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배전급 피뢰기의 신뢰성 평가에 관한 기술 동향

[1]김 선빈, [1]김 인희, [1]홍 현욱, [1]오 용, [2]황 종선, [1]최 용성, [1]이 경섭
[1]동신대학교, [2]전남도립 남도대학

A Technical Trend on New Distribution Class Arrester Ground Lead Disconnector Design

[1]Sun-Bin Kim, [1]In-Hee Kim, [1]Hyun-Wook Hong, [1]Yong Oh, [2]Jong-Sun Hwang, [1]Yong-Sung Choi, and [1]Kyung-Sup Lee
[1]Dongshin University, [2]Namdo Provincial College

Abstract - This paper introduces performance characteristics of existing distribution class arrester ground lead disconnecting devices. The paper also 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

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 to MOV resulted in lowering of the protective levels of the arrester, particularly under fast front rate of rise surges, providing improved protection to the internal insulation of the transformer. Implementation of polymer housings significantly improved the performance of the arrester in the unlikely event of arrester failure. Specifically, the polymer housed arrester removed the concern of violent porcelain fragmentation associated with porcelain-housed distribution class arresters. The predecessor porcelain-housed distribution class arrester had no required short circuit performance requirement.

For the polymer-housed designs, this "lockout prevention" clearance was relocated to the supporting bracket, which typically attaches to the base end of the polymer-housed arrester. Because this member now has the added requirement of voltage withstand after arrester failure, its composition changed from metal to an insulating plastic material. Should the polymer-housed arrester fail and remain intact (typical), the ground lead disconnector, connected between the base of the arrester and the arrester ground lead, will detonate. 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 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. Experimental

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. Regardless of which approach is utilized, both designs use the same basic internal design approach. An unprimed cartridge is used to promote separation of the disconnector. This cartridge is typically located in the vicinity of a sparkgap, which is oriented in parallel with some type of electrical grading component. Manufacturers have utilized a variety of grading components, including electronic capacitors, electronic resistors, conductive polymers, and higher wattage resistors. The sparkgap, located electrically in parallel with the resistor, provides a bypass function when the arrester assembly is subjected to abnormal surge duty. Voltage drop across the grading component during this abnormal surge duty causes the bypass gap to sparkover.

For required arrester durability tests defined in the standard, the arrester is expected to withstand the duty without failing and the detonator is expected to withstand the duty without detonating. The thermal design of the disconnector is such that there is not sufficient coulomb content in the sparkgap region to cause the adjacent cartridge to detonate during arrester durability tests. However, if the surge duty is sufficient to cause the arrester to fail, the subsequent flow of system fault current available at the arrester location is intended to provide sufficient heating of the cartridge to cause it to detonate. The design of the disconnector is such that this detonation then causes the ground lead to be separated from the base end of the arrester.

3. Results and Discussion

To address the detonation reliability concerns of the ground lead disconnector, the molded resistance grading component of the disconnector was replaced with a high voltage ceramic capacitor. A primary advantage of the high voltage capacitor grading is that the capacitor will not fail from thermal runaway when the arrester assembly is subjected to a prolonged overvoltage condition. Unlike the grading resistor, which can heat up and fail from I^2R loss, the capacitor design will withstand the capacitance portion of the total overvoltage. Ultimate arrester failure will occur when the arrester metal oxide discs fail from thermal runaway or when voltage across the capacitance-graded sparkgap becomes high enough to cause the gap to spark over.

The new capacitorgraded disconnector will detonate down to 1 ampere. As the design becomes more sensitive to low current detonation, there is a concern that the disconnector might become too sensitive and detonate on required arrester durability tests. To address this concern, the following durability tests were performed. Five arresters with capacitor-graded insulating brackets were subjected to (18) shots of 400 amp, 2ms duration, exceeding the 18 shot, 250 amp test requirement for Heavy Duty Distribution Class arresters. While not detonating as a result of the repetitive duty, all five disconnectors detonated when subjected to a 1 amp fault current. Six capacitor-graded disconnectors were also subjected to (2) 100 kA 5.5/12 discharges with no detonation occurring. In addition, the measured capacitance changed less than 5% and there was nopartial discharge measured as a result of this severe duty. As a final confirmation of the electrical integrity, three disconnectors that successfully passed the (2) 100 kA shots were tested for detonation in a 6-amp test circuit. Time to detonation on these three samples was .983, 1.0, and 1.43 seconds, well within the claimed detonation curve for the new disconnector.

4. Conclusion

Introduction of a high voltage capacitorgraded 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. The detonation range of this design has also been reliably extended to 1 amp, below the 20 amps. 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.

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[References]

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