



Power Transformer Maintenance

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PDH: 3

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The objective of this course is to outline the suggested work procedures that are typically performed for transformer preventive maintenance. The suggested procedures presented in this course do not pertain to the major overhaul and transformer repair. Nevertheless, many procedures completed during routine maintenance and transformer major overhaul may be the same. The maintenance routines discussed in this section can be applied to a transformer that has not reached an advanced deterioration stage. Also, these suggestions are written for the average circumstances under which the transformer is required to work. It is further implied that all staff involved with the maintenance are adequately trained and have transformer maintenance experience. The suggested practices presented in this course are similar to those that manufacturers suggest for their equipment. If detailed instructions are needed, the student needs to consult manufacturer manuals. Transformer preventative maintenance involves routine inspection, adjustment, testing, minor fixes, and special handling instructions. Also, the trouble-free service of the equipment over its life depends on proper installation, operation, and maintenance.

Power Transformer Installation, Acceptance, and Maintenance Procedures

Transformer successful operation depends on correct installation, loading, and maintenance. Also it depends on proper design and manufacture. As is with all electrical devices, neglecting of certain requirements may lead to severe problems, if not to the equipment loss. The objective of transformer maintenance process can be summarized as follows:

Unscheduled Transformer Maintenance

This philosophy is based on reactionary operation mode. That is to say, maintain the equipment when it breaks down, otherwise do not take any actions.

Transformer Ordinary Maintenance

This philosophy considers making irregular visual inspection and doing repairs, adjustments, and necessary replacements.

Protective Maintenance

This approach consists of completing preventive, predictive and corrective maintenance. The preventive maintenance involves schedule maintenance and regular testing. Predictive maintenance involves extra monitoring and testing, whereas corrective maintenance considers repairing and restoring transformer integrity to its original condition when degraded conditions are found. The goal of the transformer protective maintenance is to control and prevent serious oil and winding insulation deterioration. Mineral oil and winding paper insulation are impacted by moisture, oxygen, heat, and other agents such as copper, iron, electric stress, etc. The end result is that oxidation happens in the oil which leads to transformer sludging. In sealed units ingress of moisture via atmosphere or seal leaks needs to be stopped. Moisture will decrease the dielectric strength of both the oil and the winding insulation systems. Also, transformer extra heating will cause the winding insulation (paper) to decompose which in-turn creates moisture. Increased moisture created in the paper not only decreases the paper insulating strength but also, as temperature increases, the moisture will migrate from the paper insulation to the oil and decrease its dielectric strength. The most important step is to construct transformers so that moisture and oxygen are kept out. The next step is to operate transformers so that they are not operated beyond their temperature ratings and limits. Also, the severity of deterioration needs to be controlled by periodically monitoring and testing transformer insulation, and take mitigation measures to restore transformer to its original condition. This approach can be summarized by the following:

1. Measure and control transformer heat
2. Inspect and maintain transformer auxiliary elements
3. Test and maintain transformer insulation

4. Maintain transformer bushing insulation
5. Maintain transformer protective coating

These points are discussed next under installation, maintenance and transformer testing. The transformers are divided into dry and liquid types for the purposes of this course.

Dry-Type Power Transformers

Installation

Factors that need to be clearly kept in mind when installing dry-type transformers are accessibility, ventilation, and atmospheric conditions. Ventilated dry-type power transformers are typically designed for application indoors in dry locations. They will work successfully where the humidity may be high, but under this condition it may be mandatory to take precautions to keep them dry if they are shut down for appreciable periods. Areas where there is dripping water need to be avoided. If this is not possible, adequate protection needs to be provided to stop water from entering the transformer enclosure. Precautions need to be taken to guard against accidental water entrance, such as might happen from an open window, by a break in a water or steam line, or from use of water near the transformers. Proper ventilation is mandatory for the adequate transformer cooling. Clean, dry air is recommended. Filtered air may decrease maintenance if the location presents a particular issue. When power transformers are installed in vaults or other restricted locations, adequate ventilation needs to be given to keep the air temperature within established limits when measured near the transformer inlets. Typically, this requires a minimum of 100 ft³ of air per minute per kilowatt (kW) of transformer loss. The area of needed ventilating openings depends on the vault height. For self-cooled power transformers, the needed effective area needs to be at least 1 ft. for each inlet and outlet per 100 kVA of transformer rated capacity, after deduction of the area occupied by screens, gratings, or louvers. Ventilated dry-type transformers need to be installed in areas free from unusual dust-producing mediums or chemical fumes. Transformers above 75 kVA need to be placed at least 12 in. from walls or other obstructions that might prevent free air circulation through and around each unit.

The distance between adjacent power transformers must not be less than this figure. Smaller transformers can be directly installed on the wall but still need to be mounted at least 12 in. apart. Also, accessibility for maintenance needs be taken into account in locating a transformer. If the transformer is to be placed near combustible materials, the minimum clearances established by the National Electrical Code (NEC) need to be kept. The transformer enclosure is made to stop the entrance of most small animals and foreign objects. Nevertheless, in some areas it may be mandatory to give consideration to extra protection. Typically, a flat, level industrial floor is adequate and no special preparation is required because of the base construction used on these transformers, which completely eliminates the process of grouting sills into concrete floors. If noise is a factor in the location and operation of any power transformer, special consideration needs to be given to the equipment installation. The transformer impulse strength is less than that of liquid immersed units of the same voltage class. If there is any chance that transformers will be exposed to lightning or serious switching surges, proper protective equipment needs to be provided. Transformers of standard temperature rise are made to function at altitudes up to and including 3300 ft. Dry-type transformers depend on air for dissipation of their heat losses; consequently, the effect of decreased air density due to high altitude will increase the transformer temperature. Typical transformers can be used at altitudes higher than 3300 ft. if the load to be carried is decreased below nameplate rating as follows: If the power transformer is dry type, self-cooled, class AA, decrease the nameplate rating by 0.3% for each 330 ft. above the altitude of 3300 ft. If the transformer is dry type, forced air cooled, class AA/FA, decrease the nameplate rating by 0.5% for each 330 ft. above the altitude of 3300 ft. If the maximum 24 h average temperature of the cooling air is decreased below design levels, the altitude limitation of 3300 ft. can be safely surpassed without decreasing the transformer nameplate rating within the limitations of Table 1.

Table 1. Maximum 24h average cooling air temperature (°C)

Type of apparatus	Altitude			
	3300 ft.	6600 ft.	9900 ft.	13200 ft.
Dry type, class AA				
80°C rise	30	26	22	18
115°C rise	30	24	18	12
150°C rise	30	22	15	7
Dry-type, class AA/FA				
80°C rise	30	22	14	6
115°C rise	30	18	7	-5
150°C rise	30	15	0	-15

Transformer Inspection

New power transformers should be inspected for damage during transport once they are received. Inspection has to be made before removing from cars or trucks, and if any damage is evident or any indication of rough handling is noticeable, a claim needs to be filled with the carrier at once and the manufacturer has to be informed. Subsequently, covers should be removed and an internal inspection made for damage or displacement of parts, loose or broken elements, cracked porcelain, dirt or foreign material, and for the presence of free water or moisture. Corrective actions have to be if necessary. Shipping braces need to be removed if provided. After a transformer is moved, or if it is stored before installation, this examination needs to be repeated before placing the transformer in operation.

After arranging all the necessary primary and secondary connections, the transformer needs to be thoroughly examined. Before putting in operation, the operation of fans, motors, thermal protection relays, and other auxiliary elements has to be verified. All bolted connections that may have loosened in shipment must be tightened before putting in service. The case and core assembly of power transformers needs to be permanently and properly earthed.



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