Drying and Rehabilitating Distribution Transformers

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A LARGE INDUSTRIAL PLANT on the eastern seaboard has developed a method of drying and rehabilitating transformers used in its electric power distribution system in its own shops. The procedure does not require a drying oven and produces results which equal or excel oven-drying in time requirements and improvement of insulation-resistance values. Development of this process was made necessary by the fact that the plant was faced with the prospect of failure of several 5,000-kva 11.5- and 2.3-kv transformers, which would have seriously crippled operations, and which readily could have resulted in complete shutdown of the plant for an extended period.

This plant has a total of 87,250 kva in 11.5–2.3-kv transformer capacity, with individual units ranging from 750 to 6,000 kva in size. Thirteen 3,750/5,000 kva transformers, totaling 65,000 kva, constitute the most important part of the total capacity. It was in this group that failures occurred.

It is the belief of the author that industrial-type loads impose more severe operating conditions on air-breathing transformers than utility-type loads, in those industries which operate on a 5-day workweek. Transformers carry no load or such light loads over the week ends that they cool to air temperature, drawing in more air and accompanying water vapor than utility system transformers, which are seldom without load and which have shorter periods of light load. These conditions can be shown to result in a greater accumulation of free water in the bottom of the transformer tank. Loading the transformer rapidly to a substantial part of its rating when operations are resumed produces a vigorous circulation of oil, which may carry a slug of free water up into current-carrying parts, causing internal flashover and failure.

Five such failures occurred in two years, each following two or more days of practically zero-load operation and each failure occurring after about four hours of loading at about the self-cooled rating of the transformer. Each failure started in the lowermost point of an outside 2,300-volt coil, burned through the winding insulation to the high-voltage coil, starting an 11.5-kv phase-to-ground fault. Ground relay operation tripped the 11.5-kv breaker, isolating the fault.

Prior to the first two failures, transformers had been inspected visually and the water-traps on the conservator tanks drained each week. Oil was tested for breakdown strength at approximately quarterly intervals. Acidity determinations were not made routinely but a test of all transformers in 1948 had shown all oil to be below 0.10 neutralization number. Tests after first two failures showed neutralization numbers from 0.20 to 0.60. Field treatment with fuller's-earth filters resulted in producing oil samples of satisfactory breakdown and acidity, but did not remove contamination from oil which did not pass through the filter, nor from the winding insulation. Investigation showed all other transformers of this class in danger of failure, the prevention of which required untanking, cleaning, drying, and replacing of oil in each transformer.

No local shop was equipped to do this work, so the repair of the units on which failures had occurred had to be made in out-of-town shops. The time for rail shipment and the work load on these shops' facilities indicated that too long a time would be required to have the transformers rehabilitated by others. Plans were started to construct an oven and to procure the other equipment needed to do the required work. The fire hazard inherent in oven drying oil-soaked insulation ruled out doing such work in the power plant where adequate space and rail and crane service existed, and where the work could be easily supervised. Lack of personnel experienced in this work also was a factor which made oven drying questionable.

A study of the fundamental requirements for moisture removal led to the belief that transformers could be dried in a satisfactory time and manner by circulating hot oil at a safe temperature and applying sufficient vacuum to reduce the vaporizing temperature of water to a point below the oil temperature. Equipment was available to try this process immediately on a transformer which had shown such low readings that it had been removed from service to prevent failure. After cleaning, the experimental setup raised the insulation resistance from values of 5 megohms for high-voltage winding to core, 1.5 megohms for low-voltage winding to core, and 6 megohms for high- to low-voltage winding to 290, 49, and 330 megohms respectively, corrected to same temperature, in 34 days of operation. Heavy tarpaulins, which had been used to reduce heat loss, and other improvised items of equipment were replaced as the drying program progressed. All transformers with critically low insulation values have been successfully cleaned and dried without further failures. Laboratory tests show that oil is not damaged by continued circulation at the temperature used.

It is believed that the method developed produces results equal to or better than oven drying, without fire hazard, and that by its use the time and expense of transporting transformers to an oven-equipped shop can be eliminated.

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