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배전급 피뢰기의 설계

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Design and Improves Arrester Performance for Distribution Class Arrester

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Abstract - The paper introduces a new Distribution Class ground lead disconnector design that not only extends the claimable detonation range well below the 20 amps specified in industry standards, but is very durable when exposed to severe arrester durability tests. Finally, this paper shows how this next generation disconnector interacts with the connected arrester to improve the overvoltage withstand capability of the arrester assembly.

1. Introduction

It has been standard practice of utilities to protect distribution class equipment, particularly pole top transformers, with distribution class arresters. Protection of the dielectric integrity of the transformer is provided by the closely connected arrester. Approximately twenty years ago, the traditional gapped-silicon carbide distribution class arrester design was replaced by the improved gapless arrester, based on metal oxide varistor (MOV) technology. In addition to performance improvements associated with this new MOV technology, the traditional porcelain-housed arresters were replaced during this same time period by polymer-housed arresters.

Conversion from porcelain to polymer-housed distribution class arresters allowed manufacturers to reduce the active element length of their arrester designs. The porcelain designs traditionally had a ground lead disconnector attached to the base end of the arrester and the arrester was supported by a grounded metal "bellyband" bracket, typically attached around the porcelain housing approximately one-third the distance from the bottom end of the arrester housing. The distance from the top edge of the metal bellyband to the arrester top end cap provided the required line to ground insulation clearance as specified for each arrester. The distance from the bottom of the grounded belly band to the ground lead disconnector provided the necessary clearance to prevent the intact, failed porcelain arrester from locking out the system if the arrester should fail but remain intact.

Disconnection of the ground lead causes the base end of the failed (intact) arrester to assume system line potential. The composition and shed design of the insulated bracket allows the arrester location to remain energized until the utility operating personnel replace the failed arrester.

The above description is valid, assuming that the ground lead disconnector reliably detonates during arrester failure. Should the disconnector fail to operate, the base end of the failed arrester will remain connected to system ground and the line will lock out until upstream protection operates and the failed arrester is replaced.

This paper examines performance characteristics of existing distribution class arrester ground lead disconnecting devices. In particular, it will focus on how the detonator performs after the series connected arrester fails, under various system conditions. The paper also introduces a new disconnector design that not only extends the claimable detonation range well below the 20 amps specified in industry standards, but is very durable when exposed to severe arrester durability tests. It will also be shown how this device interacts with the connected arrester to improve the overvoltage withstand capability of the arrester assembly.

2. Experiment

Industry standards (1, 2) define the performance requirements of the ground lead disconnector. The performance requirements are divided into two areas of concern. The first addresses the detonation characteristic of the disconnector, essentially the current-time curve. This test specifies that the disconnector is subjected to 60 Hz power frequency currents of 20, 80, 200, and 800 Amps rms and the time to detonation at each current level is measured. From this test series, the disconnector detonation curve is established. A knowledgeable application engineer can use the arrester detonation curve to develop proper coordination with upstream protection, e.g., fuses (3).

The second aspect of performance is that the disconnector will not detonate when subjected to required arrester durability tests, including high current-short duration, low current-long duration, and duty cycle tests. Another test requirement is that the disconnector will not detonate as a result of arrester surface currents when the arrester assembly is subjected to contamination testing. Essentially, the disconnector is designed to withstand (without detonating) the same durability tests that the arrester must withstand; however, it must detonate, disconnecting the arrester ground lead, when the arrester fails and conducts system fault current.

There are two basic detonator designs used in disconnectors. As noted earlier, virtually all designs attach the isolator to the ground end of the arrester. One design mounts the arrester base end on an insulating bracket and holds the arrester to the bracket by attaching a disconnector to the underside of the assembly. This design was a carryover from porcelain arresters. The second design, targeted specifically to polymer arresters, integrates the disconnector into the body of the insulating bracket. This integrated designs attaches to the base end of the arrester.

3. Result and Discussion

As noted, the disconnector current detonation range specified in the standard is 20 to 800 amps. The standard does not specify the shape of the current time detonation curve. It merely defines the procedure for performing the test on new disconnectors. Above 800 amps, all designs should detonate very quickly from the high heat associated with the high 60 Hz fault current. Problems can be encountered on arresters applied to non-effectively grounded systems or on arresters located on weak feeders where only low fault currents are available (<20amps). Specifically, the cartridge relies on heating from the system 60 Hz fault current to cause detonation. Inherent in these weak source current locations is the possibility that the cartridge is not heated sufficiently by the available 60 Hz current to detonate before upstream protection triggers. Reliable detonation of the disconnector under this weak source condition is an issue of concern. Figure 1 shows disconnectors tested per the current standard.

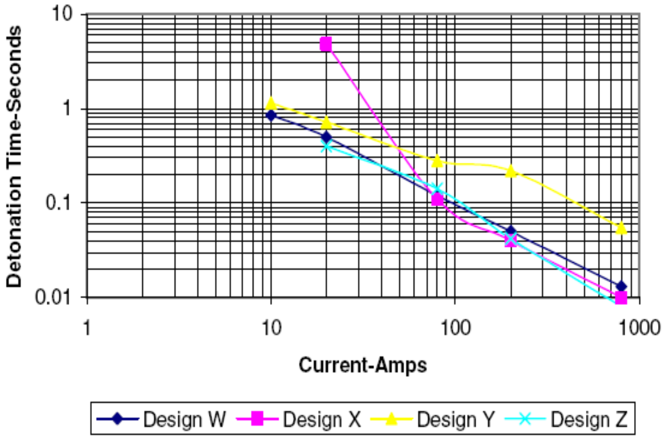

Fig. 1. Comparison of Detonation Curves for Various Domestically Produced Resistor-Graded Disconnectors.

To validate the detonation curve for the capacitor-graded design, tests were performed. Figure 2 shows the resultant detonation curve. Note that all samples tested at 1 and 5 amp current levels detonated. There was no damage to the grading capacitor other than the external arcing damage associated with the fault current arc.

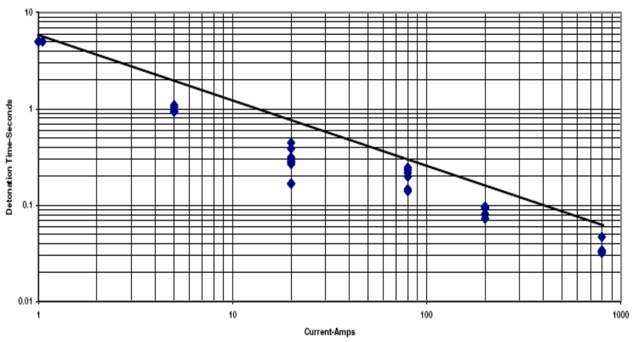

Fig.2. Detonation Curve for Capacitor-Graded Disconnector.

As noted previously, the significantly higher impedance of the capacitor graded disconnector electrically interacts with the capacitive and non-linear resistance characteristic of the metal oxide discs. At system operating voltage levels, the voltage across the capacitively graded disconnector is typically a few hundred volts, compared with tens of volts for the resistively graded disconnector. As applied voltage increases above operating levels, the parallel combination of the disconnector capacitor and its sparkgap assume a higher percentage of total voltage than does the resistively graded disconnector. Because the capacitor does not experience I^2R loss, in contrast to the resistance graded design, the disconnector can withstand overvoltages for extended periods of time, as long as the capacitor voltage does not exceed the bypass gap sparkover level. Unlike an arrester with a resistively graded disconnector, which has a claimed TOV capability that is independent of arrester voltage rating, arresters with capacitively graded disconnectors have a rating-dependent TOV curve. Figure 3 shows the TOV curve for 9 and 10 kV rated HD Distribution Class arresters.

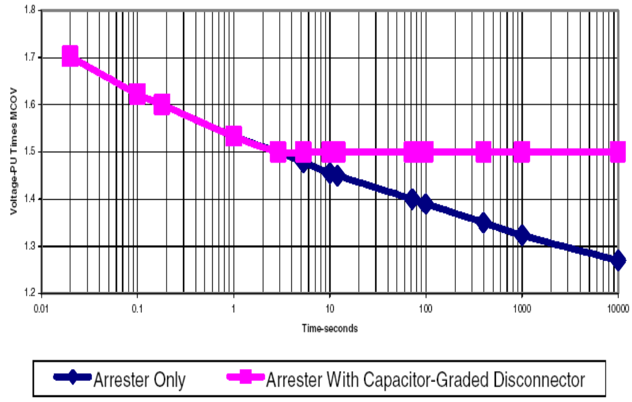

Fig.3. No prior duty TOV curves for 9 and 10 kV rated HD distribution arresters with and without capacitor- graded disconnector.

4. Conclusion

Introduction of a high voltage capacitor graded arrester ground lead disconnector addresses utility concerns regarding reliable detonation of the Distribution Class arrester disconnector. Test data confirms the detonation integrity of the disconnector is maintained even after the arrester is subjected to high current surge duty prevalent in the distribution system environment. Even under weak source temporary overvoltage conditions, which can damage the resistance-graded design affecting detonation reliability, the capacitor-graded design performs properly. Finally, the interaction of the disconnector grading capacitor with the series-connected arrester metal oxide disc elements actually improves the arrester assembly temporary overvoltage withstand capability, making the design less vulnerable to TOV failures.

[Acknowledgement]

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[References]

[1] IEEE Standard for Metal-Oxide Surge Arresters for AC Power Circuits (>1 kV) IEEE Std C62.11-1999.

[2] IEEE Guide for the Application of Metal-Oxide Surge Arresters for Alternating-Current Systems IEEE Std C62.22-1997.

[3] IEEE Guide for the Application of Metal-Oxide Surge Arresters for Alternating-Current Systems IEEE Std C62.22-1997.