cartridge to accomplish the separation of the ground lead.

In the event of a failure of the arrester to ground, the cartridge is triggered from heat generated by the fault current. This fault may cause an upstream protective device to operate. The disconnector should separate the ground lead and the faulty arrester allowing the upstream protective device to successfully reclose. The disconnected ground lead should serve as a clear identification to line crews of the faulted arrester. If the disconnector does not operate properly, the failed end of the arrester will remain connected to the system ground and the upstream device will permanently open up. It can be difficult, time consuming, and expensive to locate a failed, but not cleared, arrester.

Disconnector Standards

The clearing performance characteristics of ground lead disconnectors are basically the same as a fuse curve – the higher the level of power frequency current, the shorter time to detonation. Industry standards define the performance requirements of the ground lead disconnector. These standards involve testing the disconnector at various fault current levels so that a standard detonation curve is established. This allows engineers to effectively coordinate with upstream protective devices.

It is preferable, in the event of an arrester failure to have the ground lead disconnector clear before any upstream device operates. When lower current levels are encountered, one operation of the upstream device may be necessary before the ground disconnector clears. Standards require that the ground lead disconnector should only operate when the arrester fails and never during normal operation.

Disconnector Design and Operation

Most designs use the same basic internal design that is shown in Figure 1. The unprimed (heat activated only) cartridge (detonator) is used to provide the

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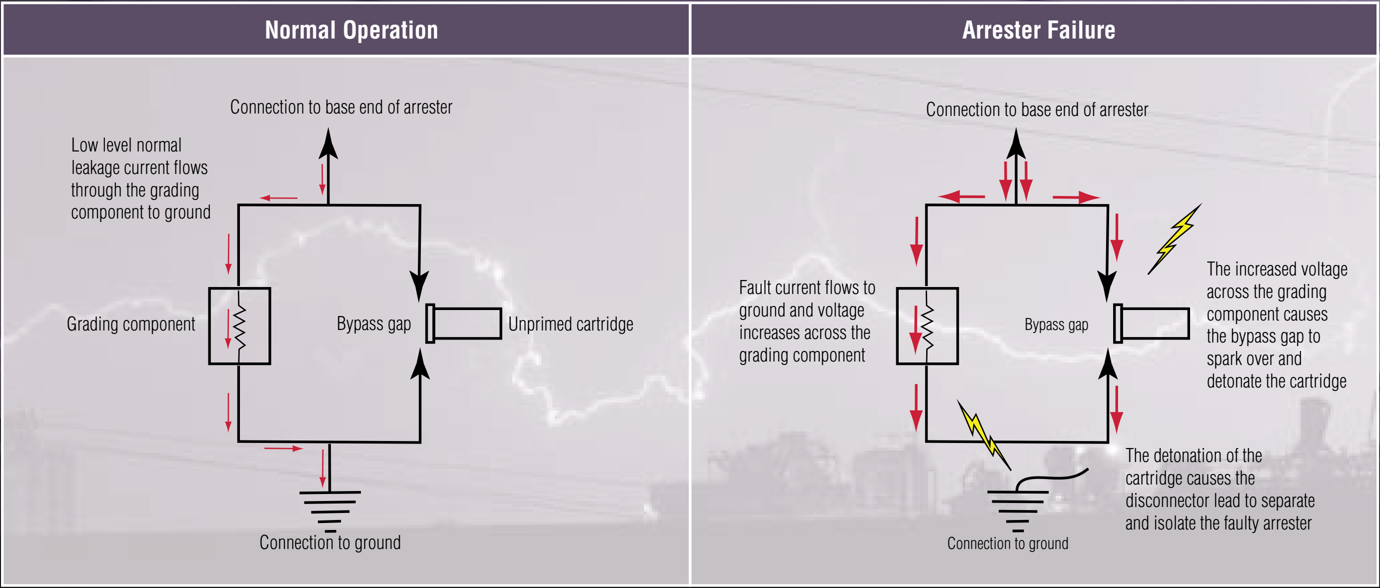


FIGURE 1

force needed to clear the ground lead. The normal power frequency "leakage" current flows through the internal grading component, which is typically a high wattage resistor, or to a lesser extent, an electronic capacitor. The leakage current flow is kept away from the detonator by a by-pass gap. In the unlikely event of an arrester failure, the increase in power frequency current will cause a voltage to develop across the grading component. This voltage causes the by-pass gap to spark over allowing the current to flow through the detonator. The heating will trigger detonation and the arrester will be disconnected from the line.

Problems with Current Designs

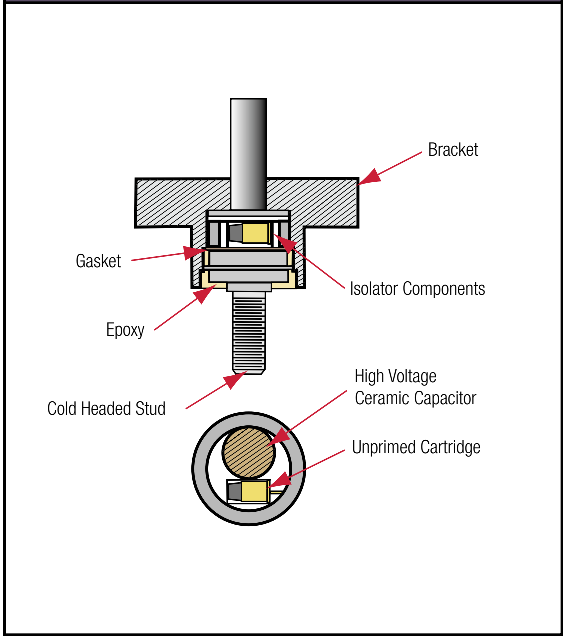
Standards require ground lead disconnector operation at currents in the range of 20 – 800 amperes. At fault currents above 800 amperes, nearly all designs will detonate and clear the faulty arrester from heat generated by the flow of fault current across the spark gap. The major concern occurs when arresters are applied to non-effectively grounded systems, or on systems where low line to ground fault currents exist. In these cases, the possibility exists that the detonator is not heated sufficiently to detonate and clear the faulty arrester before the upstream protective device does.

The grading resister is the weak link and it can short out in the event of excessive temporary overvoltage caused by a low level of fault current. When this occurs, total system overvoltage is then placed across the arrester MOV disks causing them to fail. The low fault current may not generate enough heat to cause the detonator to fire and clear the faulty arrester. Now the power company will experience a circuit or a portion of a circuit without power, and a faulted arrester connected to it, that will be difficult and time consuming for line crews to discover.

Improvements to Current Designs

Replacing the grading resistor with a high voltage ceramic capacitor results in a significantly more

FIGURE 2



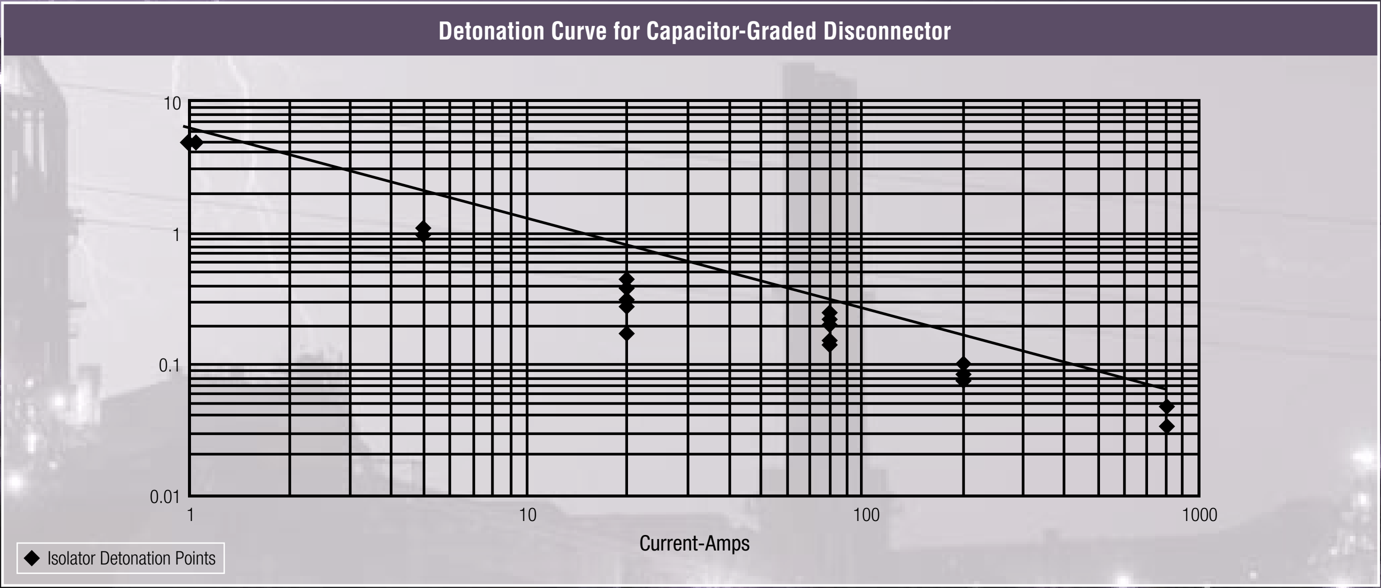
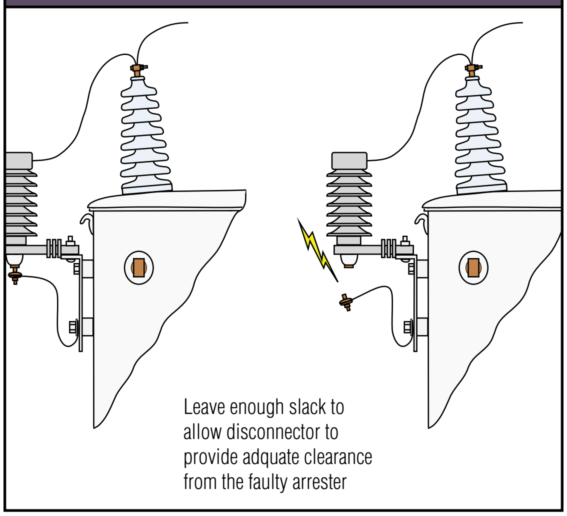


FIGURE 3

reliable design. This capacitor will not fail when it is subjected to a prolonged overvoltage condition. Since the capacitor-graded disconnector removes failure concerns associated with the resistor-graded capacitor, time to detonation for low fault applications becomes strictly an issue related to the thermal design of the disconnector spark gap. Figure 2 shows a cross-sectional view of a capacitor-graded disconnector designed as an integral part of the insulating bracket.

The standard detonation test was performed on the disconnector at fault current levels of 1 and 5 amperes. In all tests, successful detonation occurred within 10 seconds. With the disconnector satisfactorily operating for low levels of fault current, concerns arise about the disconnector being over sensitive and detonating under normal load operation. To address this concern, durability tests were performed which simulated the arresters ability to discharge surges. Five capacitor-graded arresters were subjected to 18 shots of 400 ampere, 2 millisecond surges. None of the units detonated and all five successfully detonated when subjected to a 1 amp fault current. Figure 3 shows the resultant detonation curve.

FIGURE 4



To assure that the disconnector operates as it was designed, it is important for line crews to leave enough slack in the lead wire to allow the detonator to clear the lead adequately from the faulty arrester. Stiff wire, such as hard drawn copper, should not be used for the same reason. (Figure 4)

Conclusion

Until now, disconnector designs have not changed in response to the transition form SiliconeCarbide technology to MOV type surge arresters. The introduction of a high voltage capacitor-graded arrester ground lead disconnector, addresses utility concerns regarding the reliable detonation of the Distribution Class arrester disconnector. Power companies and line crews should have confidence in new arrester designs that use this technology. Experiencing faulty arresters should be a rare occurrence and when it does occur, the arrester should clear itself without causing a sustained outage. ▼