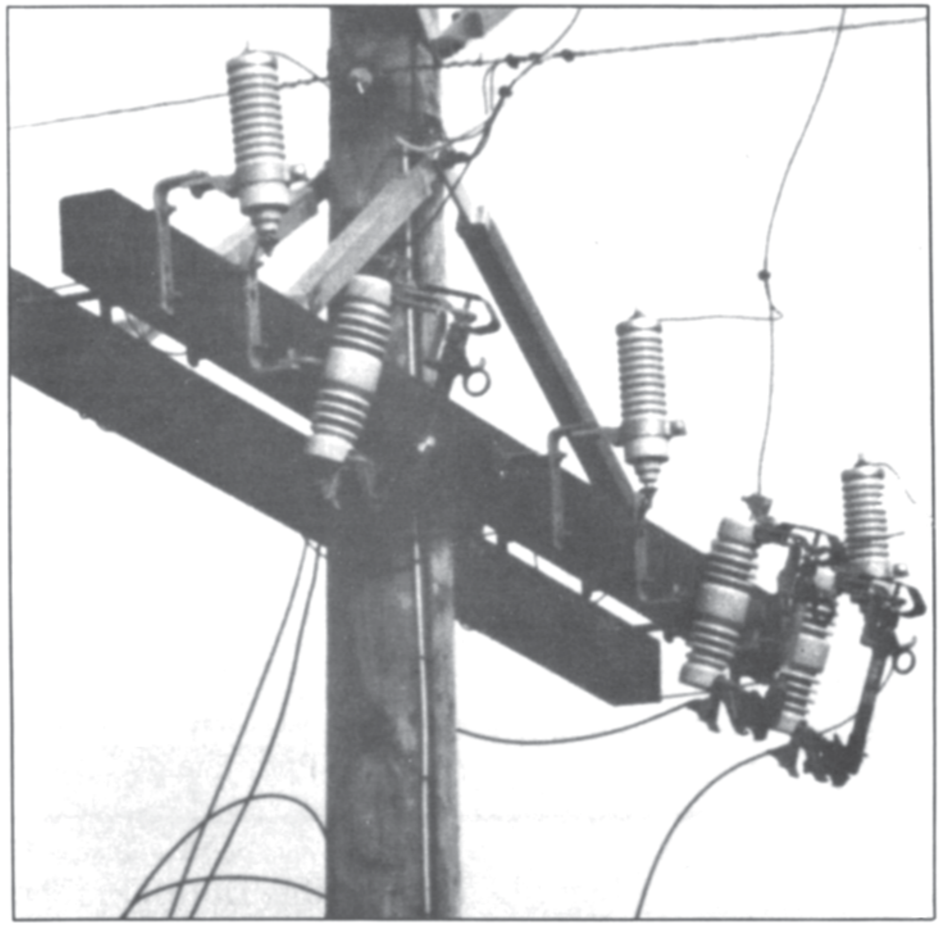
Metal-Oxide Arresters and Wye-Delta Transformer Banks

Metal Oxide arrester connections are sometimes made with MOV arrester on the line side of the fused cutouts as shown. However, this connection allows the extreme overvoltages across the transformers during energizing.



Introduction

Safety of the public and operating personnel is always a concern for utilities. Failures of metal-oxide arresters which occur while energizing wye-delta transformer banks have caused utilities concern when applying MOV arresters to these installations. This presentation will discuss reasons why utilities use this type of transformer bank connection, the problems experienced with application of metal-oxide arresters on these banks, and how operating practices can be revised to reduce the likelihood of arrester failures on these applications.

The Advantages of Wye-Delta Connections

There are several reasons the wye-delta transformer bank is used by utilities. Probably the most useful function this bank connection serves is its ability to simultaneously serve single-phase and three-phase loads. Single-phase load can be added to one leg of the bank with two-thirds of the load being carried by that transformer and one-third shared equally by the other two. This means the utility can increase the size of one transformer in the three-phase bank for single-phase loads while serving the three-phase loads. A balanced three-phase load will divide equally among the three transformers, even if the transformers have different impedances. Due to the wye connection, circulating currents within these types of banks are of no concern. Also, third harmonic currents in the supply lines are eliminated due to the delta configuration.

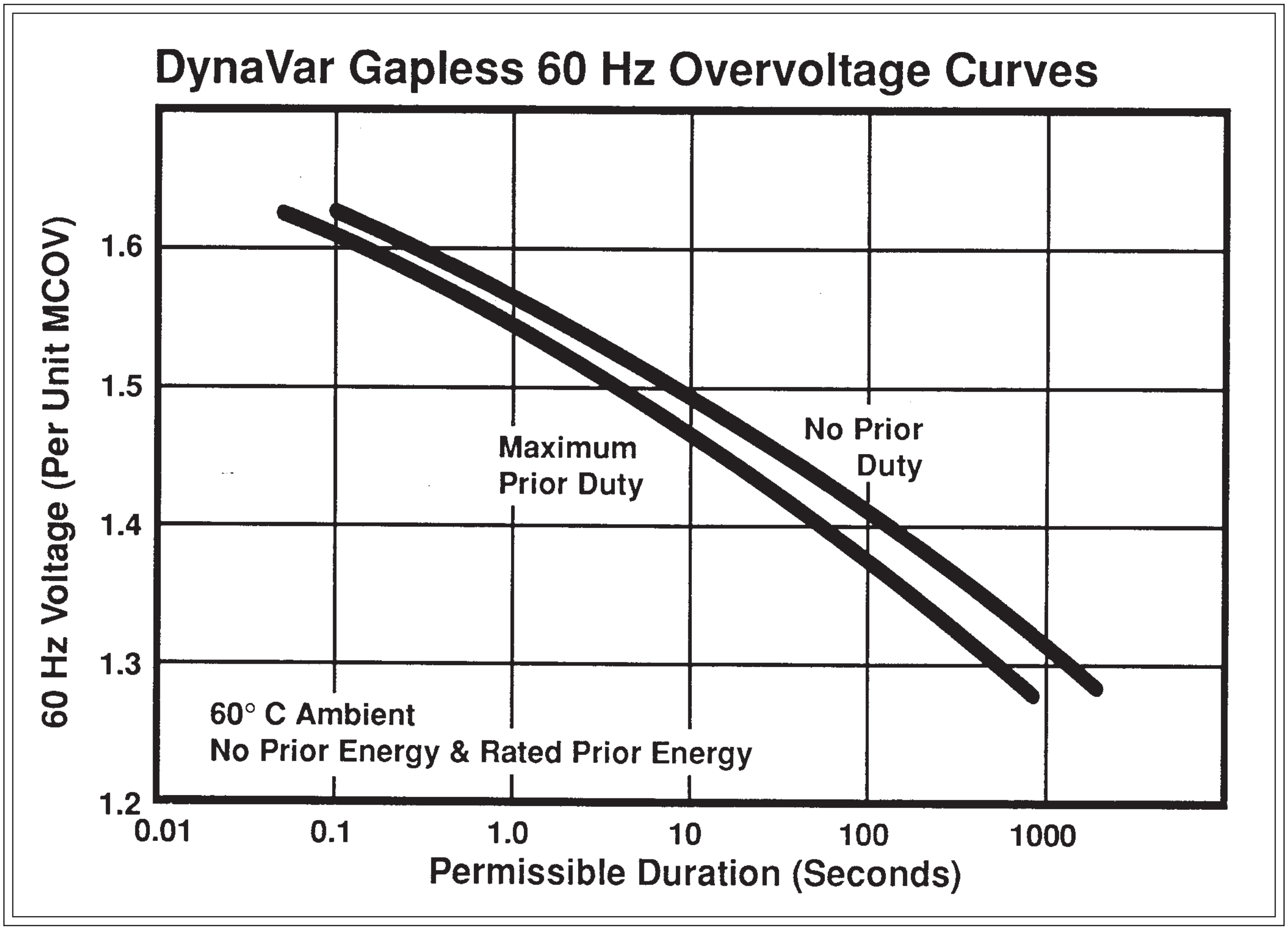
WHY UNGROUNDED?

Problems can be created with these transformer connections if they are normally operated with the wye grounded. Transformers can be destroyed due to a number of conditions that will exist when this bank is grounded. As noted above the delta will attempt to balance loads. This will cause circulating currents to be generated if the delta sees an unbalanced load on the primary side. Also, grounding the wye produces a path in the delta for third harmonic currents. The bank will act as a grounding bank and supply fault current to faults on the circuit. If this fault is a single-phase fault, and is cleared by single-phase equipment, the transformer bank will be overloaded when one phase is opened since it will become an open delta bank. The combination of all these conditions will add to the loading of the bank causing conditions of overload to exist when they normally would not occur. Therefore, the best operation of this type of bank is to operate ungrounded.

OVERVOLTAGES CREATED DURING OPERATION

Operating these transformer banks creates an overvoltage condition when they are ungrounded. This condition will arise when energizing a bank with an unbalanced load. When two phases

Per unit overvoltage capability of a DynaVar MOV arrester is determined by the chart below.



of the bank have been energized with no neutral, the third phase will be backfed through the delta. The voltage created on the primary side of the open-phased transformer can be higher than 2.5 times normal line to-ground voltage. If a metal-oxide arrester is installed on this phase, the arrester will try to limit this voltage by conducting enough current to limit the line-to-ground. When the third phase is finally closed, the operating arrester immediately sees the overvoltage plus the normal line-to-ground voltage with enough available current to cause failure of the arrester.

Overvoltage conditions have always existed when single-phase switching these banks. However, silicon-carbide arresters were not capable of recognizing the overvoltages present. Since a silicon-carbide distribution arrester had gap sparkover at levels approaching three times normal line to-ground, the arrester would not have reached sparkover before the third phase was closed. Therefore, the silicon-carbide arresters would allow these high overvoltage conditions to exist on the transformer banks rather than limiting them.

SOLUTIONS

There are several things which can be done to eliminate the safety hazards caused by failing arresters. One obvious solution is to eliminate arresters on these applications. This naturally affords no transformer protection for lightning, switching surges or other overvoltage conditions existing across the transformers.

Although a solution to the safety problem, the number of transformer failures can be expected to increase dramatically.

Another solution used in the past was the installation of silicon-carbide distribution arresters on these transformer banks. But, with their high sparkover levels, the silicon-carbide arresters will not protect the transformers from switching surges and overvoltages such as those experienced in operation of the banks. The safety hazard will have been reduced, but the protection of transformers will also be sacrificed.

An expensive solution to the problem is to only three-phase switch this type of transformer bank. Switching ail three phases at one time assures one phase will not be allowed to rise above the others. Most utilities will agree that three-phase switching of distribution wye-delta transformer banks is not economically feasible.

Probably the best solution to these situations is the addition of a temporary ground to the wye bank during operation of the bank. This can be accomplished with a fused cutout installed between the center of the wye and ground, operated normally open. When conditions exist, which require energizing of the bank, the crew could simply close the cutout prior to energizing the phases. This would tie the bank neutral to ground eliminating the floating neutral condition which causes the overvoltage on the last phase to be closed. Therefore, the voltage on the phases would be limited to the normal system line-to-ground voltage. After the bank is energized and operating, the crew could disconnect the ground and eliminate the problems previously discussed with operating these banks in the grounded mode. This solution permits use of normal ratings of modern metal-oxide arresters, without creating concern for overvoltage-caused failures.

SUMMARY

The wye-delta transformer connections are used in utility systems to serve three-phase customer loads when single-phase load can also be expected. The inherent capability of these transformer connections make them valuable due to their ability to share load between the transformers. Because of several factors, the best way to operate these banks is with the wye isolated from the system neutral and ungrounded. However the ungrounded mode of the wye-delta bank allows high overvoltage conditions to exist during operation of the banks. This overvoltage condition is recognized and corrected by MOV arresters. An operating procedure can be implemented by utilities which allows temporary grounding of the bank to eliminate the hazard of possibly violent failure of the MOV arresters.

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