Polymer distribution arresters replace porcelain

New arresters provide safety from fragmentation

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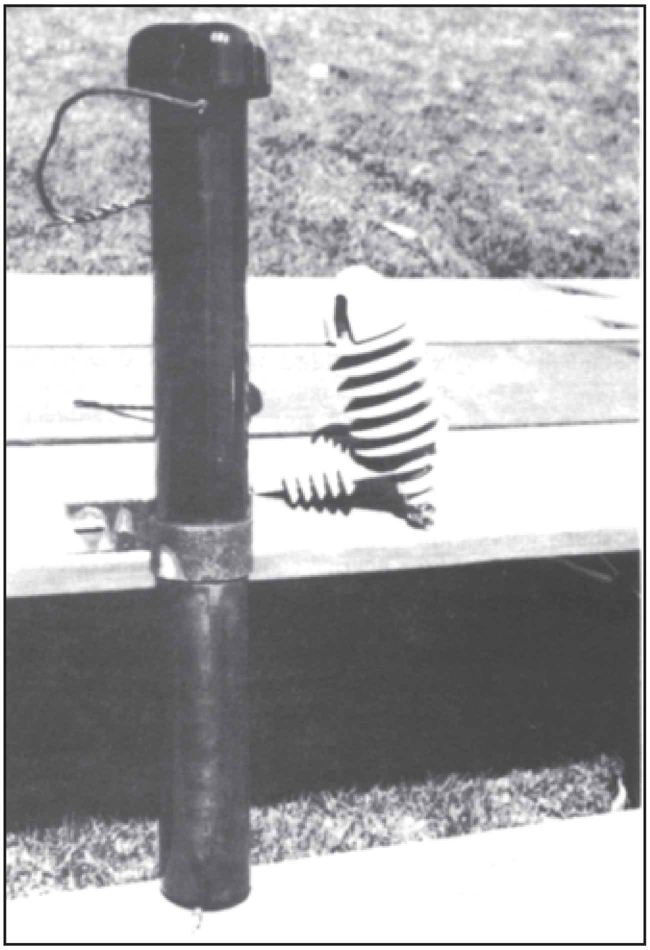

Fig. 1. *Arresters for 12-kV lines, designs 1925 (left) to 1987.*

Pennsylvania Power and Light Co. (PP&L) is using polymer-housed distribution class surge arresters on its 12-kV system. These arresters were first installed during the first quarter of 1987. Since the late 1970s, the distribution arresters used by PP&L have changed dramatically with the gapped silicon-carbide block construction being replaced by the gapless metal-oxide block construction. The conventional porcelain-housed distribution arrester without pressure relief was first replaced with non-fragmenting porcelain-housed arresters and now with a non-fragmenting arrester in a polymer housing. Figure I shows the quantum leap in down-sizing arrester design, from about 1925 to 1 987. The driving force behind this evolution is safety, having a goal using arresters that will not cause injury or property damage when they fail. The desired arrester is called a "Controlled Failure Arrester" or CFA, meaning that it is designed to fail in a non-violent manner. The arresters in Fig. 2 represent some of the additional steps in the design evolution. The CFA designs have yellow disconnectors.

Safety concerns

In the fall of 1979, a PP&L lineman was injured by an exploding arrester that had been in service for several years and was de-energized to allow the replacement of an overloaded transformer. The arrester failed as the installation was being returned to service.

This incident triggered other reports of near accidents and property damage. Over a 3-month period in early 1980, about 50 arresters were returned to PP&L's Distribution Engineering Dept. for evaluation. Each arrester had failed violently. The overall failure rate for arresters ranged between 0.2 and 1.0% and about 25% of these failures were of the catastrophic type.

The arrester that fails on a clear day, when least expected, is the greatest concern. Arresters that fail during lightning storms can be tolerated since line personnel are not usually working on a pole when a lightning-initiated failure occurs.

Defensive positioning and CFA

There were two paths that PP&L followed beginning in late 1979 to reduce the hazard of a failing arrester. The first was defensive positioning and the second was to develop a controlled failure arrester.

Defensive positioning was developed first since it could be managed in-house. Most pole framings were changed so that the linemen could be positioned defensively when energizing or de-energizing an arrester by using the pole or some other piece of equipment as a barrier to deflect flying parts. He is required to use a shot-gun stick when making the line connection (Fig. 3).

We tested temporary guards, such as rubber blankets and nylon rope bags (modified blasting mats), to cover the arrester before it was energized. These devices were quickly discarded because they were not effective or they were too cumbersome and in January 1980, PP&L asked all arrester manufacturers if a distribution arrester could be produced that would fail in a safe manner. We proposed that the arrester withstand an internal fault of 10,000A for 8 cycles without expelling internal or external parts.

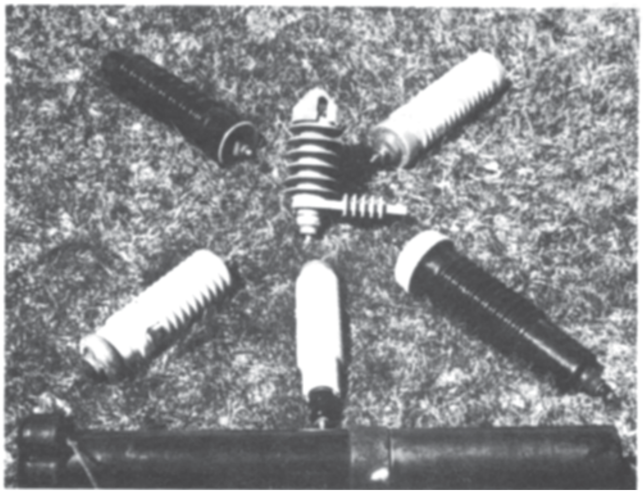

Fig. 2. *Convention arrester and CFA evolution.*

Our inspections of failed arresters, showing that moisture ingress through poor seals or cracked porcelain was the major cause of arrester failure, was confirmed by independent work done at both Detroit Edison Co. and Ontario Hydro Research Div. Therefore, we discussed sealing methods and test procedures with the manufacturers, since our experience is, even with the best seals and careful testing, that moisture will enter some percentage of the arrester population.

Manufacturers develop CFAs

In 1979, the General Electric Co. started work on a non fragmenting arrester design under an EPRI project, RP-1470.

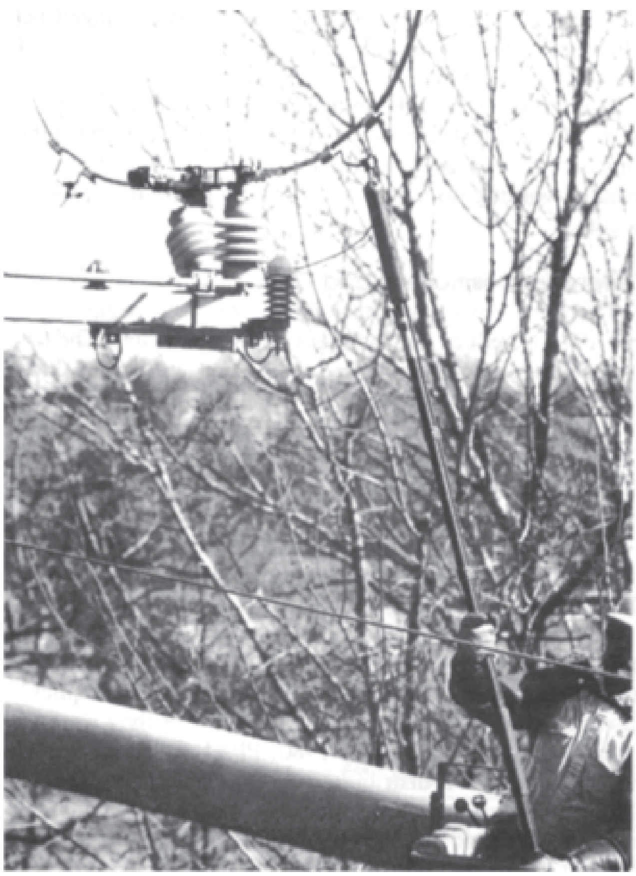

Fig. 3. *Linemen must use hot-line tool to energize any arrester.*

They developed an arrester that transferred the internal arc to the outside in 2 to 3 cycles by allowing the top and bottom caps to lift off the arrester. The porcelain was designed to remain intact and the internal parts were held inside the housing. The first of these arresters was installed at PP&L in early 1982.

The Joslyn Co. began work on a high-fault withstand arrester in early 1980. This arrester was designed to contain the energy of the fault inside the arrester until the fault. 10 kA for 8 cycles, was cleared. The first shipments of this design arrived at PP&L in mid-1982. McGraw-Edison Co. started working with PP&L on a new arrester design in late 1981. This design is based on the arc-transfer principle. PP&L started using this arrester in late 1983.

Each of these designs represents a definite improvement over the non-CFA, porcelain-housed distribution arresters. But our records show that occasional violent failures still occur with these improved designs even with special precautions and procedures to avoid physical damage to the arrester during handling.

Development of the polymer-housed arrester

The Ohio Brass Co. (OB) developed the next generation of controlled-failure arresters with a new design that incorporates a polymer EPM housing in combination with an internal fiberglass wrap providing mechanical strength to the valve block elements. Figure 4 shows cross-section views of the polymer-housed arrester and a conventional porcelain-housed metal-oxide distribution arrester. The polymer-housed arresters have a fault-current withstand capability up to 20,000 A for 10 cycles. This pressure-relief capability applies to arresters from 6 through 36 kV duty-cycle rated. Should the internal components of the arrester fail, the fiberglass wrap ruptures much like a green stick fracture, with the remaining strands and wrap holding the internal components together and allows the internal gasses generated within the arrester to be relieved. This arrester is much less likely, therefore, to expel fragments violently since there is no porcelain housing to fracture and become shrapnel. The arrester in Fig. 5 was prefaulted by placing a fuse wire under the fiberglass wrap and tested at 20,000A for 10 cycles. The arrester vented through its sidewall and no parts were expelled.

Another achievement in this new arrester design is the virtual elimination of free air space within the arrester. In conventional CFA and non-CFA arresters, nearly half of the internal volume consists of free gas. With temperature variations, this space tends to breathe and thus moisture can accumulate resulting in internal flashover and violent failure. The OB modular design completely seals the arrester from the environment and maintains a free air space of less than .05 cu inches. Consequently, there is no seal pumping action and no moisture can accumulate.

The OB design for the 10-kV arrester provides a leakage distance of 16 inches compared to as little as 9.2 inches on conventional and CFA porcelain-housed arresters. At larger kV ratings, there is in excess of 100% more leakage distance than the equivalent porcelain designs. The arrester is a heavy-duty type as defined by ANSI Standard C62.11, which, in conjunction with its very low discharge voltage levels, provides the best protection for our equipment and cables.

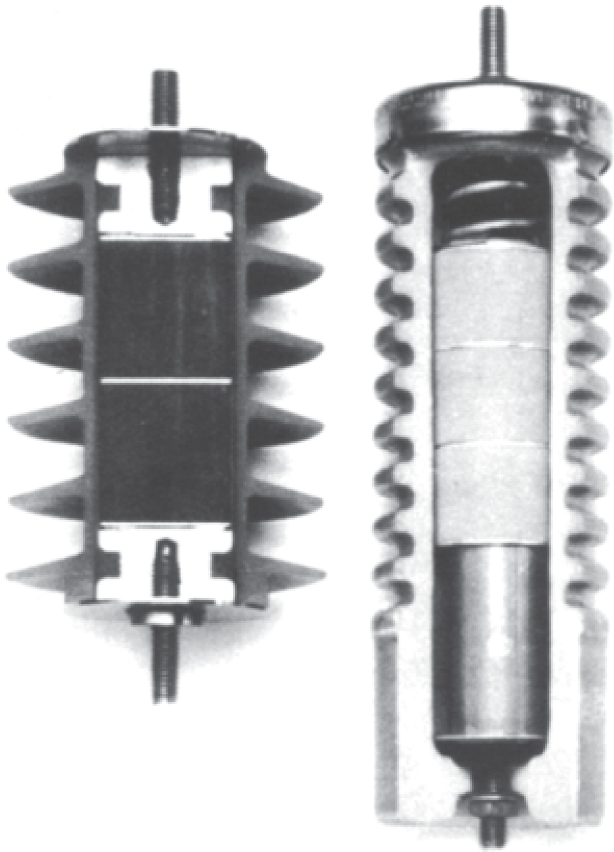

Fig. 4. *Ohio Brass 10-kV polymer-housed arrester (left) and conventional porcelain-housed arrester (right).*

PP&L has experience with the polymer material used in the arrester, having installed high-voltage transmission insulators from OB that incorporate the same polymer material. We have had these units in service for more than 7 years with a good operating record. In addition, we have considerable experience with other polymer insulation materials used outdoors at primary distribution voltages. In the late 1960s, we started using the epoxy and polymer deadend insulators offered by General Electric and A.B. Chance, and we are currently using only non-porcelain suspension insulators on the distribution system. We established a research contract with Westinghouse Advanced Systems Technology Div. as the main contractor and A.B. Chance as the subcontractor to study our in-service insulators and the new insulators on the market. Based on this research and other work done at Ontario Hydro, PP&L is confident that the polymer material used with the OB arrester will prove reliable.

Operation and maintenance procedures

The operating procedures at PP&L are based on the premise that the most likely time for an arrester to fail is when it is electrically disturbed. Therefore special precautions must be taken when energizing or de-energizing an arrester. Our procedures summarized below, based on porcelain-housed arresters, may change with respect to the polymer-housed arrester. However, until we have more field experience the procedures remain as follows:

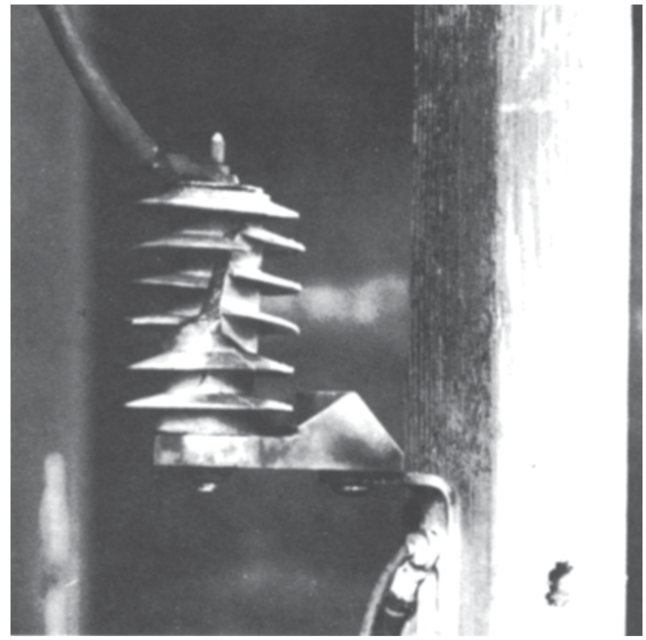

Fig. 5. *Polymer-housed 10-kV arrester after 20,000-A fault test for 10 cycles; arrester vented through side wall, no parts expelled.*

- Only porcelain or polymer-housed controlled failure arresters may be installed.
- When a conventional distribution arrester is de-energized to work at a location, it is replaced with a controlled-failure porcelain- or polymer-housed arrester.
- When work at a location does not require de-energizing the arrester, the operating arrester remains in place.
- All arresters are kept in their shipping carton until they are installed to prevent handling damage. An exception is that arresters may be preassembled onto large equipment such as air switches and reclosers at the crew location.
- Controlled-failure porcelain and polymer arresters are reused if they show no physical damage.

Experience/conclusions

To date we have experienced 100% success with the OB arrester, whose design virtually eliminates air space inside the arrester. Therefore, breathing/pumping action during temperature changes is nonexistent and moisture entry is improbable. The elimination of the porcelain housing reduces the hazard and probability of a violent failure. Polymer-housed arresters are much less susceptible to shipping/handling damage than porcelain-housed arresters.

Overall we expect the polymer-housed arrester to provide long, reliable service with improved safety at a lower cost to own and operate than porcelain-housed arresters.

The Author

Donald E. Fritz is Supervisor-Distribution Standards with PP&L. Allentown, PA. He received a BSEE from Drexel University. 1964, and has held various positions in distribution engineering at PP&L since that time He is a registered professional engineer in PA and is a member of the NFPA/NEC committee.

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