Electrical Equipment - Course 230.2

TRANSFORMERS: PART 2

OPERATING PROCEDURES

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1. OBJECTIVE

The student must be able to:

1. For (i) ANN,
(ii) ONAN & ONAF, and
(iii) OFW

transformers, state the checks that have to be done:

(a) before returning transformer to service.

(b) in service operation.

(c) taking transformer out of service.

2. Briefly explain the consequences of not doing the above checks.

2. INTRODUCTION

This lesson does not give the detailed the procedures that must be adopted from a work protection point of view. It explains the routine, "before returning to service", "in service" and "taking out of service" checks that must be done to ensure safe transformer operation. It also explains the consequences of not doing these checks.

The accompanying Tables 1, 2 and 3 give the operating procedures for each type of transformer.

In this lesson, it is assumed that each transformer has been previously commissioned.

3. TRANSFORMER OPERATION

3.1 ANN Transformers

ANN transformers have their core and windings Air Naturally cooled. The cooling air is then allowed to circulate Naturally from the transformer enclosure to the surrounding atmosphere. This type of transformer is used indoors and is replacing Askarel filled transformers.

3.1.1 Inservice Operation. ANN transformers, from an operational viewpoint, have three areas which require careful attention.

ANN transformers must:

(a) Be kept dry and free from condensation. Any moisture or condensation collecting on the windings and connections will lower the electrical strength, and if energized under this condition, will in all probability, result in a short circuit within the transformer.

(b) Be kept reasonably dust free. An excess of dust will impair the flow of cooling air with the consequential risk of overheating. Excess temperatures will shorten the life of components, in particular insulation. If the temperature rise should become extreme, the transformer could fail in a very short period of time (hours). Dust often contains corrosive products which can attack the insulation. This can lead to electrical or mechanical failure.

(c) Have adequate ventilation. The ventilation passages and metal clad cubicle louvres must be kept clear. In addition, the room in which the transformer is operated must be properly ventilated to prevent excess ambient temperatures.

Inadequate ventilation will result in excess temperatures of the windings and other components.

3.2 ONAN and ONAF Transformers

ONAN transformers have their windings and core cooled by Oil Naturally circulating (thermo syphon). The oil is then cooled by Air which is Naturally cooled. With the ONAF transformers, the cooling Air is Force circulated using a fan or fans.

3.2.1 Inservice Operation. ONAN and ONAF transformers, from an operational viewpoint,have five areas which require careful attention. These transformers must:

(a) Have the **oil level at the correct level** for the ambient temperature. It is essential that at all times, while the transformer is energized, that the core, windings and connections are submerged in oil. If any of these components are not submerged while the transformer is energized, there is the probability of a short circuit occurring in the transformer. Any short circuit in a transformer will cause severe and in many cases irreparable damage.

It is important to ensure that the oil in a transformer is allowed to expand as it heats up. When it is not allowed to expand, for example if the valve between the conservator and main tank has been left closed, the tank and other components will be pressurized and may rupture. For this reason, it is important to observe the oil level indicator moves as the transformer heats and cools. An indicator that does not move may be caused by its mechanism being seized.

(b) Have the **conservator tank breather and dryer in operation.** As the transformer warms up and cools down, the oil expands and contracts. The conservator tank is provided to allow for the change in oil volume. When the transformer heats up, the air at the top of the conservator tank is forced out through the breather. Air enters the breather when the transformer cools. If the breather is blocked, the transformer will pressurize when it heats up or be under vacuum when it cools down. This effect may damage the tank, conservator tank or explosion vent (which has a thin diaphragm). It is therefore important that the breather is allowed to breathe freely through its dryer. The dryer is provided to ensure that air entering the breather and the conservator tank top air space is as dry as possible. If the dryer fails, the oil in the conservator tank (and then in the main tank) will soon become contaminated with moisture. When oil becomes damp, it loses its electrical strength. It also becomes acidic, the acid products will attack the insulation and other components.

(c) Have **no oil leaks.** A transformer which has a small oil leak when cold will have a larger oil leak when hot. It is essential, that as soon as an oil leak is discovered, it receives urgent attention. Failure to observe this precaution may result in the transformer oil level falling and uncovering components within the transformer tank. In addition, the oil that escapes from the transformer will be a potential pollution hazard to the surrounding area.

(d) Have **no gas collected** in gas accumulation relay. This relay is provided with an indicator which shows when any gas has been collected. If the level exceeds the preset value, an alarm is brought up in the control room.

When gas collects in the relay, it is a sign that either trapped air is rising to the highest point, or that arcing, sparking or overheating is breaking down the oil into gases and carbon. Analysis of the collected gases will determine whether the situation is not dangerous (air collected) or dangerous (hydrogen methane, acetylene and other gases collected). If dangerous gases are being collected, it is a sign that serious deterioration is taking place within the transformer and an immediate investigation is required. This will include off loading and probably taking the transformer out of service for extensive tests.

(e) Have their **fans operational,** (ONAF type). With some transformers, the fans are controlled and cut in as the winding or oil temperature rises. On other transformers, the fans have to be placed in service before the transformer is energized. Depending on the type of control is used, it is essential that before the transformer is energized, all fans are checked to be operational. Failure to do these checks can result in the transformer overheating, when the transformer is put on load.

3.3 OFW Transformers

OFW transformers have their windings and core cooled by Oil which is Force circulated by pumps. The oil is then cooled by oil/Water heat exchangers.

3.3.1 Inservice Operation. The operation of OFW transformers generally follows the operation of ONAN and ONAF transformers, ie, the same:

(a) oil level checks.

(b) conservator breather and dryer checks.

(c) checks for oil leaks.

(d) gas accumulation relay indication checks.

In addition to the above, the oil/water heat exchangers require special attention.

(i) when there is no danger of freezing, the oil circulation pumps and heat exchangers must be put into service before the transformer is energized. The pumps and heat exchangers must then remain in service whilst the transformer is energized.

(ii) when there is a danger of freezing, the heat exchangers can be damaged by either one of two ways:

- water, allowed to stand in the heat exchangers, can freeze. For this reason, whenever there is a danger of freezing, the heat exchangers must be drained on the water side.

- under very cold conditions, the oil in an de-energized transformer can attain a temperature which is well below 0°C. If the oil pumps are now started and cooling water is admitted to the heat exchangers, there is the very real danger that the very cold oil will freeze the water in the heat exchangers. Damage will result. Water may then start to mix with the transformer oil and reduce the oil's insulating properties. Even if heat exchangers are not damaged, the blockage of the water circuit will

cause the transformer to overheat (due to reduced cooling). For this reason, when the oil in a transformer is below 0°C, no water should be admitted to the heat exchangers until the oil temperature has risen to 0°C. The circulation pumps, must however, be started before the transformer is energized. This is to ensure there are no local hotspots in the windings or core.

When taking OFW transformers out of service, to save energy and undue wear, the heat exchangers should be taken out of service by shutting off the cooling water and shutting down the oil circulation pumps. If there is any danger of freezing, the water side of the heat exchangers must be drained.

3.4 Transformer Operating procedures: Tables

Tables have been included which list the following procedures for power transformers:

- before returning to service
- in service operation
- taking out of service

The information given in these tables has purposely been made brief. If fuller explanations are required, the information can be found in earlier sections of this lesson.

TABLE 1: TRANSFORMER OPERATING PROCEDURES ANN

Transformer Type & Cooling System	Precautions to be Observed	Consequences of Failure to Observe Precautions
ANN Air Naturally convects through vents at base of transformer enclosure and cools core and coils. The air then passes through vents at top of enclosure and convects Naturally into surrounding atmosphere.	1. Before returning transformer to service.	
	Ensure:	
	a) Transformer and surrounding areas are dry.	a) Damp insulation may not be able to withstand electrical stress and may fail.
	b) Core and coils are reasonably dust free.	b) An excess of dust will impair cooling. Consequential overheating will reduce insulation life. Corrosive products may be formed which will attack insulation.
	c) Ventilation passages and cubicle louvres must be kept clear. Adequate ventilation must be provided in transformer room.	c) If cooling is inadequate in service overheating will occur.
	2. During service.	
	Ensure transformer is kept:	
	a) Dry.	a) As 1(a).
	b) Reasonably dust free.	b) As 1(b).
	c) Properly ventilated.	c) As 1(c).
	3. Taking transformer out of service.	
	Ensure transformer is kept:	
	a) Dry.	a) As 1(a).
	b) Reasonably dust free.	b) As 1(b).

TABLE 2: TRANSFORMER OPERATING PROCEDURES ONAN & ONAF

Transformer Type & Cooling System	Precautions to be Observed	Consequences of Failure to Observe Precautions
ONAN	1. Before returning transformer to service.	
Oil Naturally converts through transformer core and coils. The oil is cooled by Air Naturally convecting through the tank and radiators (if used).	Ensure: a) Oil level is not below the LOW mark for the ambient temperature.	a) Windings must be covered with oil to ensure correct cooling and insulation. A low oil level may cause transformer to fail due to cooling or insulation problems.
	b) The conservator breather and dryer are operational.	b) To prevent the transformer from becoming pressurized, the breather must be operational. Dryer must be in service to prevent atmospheric moisture contaminating oil.
	c) There are no oil leaks.	c) If oil is leaking when it is cold, it follows more oil will leak when it is hot. See (a).
	d) The gas accumulation relay indicator indicates zero.	d) Gas accumlation is a sign of serious transformer deterioration. Problem must be investigated before transformer is put into service.
	e) Valves to conservator and radiators are all open.	e) If conservator tank valve is closed, tank will be pressurized. If radiator valves are closed transfomrer will overheat.
ONAF	a) to e) above, and	
As above but cooling Air is Forced through radiators by fans.	f) Fans are operational.	f) Lack of operational fans may cause transformer to overheat with consequential risk of damage.

TABLE 2: TRANSFORMER OPERATING PROCEDURES ONAN & ONAF (Continued)

Transformer Type & Cooling System	Precautions to be Observed	Consequences of Failure to Observe Precautions
ONAN & ONAF	2. During service.	
	Ensure:	
	a) Oil level rises slightly as the transformer warms up.	a) If indicated oil level does not rise, this is an indication that the conservator valve is closed or that indicator has seized
	b) The conservator and dryer are operational.	b) As 1 (b).
	c) There are no oil leaks.	c) As 1 (c).
	d) The gas accumulation indicator indicates zero.	d) Any gases produced indicate that serious internal deterioration is taking place. Investigation is required to prevent further damage.
	e) N/A.	e) N/A.
ONAF ONLY	f) Fans are operational.	f) As 1 (f).
ONAN & ONAF	3. Taking transformer	out of service.
	Ensure:	
	a) Oil level falls slightly as the transformer cools.	a) If indicated oil level does not rise, this is an indication that the conservator valve is closed or that indicator has seized.
	b) The conservator breather and dryer are operational.	b) As 1 (b).
	c) There are no leaks.	c) As 1 (c).
	d) No gas accumulation.	d) Any gases produced indicates that internal deterioration is taking place. Investigation is required to prevent further damage.
	e) N/A.	e) N/A.
ONAF ONLY	f) Fans are shutdown.	f) To prevent undue fan wear and unnecessary energy consumption.

TABLE 3: TRANSFORMER OPERATING PROCEDURES OFW

Transformer Type & Cooling System	Precautions to be Observed	Consequences of Failure to Observe Precautions
OFW Oil is Forced through transformer core and coils by pumps. The oil is cooled by oil/Water heat exchangers.	1. Before returning transformer to service.	
	Ensure:	
	a) Oil level is not below the LOW mark for the ambient temperature.	a) Windings must be covered with oil to ensure correct cooling and insulation. A low oil level may cause transformer to fail due to cooling or insulation problems.
	b) The conservator breather and dryer are operational.	b) To prevent the transformer from becoming pressurized, the breather must be operational. Dryer must be in service to prevent atmospheric moisture contaminating oil.
	c) There are no oil leaks.	c) If oil is leaking when it is cold, it follows more oil will leak when it is hot.
	d) The gas accumulation indicator indicates zero.	d) Gas accumulation is a sign of serious transformer deterioration. Problem must be investigated before transformer is put into service. Failure to observe this may result in severe damage to the transformer.
	e) Valves to conservator and heat exchangers are all open.	e) If conservator tank valve is closed, tank will be pressurized.
	f) Cooling system.	f) If heat exchanger valves are closed, transformer will overheat.
	i) SUMMER Cooling systems, oil pumps and oil/water heat exchangers must be operational.	i) Lack of cooling will cause transformer to overheat with consequential risk of damage.
	ii) WINTER Oil pumps to be put into service, water must not be passed through coolers until oil has attained a temperature of 0°C.	ii) When oil below 0°C and cooling water are passed through heat exchangers at the same time, the oil will freeze the water in the heat exchangers. This freezing action will damage the heat exchangers and may allow water into the oil. Transformer overheating may also occur.

TABLE 3: TRANSFORMER OPERATING PROCEDURES OFW (Continued)

Transformer Type & Cooling System	Precautions to be Observed	Consequences of Failure to Observe Precautions
OFW	2. During service.	
	Ensure:	
	a) Oil level rises slightly as the transformer warms up.	a) If indicated oil level does not rise, this is an indication that the conservator valve is closed or that indicator is seized.
	b) Conservator breather and dryer are operational.	b) As 1(b).
	c) No oil leaks.	c) As 1(c).
	d) No gas accumulation.	d) As 1(d).
	e) N/A.	e) N/A.
	f) Cooling system is operational whenever transformer is energized.	f) As 1(f).
OFW	3. Taking transformer out of service.	
	Ensure:	
	a) Oil level falls slightly as the transformer cools.	a) If indicated oil level does not fall, this is an indication that the conservator valve is closed or that indicator is seized.
	b) Conservator breather and dryer operational.	b) As 1(b).
	c) No oil leaks.	c) As. 1(c).
	d) No gas accumulation.	d) As 1(d).
	e) N/A.	e) N/A.
	f) (i) Oil pumps to be shut down.	f) (i) To save energy and pump wear.
	(ii) In winter, oil coolers to be isolated and drained.	(ii) To prevent frost damage.

ASSIGNMENT

1. For an ANN transformer, state the checks that have to be done, and brefly explain the consequences of **not** doing the checks.

   (a) before returning transformer to service.

   (b) in service operation.

   (c) taking transformer out of service. (Sections 3.1 and 3.4 Table 1.)

2. Same question for ONAN and ONAF transformers. (Sections 3.2 and 3.4 Table 2)

3. Same question for OFW transformers. (Sections 3.3 and 3.4 Table 3)

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