

Overvoltage Protection for Pad-mounted Transformers

At Issue

Overvoltages brought on by lightning, switching, or ferroresonance can cause the premature failure of a pad-mounted transformer. Arresters protect equipment from these overvoltages, extending transformer life. Understanding the different arrester types and duty cycles available can greatly reduce the risk of losing a transformer due to an overvoltage, while minimizing the cost of overvoltage protection.

Rationale and Evidence

Arresters are inherently designed to provide overvoltages with a path to ground. This path is not available during normal transformer operation. An arrester conducts electricity only during an overvoltage, bleeding the current off to ground. Once the overvoltage has left the system, the arrester closes the path to ground, and stops conducting.

The key to an arrester's performance lies in its use of a material which acts as an insulator at rated voltage, but becomes a conductor at some higher voltage. An arrester selectively conducts overvoltages but draws no current during normal transformer operation. The most popular arrester material with this property today is metal oxide varistor (MOV). Blocks of MOV are arranged to provide resistance to the correct amount of voltage. All arresters use this concept; differences in duty cycle and class are proportional to the type, mass, and configuration of MOV material used in the design.

This document addresses Distribution class and Secondary arresters – the types most commonly used in pad-mounted transformers. Station and Intermediate class arresters are larger, more expensive devices commonly used to protect substations. These larger arresters are addressed in the document, *Overvoltage Protection for Substation Transformers*.

Arresters reduce overvoltages but do not eliminate them. Duty cycle is a measure of the performance characteristics of an arrester. The higher the duty

cycle of the arrester, the lower the arrester's discharge voltage.

Duty cycle also impacts the thermal capacity of arresters. An arrester conducts electricity only at and above its rated voltage. The higher the duty cycle of an arrester, the more conductive material present in the arrester, and the longer the arrester can survive overvoltages without failure. Choosing the correct class and duty cycle of arrester involves margin of protection calculations and thermal considerations. A demonstration of the margin of protection calculations can be found in Eaton's technical data sheet TD192, *Insulation Coordination (For OVP)*. Recommendations for arrester kV based on system kV are found in the individual Eaton arrester catalog sections.

Within the Distribution class of arresters, there are three duty cycles: light duty, normal duty, and heavy duty. There are also riser pole arresters, which have performance characteristics slightly better than heavy duty Distribution class. Characteristics of the riser pole arrester are not governed by standards, but these arresters are often used at the last pole before overhead lines go underground. Here, they provide extra protection for the relatively expensive underground cable at its most vulnerable point.

There are three different types of Distribution class arresters: deadfront, livefront, and underoil. The different arrester types are utilized on different types of distribution systems. The following paragraphs describe the three types of arresters, and three duty cycles available for each.

Deadfront arresters are designed for use with 200 amp deadfront bushings. There are two varieties: elbow and parking stand. The elbow arrester is plugged into a bushing insert, which is then plugged into a transformer bushing. To use an elbow arrester in this manner, one side of a loop-feed transformer is energized, and the other side has arresters plugged into it. If an overvoltage travels to the transformer via the energized primary cable, it will pass through the transformer's loop-through cable, and be diverted to ground via



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the elbow arrester attached to the non-source high voltage bushing. The elbow arrester can also be plugged into a feed-through insert. This would allow a load bushing to be connected to the transformer via the same bushing well. Then, if an overvoltage travels toward the transformer via the energized primary cable, it is diverted to ground via the elbow arrester.

As the name implies, parking stand arresters mount to a transformer's frontplate at individual parking stands. De-energized cables are plugged into these arresters. If a surge travels down one of the de-energized cables, it is diverted to ground via the parking stand arrester instead of entering the de-energized transformer (as it would if the elbow were still plugged into the transformer), or travelling back up the de-energized cable. Note that reflection back through the cable is particularly troublesome because the overvoltage doubles in magnitude when the wave is reflected back. Both elbow and parking stand arresters are available as light duty Distribution class products. This duty classification takes into account the infrequency of lightning surges on pad-mounted equipment.

The location of underoil arresters is self-evident. They are connected to the line lead of a transformer, on the load side of any primary fusing, inside the transformer tank. A surge moving toward the transformer from either the "A" side or "B" side bushings will be diverted to ground by the underoil arresters. Underoil arresters are available as light duty Distribution class, but their thermal withstand characteristics are improved by the fact that they are surrounded by oil. The oil acts as a very good heat-sink. The arrester dissipates the heat of conduction via the oil such that the underoil arrester resists thermal breakdown. These arresters are available with exterior disconnect switches to allow overvoltage testing of the transformer without removing the tank cover.

Livefront arresters are used on livefront transformers. These are the same arresters used on pole-mounted transformers. Any surge approaching the transformer will be diverted to ground before entering the transformer. The housing material for livefront arresters may be polymer or porcelain. The arresters are available in normal and heavy duty. All livefront pad-mounted transformers come with arrester mounting provisions welded to the tank wall beneath each of the phase bushings.

Secondary arresters are the other type of arrester commonly found on pad-mounted transformers. These arresters protect the transformer against surges delivered to the transformer via the secondary cables. These surges can occur when the secondary cables are directly struck by lightning, or when a primary lightning strike travels down the secondary neutral to the service ground and is reflected back to the transformer via the service cables. There are single-phase and three-phase versions of Eaton's secondary arresters available, at 175 volt, 240 volt, 480 volt, and 650 volt classes.

The Eaton Connection

See Eaton Publications

- CA235025EN: M.O.V.E. Surge Arrester (Deadfront type)
- CA235027EN: Metal Oxide Parking Stand Surge Arrester (Deadfront type)
- CA235016EN: VariSTAR® Type AZU Heavy Duty Distribution Class Under-Oil MOV Arrester (Underoil type)
- CA235015EN: VariSTAR® Storm Trapper® High Energy Low Voltage Arrester (Secondary type)
- TD-192: Insulation Coordination

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