Padmounted Transformer Tank Fault Withstand Capabilities

White Paper Executive Summary

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Report Prepared By:
P.E. Sutherland
R.A. Walling

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An objective of transformer fuse coordination is protection against violent failure of the transformer tank. While protection against high-impedance, low-current internal faults can be obtained from pressure relief devices, these devices offer no protection against the sudden application of pressure resulting from low-impedance, high-current faults. Unlike poletop transformers for which the standards provide a fault withstand test, based on cover retention, the present standards do not address the withstand capability of padmounted transformers to high- current internal faults.

This report summarizes research performed to determine the fault energy withstand capabilities of single-phase and three-phase padmounted transformers. In brief, the conclusions of this project are:

- The weak points of the padmounted transformers tested were accessory components, such as bushings and bayonet fuse holders, as well as covers on units with hand holes. Catastrophic failure of the tanks, such as gross weld splitting, was not observed in these tests for the fault duties applied.
- The failure threshold appears to be related to the ratio of fault energy to the air space volume above the oil in the transformer tank. A failure criterion of 40 J/in^3 has been identified by this research for padmounted transformers with flat tank walls and no radiator fins.
- Padmounted transformers with radiator fins appear to have substantially less fault energy withstand, due to stresses applied on the welds joining the fins to the tank. This is due to the relative stiffness of the fin against outward force compared to the tank wall.
- Fault energy is the product of the I^2t times an effective arc resistance, and the arc resistance is a nonlinear function of the arc current. For the 3" open arc used in this testing, a conservative estimate of arc resistance is:

$$R_{eff} = 0.5 \times I_{crest(kA)}^{-0.75}$$

Based on the above conclusions, definitive tank withstand guidelines have been created for padmount transformers without radiator fins. These guidelines are in the form of maximum current and time-current curves which can be used for overcurrent protective device coordination.